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Gravel Pit Ponds as Habitat Enhancement for Juvenile Coho Salmon

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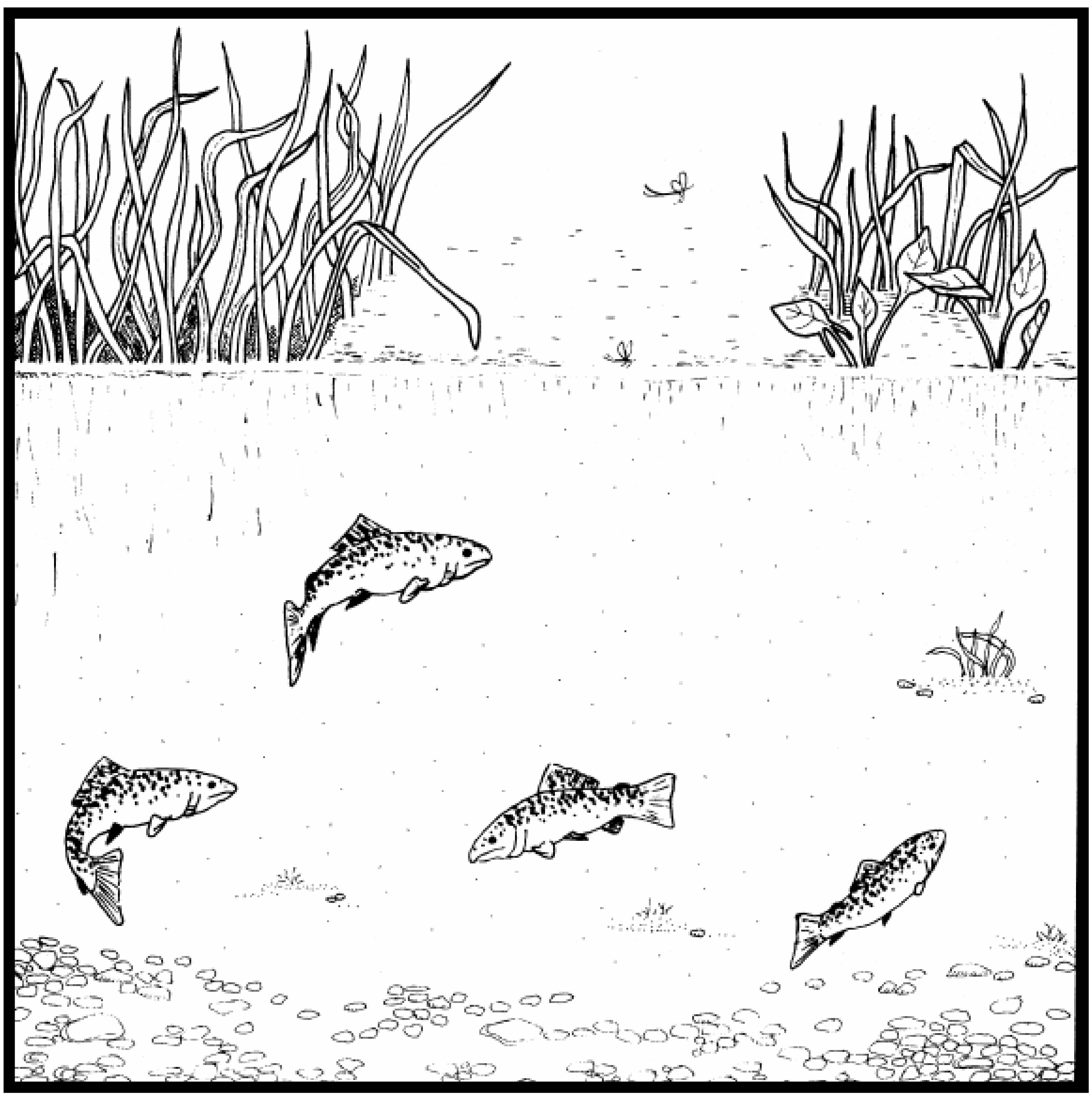

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Abstract

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Gravel pits built during road construction in the early 1970's near Yakutat, Alaska, filled with water and were connected to nearby rivers to allow juvenile salmonids to enter. Seasonal changes in population size, length and weight, and length frequencies of the coho salmon population were evaluated over a 2-year period. Numbers of coho salmon fluctuated, but two of the ponds supported high populations, more than 2,000 fish, throughout the study. These ponds appeared to support coho salmon throughout the winter. The range of physical measurements of the ponds did not seem to account for differences in numbers of salmon, but low concentrations of dissolved oxygen were detected in all ponds near the bottom. Aquatic vegetation, water exchange rate, and access may have affected the number of coho salmon in the less-productive ponds.

Keywords: Fish habitat, salmonids, stream habitat management, southeast Alaska, Alaska (southeast).

Contents

Introduction

Road construction and forest development are commonly associated with detrimental effects on salmonid habitat; with proper planning, however, such effects can be avoided. In this paper, I discuss a method to improve salmonid production in conjunction with road construction.

Juvenile coho salmon *(Oncorhynchus kitsuch)* are aggressive, invasive, and mobile (Allee 1974, Chapman 1962, Skeesick 1970). Sheridan 1 suggested that the gravel pits, created during road construction on the glacial outwash of the Yakutat forelands (Alaska Department of Fish and Game 1984), would be exploited by juvenile coho salmon if the ponds were connected to river systems containing coho salmon. Several gravel pits that had filled with water were connected by artificial channels to nearby rivers during the 1970's. Coho salmon fry were observed in the ponds, but no systematic effort was undertaken to estimate the number of fish in the ponds or to evaluate their effectiveness as rearing habitat.

The purpose of this study was to determine if these ponds were suitable rearing habitat for juvenile coho salmon. Numbers of juvenile coho in four ponds were estimated over several seasons. Size and ages were determined. Selected chemical and physical measurements were taken on the ponds to identify factors that could account for differences in salmon populations.

Although ponds are not generally associated with coho salmon habitat, beaver ponds and riverine ponds have been identified as productive coho habitat in Alaska and in Washington in recent years[2] (Bryant 1984, Peterson 1982). Russell and Schramek (1984) found about 2,500 coho salmon fry and 500 fingerlings in a gravel pit associated with a beaver pond during the summer of 1977. They did not follow the populations through the winter, however. Both Peterson (1982) and Russell and Schramek (1984) reported seasonal migrations to and from the ponds. Although most of these studies were on natural ponds, their results indicate that ponds created by gravel borrow pits can support juvenile coho salmon; such ponds may be an inexpensive method to increase coho salmon production.

Methods

Four ponds-Nine-Mile, Green, Twenty- Two-Mile, and Beanbelly-were sampled monthly from July through October 1983 and during spring or early summer and autumn in 1984 and 1985. Minnow traps (mesh size = 6.3 mm) were baited with salmon eggs and distributed along the edge of the ponds, usually within a few meters of the bank, 1 to 2 m deep. A few were placed in the middle of the ponds. Between 26 and 30 traps were sufficient to sample each of the ponds. In 1984, Twenty- Two-Mile Pond was not sampled because of low coho salmon populations. Green Pond was not sampled in 1985 for the same reason. Traps were allowed to fish for 1 hour, long enough to capture a sufficient sample. Longer periods occasionally resulted in high mortalities. Mortalities incurred during handling were identified and removed from the experiment.

All fish were identified and measured (total length). Scales and weights were taken from a subsample of the salmonid population. Salmonids were marked by punching a hole in the caudal fin. In the fall of 1984, salmonids were marked by freeze branding (Bryant and Walkotten 1980).

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[1] Sheridan, W.L 1970. Coho salmon habitat improvement-on glacial outwash plains. U.S. Department of Agriculture, Forest Service, Region 10. Unpublished.

[2] Sanders, G.H. Movement and territoriality in juvenile coho salmon *(Oncorhynchus kisutch)* in a southeast Alaska pond. Alaska Department of Fish and Game, Juneau, AK. Unpublished report.

Population size was estimated either with the Schnabel multiple mark and recapture method or the Bailey modification of the Peterson estimate (Ricker 1975). The Schnabel method was used in all the 1983 samples. The method varied in later samples because of limited sampling time. The multiple mark and recapture experiments were conducted over a period of 5 days or less. Emigration and immigration were negligible during the summer. During of the summer sampling periods, water levels were low and streams into and out of the ponds were either not running or had small flows. Increased rainfall in the autumn resulted in higher flows, but mark and recapture samples were done over a period of 2 or 3 days to minimize the effect of fish moving into or out of the ponds.

All four ponds were surveyed to determine surface area. Depth profiles were not made, but maximum depths were determined during secchi disk and oxygen measure ments. Temperature and oxygen were measured with a YSI[3] oxygen meter in 1983 and 1984. Oxygen measurements in June 1985 were made with the Alsterburg modification of the Winkler method (U.S. Environmental Protection Agency 1974).

Results

The number of coho salmon in Nine-Mile and Beanbelly Ponds increased from July to October in 1983. Each pond supported more than 3,500 coho salmon in the fall of 1983 (fig. 1). Green and Twenty-Two-Mile Ponds were not sampled after October 1983 because few fish were captured. The number of coho salmon in Green Pond declined from an estimated 2,700 in August to a point where no estimate was possible in October (fig. 1). The number of coho salmon in Twenty-Two-Mile Pond was consistently low.

[3] Use of trade names is for the information and convenience of the reader. Such use does not imply endorsement by the U.S. Department of Agriculture of any product or service to the exclusion of others that may be suitable.

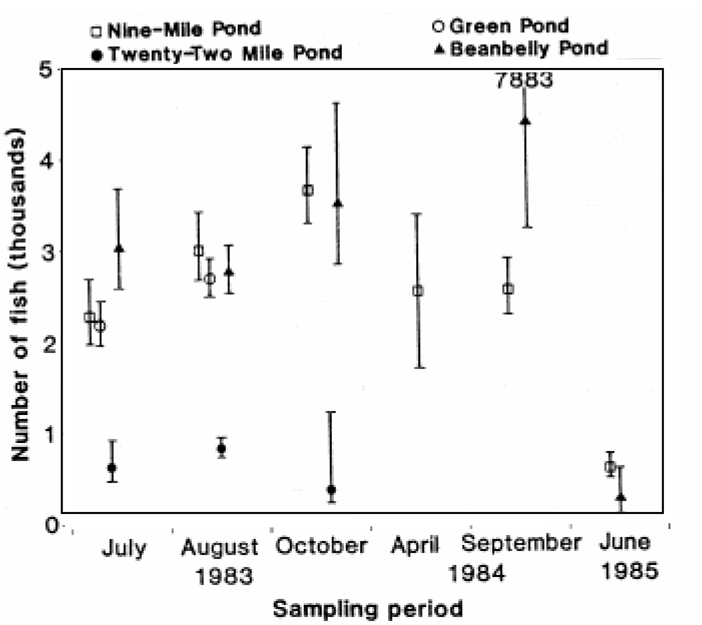


Figure 1—Population estimates of coho salmon captured in Nine-Mile, Green, Twenty- Two-Mile, and Beanbelly Ponds from 1983 to 1985.

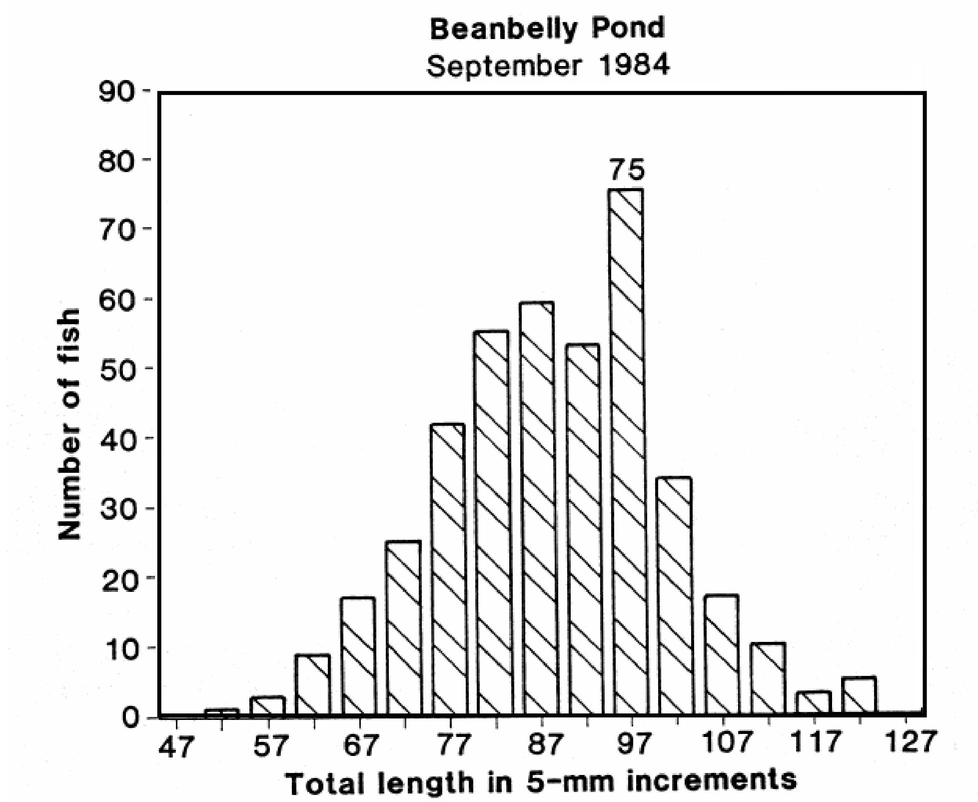
Population estimates in Nine-Mile and Beanbelly Ponds were made October 1983, April 1984, September 1984, and June 1985 to assess overwinter use of the ponds. Beanbelly Pond was not sampled in April. 1984 because snow on the road made it inaccessible. In Nine-Mile Pond, the number of juvenile coho salmon decreased from 3,666 to 2,547 between October 1983 and April 1984. Fin punches applied in October were observed in the April sample; therefore, coho salmon overwintered in the pond, but emigration and immigration likely occurred between the sample periods. Because of heavy snow, the ponds were not sampled until the 1st week in June 1985. The low populations in both ponds in June may be attributed to smolt migration. Comparison of length frequencies in September 1984 and June 1985 in Beanbelly Pond corroborate this migration (fig. 2). In September 1984, the median length of coho salmon in Beanbelly Pond was 88 mm (total length), and more than 10 percent of the total catch was longer than 100 mm; in June 1985, the median length was 82 mm, and less than 2 percent of the total catch was longer than 100 mm.

A few coho salmon marked with freeze brands in September 1984 were recovered from both ponds in June 1985, but they numbered less than 1 percent of the total catch; therefore, overwinter survival cannot be estimated. Recovery of marked fish in June 1985 and the persistence in the ponds of coho salmon that were at least 1 year old in the spring and early summer of 1984 and 1985 indicate that the ponds are used over the winter.

Recruitment to the ponds appears to be the result of upstream migration of juvenile coho, except in Beanbelly Pond which is fed by a stream with spawnable habitat. Recruitment of fry into the ponds appears to begin in June. During May 1984, fewer than 5 percent of the coho salmon caught in Nine-Mile Pond were smaller than 62 mm (total length); by September, more than 16 percent were smaller than 62 mm (fig. 3). Between July and September, the percentage of smaller coho salmon increased slightly in Nine-Mile Pond, indicating that fry moved into the pond. In Beanbelly Pond, the percentage of smaller coho salmon decreased slightly from July to September in 1983, suggesting that smaller fish did not move into the pond and that the difference in size was the result of growth.

Significant differences occurred among the length-weight regressions computed for the coho salmon captured in the four ponds in July and August 1983 (table 1). Throughout the analysis, Nine-Mile Pond shows a consistently higher slope than the other ponds, indicating more robust fish and better growth. In September 1983, large differences appear in the slope of the regression for Twenty- Two-Mile Pond (2.2) compared to those of Nine-Mile and Beanbelly Ponds (2.8 and 2.7). The lack of significance in September 1983 may result from the smaller sample size in Twenty-Two-Mile Pond compared to that in the other two ponds.

Although depths of each pond varied, each had a relatively uniform profile tapering from a deep end to a shallow end with steep sides. The least productive pond, Twenty-Two-Mile, was also the shallowest. Green Pond and Nine-Mile Pond were similar in depth and shape (table 2); both are connected to the Situk River. Beanbelly, the largest and deepest of the four ponds, has an irregular shape and is more like a natural pond. It is fed by a perennial stream.



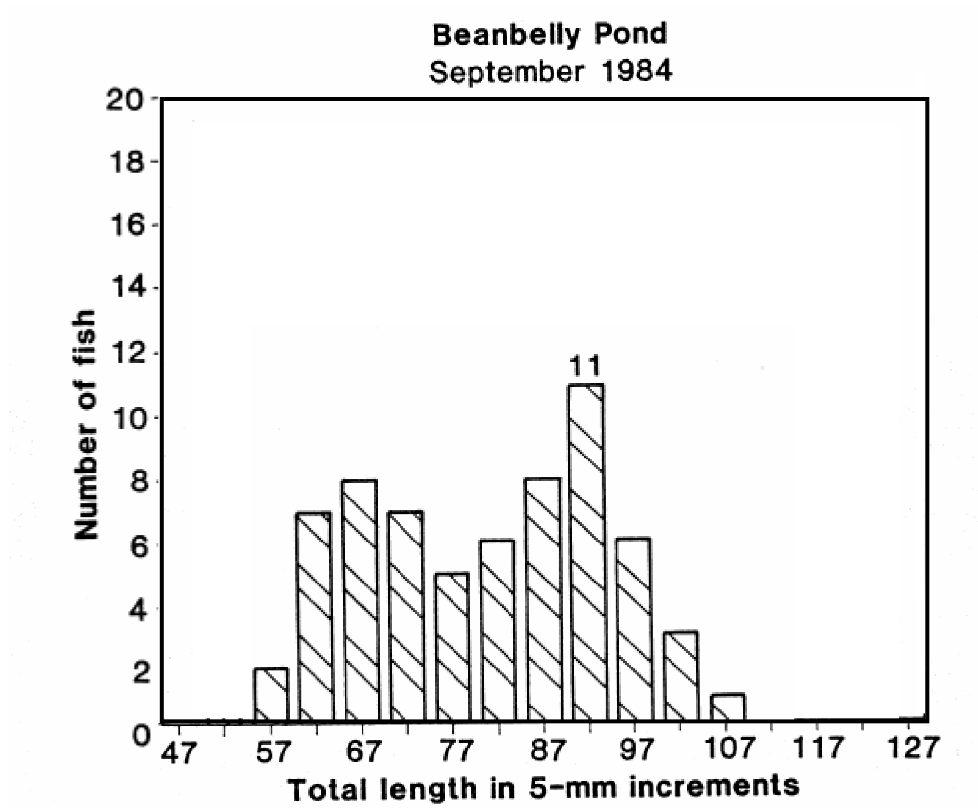
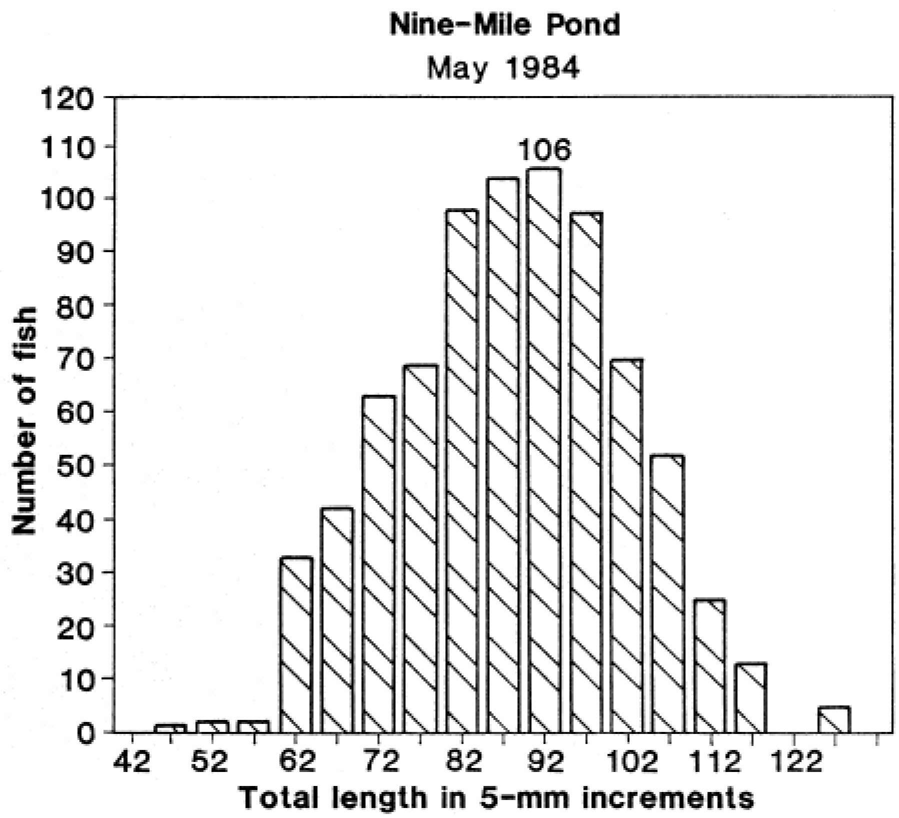


Figure 2—Length frequency distribution of coho salmon captured in Beanbelly Pond in September 1984 and June 1985.



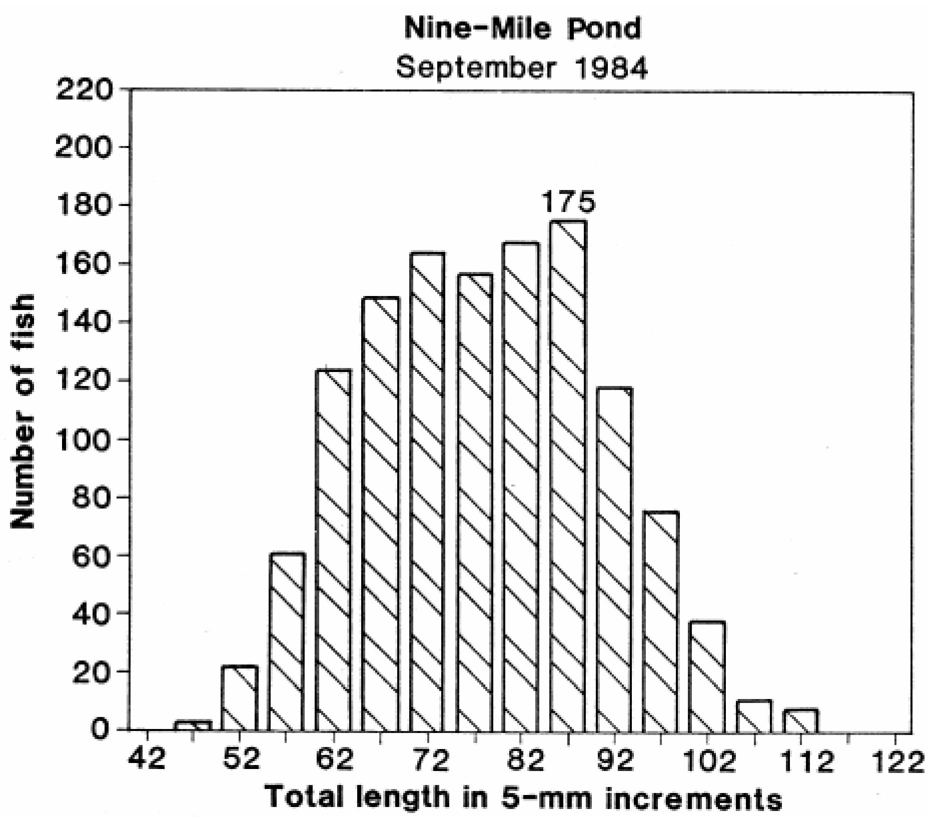


Figure 3—Length frequency distribution of coho salmon captured in Nine-Mile Pond in May and September 1984.

Table 1-Differences among ponds in length-weight regressions

Date and pond	Intercept a	Slope b	Significance Level	Significance Slope
July 1983:				
Nine-Mile	-5.3683	3.157		
Green	-4.0452	2.482	≤ .05	≥ .05
Twenty-Two-Mile	-4.1865	2.5663		
Beanbelly	-3.9622	2.4281		
August 1983:				
Nine-Mile	-5.1244	3.0233		
Green	-4.153	2.5325	≤ .05	≥ .05
Twenty-Two-mile	-4.844	2.867		
Beanbelly	-5.1789	3.0326		
Sept. 1983				
Nine-Mile	-4.783	2.8378		
Green	—			
Twenty-Two-Mile	-3.6585	2.2101	≤ .05	≥ .20 (NS)
Beanbelly	-4.5538	2.7266		
April 1984				
Nine-Mile	-5.1337	2.9813		
Green	-4.6439	2.7453	≤ .05	≥ .05
Twenty-Two-Mile	—			
Beanbelly	—			

— = no data: NS = not significant

Table 2—Yakutat gravel pit ponds morphology

	Area	Volume[a]	Maximum depth	Average depth[b]
	Square meters	Cubic meters	--------Meters--------	
Green	7,644	9,500	2.5	1.25
Nine-Mile	10,010	12,513	2.5	1.25
Twenty-Two-Mile	27,972	27,513	2.0	1.0
Beanbelly	34,954	61,170	3.5	1.75

a Volume = area times average depth.

b Average depth = maximum depth divided by 2.

Temperature and oxygen were slightly stratified in all ponds during the summer and winter. The ponds were isothermal in the spring and fall (fig. 4). Oxygen supply depends partly on the water-exchange rate in each of the ponds during periodic thaws throughout the winter. Oxygen levels near the bottom of the ponds were lowest during December but were above 5 p/m at the surface in all four ponds. The dissolved oxygen supply may have become critically low later in the winter after a thick layer of ice formed.

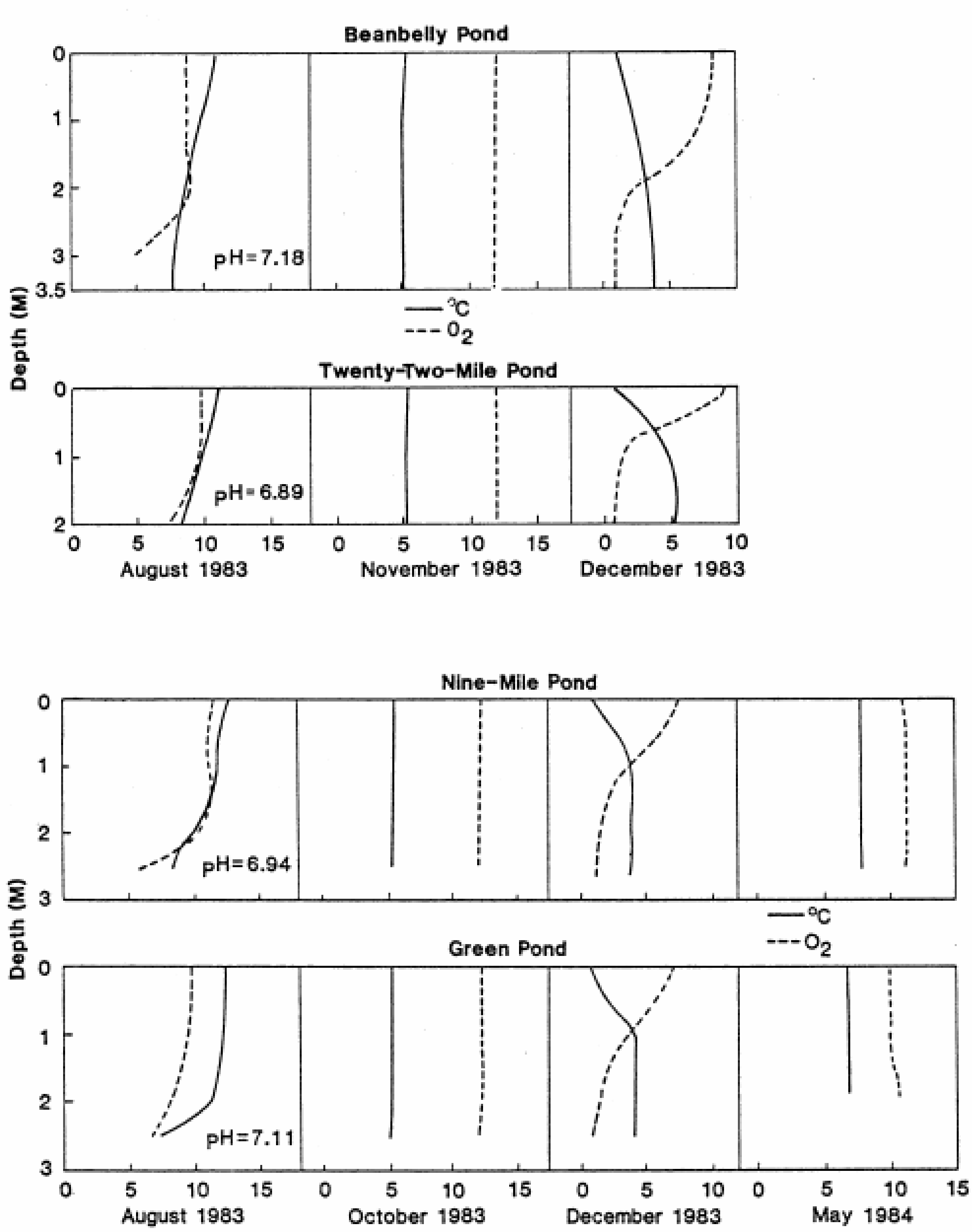


Figure 4—Seasonal temperature and oxygen profiles for Green, Nine-Mile, Twenty- Two-Mile, and Beanbelly Ponds.

Discussion

All four ponds were used to a greater or lesser extent by juvenile coho salmon during the study. Even over the short period of this study, populations fluctuated from year to year. In Green Pond, the salmonid population virtually disappeared after the fall of 1983. The population at Twenty-Two-Mile Pond was consistently low. Beanbelly and Nine-Mile Ponds consistently supported the highest populations of coho salmon.

None of the morphological or chemical features measured during the study appear to account for the differences and changes in the coho salmon population in the ponds. A more likely explanation may be the connection between the ponds and the river. Both Nine-Mile Pond and Beanbelly Pond had well-defined channels between the ponds and the river. The outlet to Twenty-Two-Mile Pond was poorly defined. Neither Twenty- Two-Mile Pond nor Green Pond had a defined inlet channel. Although ground water is an important source of water for the ponds, flow of surface water into and out of the ponds may be an important factor determining the water quality of the ponds as habitat for juvenile coho salmon.

Because all juvenile coho salmon immigrated into the ponds, the channel between the river and the ponds is critical to their use by coho salmon. All ponds were apparently accessible at high-flow periods (spring and fall) to juvenile coho salmon in the adjacent rivers, but the less well-defined channels connecting Twenty-Two-Mile Pond and Green Pond may have contributed to the low populations in these ponds. A poorly defined channel has lower velocity and is less likely to be found by the fish. Once found, it may not offer a clear path to the pond.

The coho salmon in the less productive ponds appeared to be less robust than those in the other two ponds. Where significant differences among length-weight regressions occurred, the lower values were associated with the ponds that had fewer coho salmon; therefore, factors other than access may be affecting productivity in the ponds. Among possible factors that were observed but not evaluated in this study are food and competition. Food may be a limiting factor and the differences in length-weight ratios may reflect fewer aquatic organisms available for food in these ponds. Large populations of threespine sticklebacks *(Gasterosteus aculeatus)* were observed in all the ponds. Beanbelly, Nine-Mile, and Twenty-Two-Mile Ponds had a dense cover of aquatic plants, and the bottom of Green Pond was covered with a dense mat of algae. The dense cover of aquatic vegetation would contribute to a large stickleback population by providing excellent habitat for reproduction and cover for newly hatched sticklebacks. The effect of competition for space and food between sticklebacks and coho salmon was not studied. Aquatic plants and algal growth would also contribute to low concentrations of benthic dissolved oxygen during fall and winter as the vegetation died and began to decompose. In addition, sticklebacks may be able to tolerate lower dissolved oxygen concentration than coho salmon.

Timber along the bank was apparently not a factor in any of the ponds. Twenty- Two-Mile Pond was the only one with large trees along the bank. These trees did not appear to influence the pond. Willow *(Salix* sp.) and alder *(Alnus* sp.) were the dominant vegetation along the banks of the other ponds. Based on observations of numbers of coho salmon captured near vegetation in the water, coho salmon do not appear to prefer brush habitat associated with these ponds. Nevertheless, shrubs along the bank may provide cover and a source of terrestrial insects to coho salmon.

Although the results of this study show differences among the ponds, specific factors controlling numbers of coho salmon in the ponds were not identified. The range of morphological and chemical differences measured in the ponds did not appear to affect numbers of coho salmon. The ponds apparently provide habitat for juvenile coho salmon although low dissolved oxygen sometimes may increase mortality. Coho salmon apparently remain in the ponds through winter.

The design of artificial ponds for juvenile coho salmon habitat should include several important morphological features. Adequate water quality is necessary throughout the year, particularly during the winter. A perennial flow of surface water into the pond may satisfy this requirement. The second requirement is access. An effective method for providing both these features is to construct an upstream inlet from the stream to the pond and a downstream outlet from the pond to the stream. Other favorable features include an average depth greater than 2 meters and bank vegetation for shade and cover.

Additional study on the effects of competitive interaction between salmonids and other species such as sticklebacks, the role of aquatic vegetation as cover and its effect on water quality, and the effects of pond morphology and water exchange rates could improve the design of artificial ponds. As projects are effectively evaluated, design criteria will be improved to increase the effectiveness of similar ponds. Ponds have not been extensively used as an enhancement tool for increasing coho salmon production, but they offer a promising and often low-cost enhancement method.

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