A Review of Pink Salmon (Onchorynchus Gorbuscha) Transplants to Robertson Creek (1959-1964)

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October 1982

Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 1696

Canadian Manuscript Report of Fisheries and Aquatic Sciences

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Fisheries and Aquatic Sciences 1696

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Cat. No. Fs 97-4/1696 ISSN 0706-6473

Correct citation for this publication:

Lim, P.G. and Barrett, D.T. 1982. A Review of Pink Salmon (Oncorhynchus Gorbuscha) Transplants to Robertson Creek. Can. MS Rep. Fish. Aquat. Sci. 1696: vi + 19 p.

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ABSTRACT

Lim, P.G., and D.T. Barrett. 1982. A review of pink salmon (Oncorhynchus gorbuscha) transplants to Robertson Creek (1959-1964).

An artificial spawning channel was built on Robertson Creek in 1959. One of the primary objectives of the channel was to establish a commercial-sized run of pink salmon (Oncorhynchus gorbuscha) in the upper Somass River and to increase the numbers of coho (O. kisutch) and chinook (O. tshawytscha) salmon. Massive pink salmon egg transplants from various B.C. sources ensued with variable, but overall poor results. Egg to fry survival was extremely high, ranging from 86 to 95 percent, but adult returns, good one year, were dismally poor in others during the period 1961 to 1967. The project was consequently abandoned and by 1971 local people were aware that the expensive facility was sitting idle. Eventually the Department of Fisheries and Forestry (now Fisheries and Oceans) converted the site to an enormously successful chinook, coho, and steelhead trout (Salmo gairdnerii) hatchery which is operating at high production levels today.

This paper reviews the data gathered from 1960 to 1967 on the pink egg transplant experiments at Robertson Creek. Previously presented information, that found in literature, and perhaps, most important, that gleaned from personal communication with people who were directly involved with the project, are reviewed. Reasons for failure were found to be academic to the problem of establishing pinks in a stream previously barren of that species. Some problems unique to Robertson Creek are its warm temperature, long distance to the sea, proximity to a pulp mill, and presence of many fish species which prey on migrating fry.

Key words: pink salmon, transplants, spawning.

RÉSUMÉ

En 1959, on a construit un canal artificiel pour la fraie sur le ruisseau Robertson dans le but principal d'établir une remonte d'importance commerciale de saumons roses (Oncorhynchus gorbuscha) dans la partie supérieure de la rivière Somass et d'accroître le nombre de saumons cohos (O. kisutch) et chinooks (O. tshawytscha). Des résultats variables, mais en général pauvres, ont été obtenus suite aux ensemencements importants d'oeufs de saumons roses obtenus de diverses sources en Colombie-Britannique. La survie de l'oeuf à l'alevin était très élevée, variant de 86 à 95 %, mais la remonte des adultes, quoique élevée une année, était lamentablement pauvre l'année suivante pour la période de 1961 à 1967. Le projet fut donc abandonné; en 1971, les habitants étaient conscients du fait que cette installation coûteuse était en chômage. Finalement, le ministère des Pêches et des Forêts (maintenant Pêches et Océans) transforma cette installation en piscifacture extrêmement rentable où de grandes quantités de saumons chinook et coho et de truite arc-en-ciel (Salmo gairdneri) sont produites.

Le présent rapport examine les données recueillies de 1960 à 1967 sur les expériences d'ensemencement d'oeufs de saumon rose dans le ruisseau Robertson. Sont aussi présentées les données déjà publiées, celles retrouvées dans les écrits et celles glanées au cours d'échanges verbaux avec les personnes directement concernées. On a découvert que les raisons pour cet échec sont imputables au problème d'établissement d'une population de saumon rose dans un ruisseau où cette espèce était absente. Quelques caractéristiques uniques au ruisseau Robertson sont sa température élevée, son éloignement de la mer, sa proximité à une usine de pâte et la présence de plusieurs espèces de poisson prédateur des alevins migrateurs.

Mots-clés: saumon rose, ensemencement, fraie

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INTRODUCTION

In 1959 Robertson Creek spawning channel began operation near Port Alberni, B.C. (Figure 1). At that time, spawning channels were a relatively new idea for artificially increasing salmon stocks, with Robertson Creek being only the third such project to be built in North America (Lucas, 1960). Theoretically, spawning channels improve egg to emergent fry survival by providing optimum incubation conditions, thereby avoiding the effects of erosion, siltation, and reduced water flow through gravel. Stocks are therefore able to spawn in stable and optimum physical conditions (Lucas, 1960; Everhart and Young, 1981).

The Robertson Creek project was the site of major pink salmon transplants which have been, on the whole, very unsuccessful (Neave, 1965; Withler, 1982). Robertson Creek was not only a stream barren of pinks, but also outside the recorded limits of pink salmon in British Columbia. The objective of establishing commercial pinks in the Somass River system was therefore very ambitious.

By the mid-1960's pink transplants into the Robertson Creek spawning channel were terminated. In all years but one, adult returns had been inadequate to replace the eggs which had been planted. Although this project was a failure, spawning channels have subsequently been proven to be economical and practical solutions to salmon stock enhancement (Cooper, 1977). Successful transplanting of pink salmon, however, requires further research.

This report presents a summary of existing information on the Robertson Creek spawning channel plus an analysis of field data previously unreported.

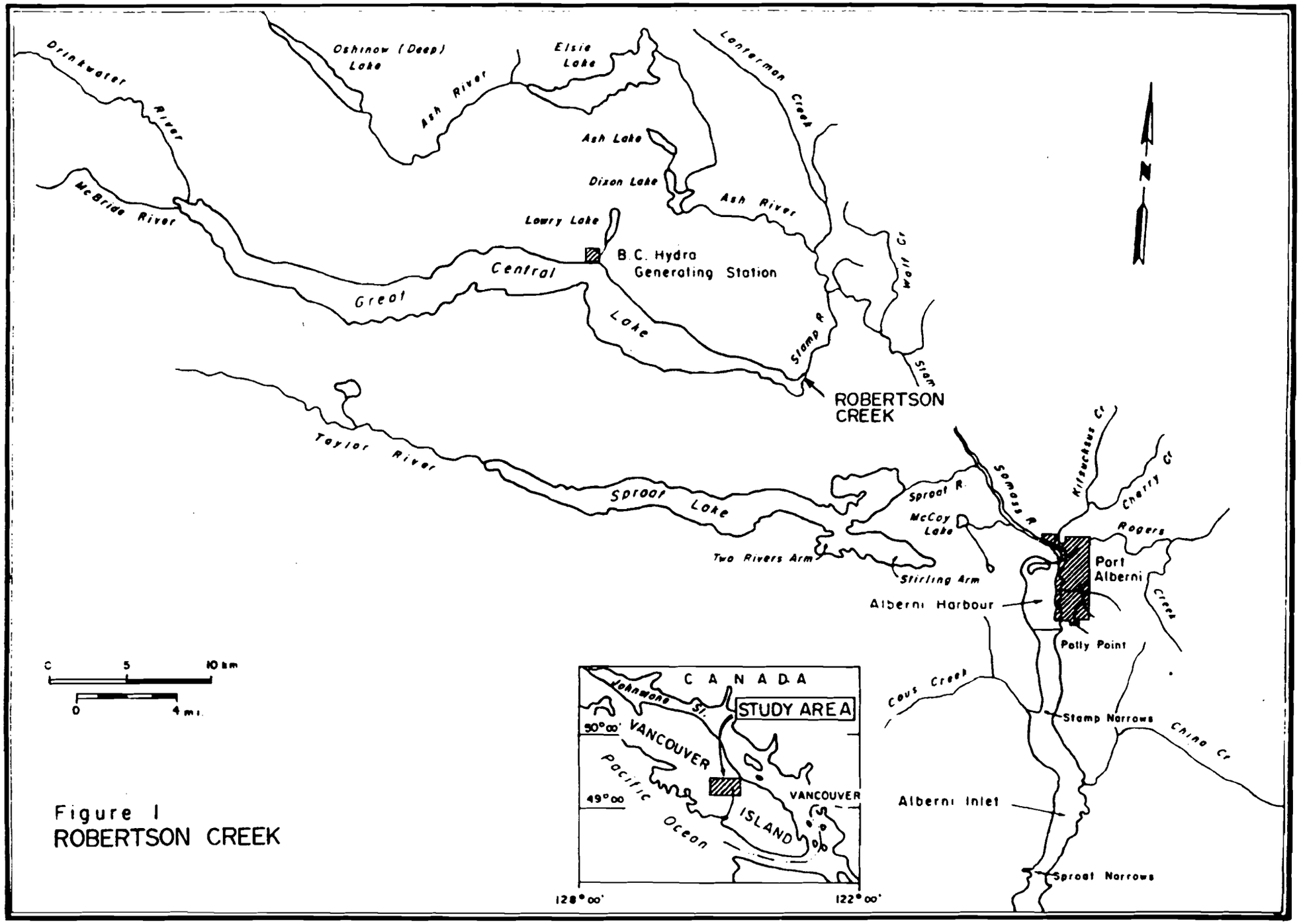


Figure 1
ROBERTSON CREEK

STUDY AREA DESCRIPTION

Robertson Creek is a tributary of the upper Stamp River which is a major part of the Somass River system (Figure 1). It is a secondary outlet of Great Central Lake and historically was dependent on high lake levels for water flow. Damming for industrial purposes in the 1950's made it a perennial stream. Robertson Creek ultimately drains into Alberni Inlet after travelling a distance of approximately 24 kilometres. Enroute a fishway has been built at Stamp Falls to aid upstream migration. Port Alberni, B.C. is located at the mouth of the Somass River which is the site of a pulp and paper mill, two sawmills, and a plywood mill. The area has moderate year-round temperatures and major flooding is not a problem.

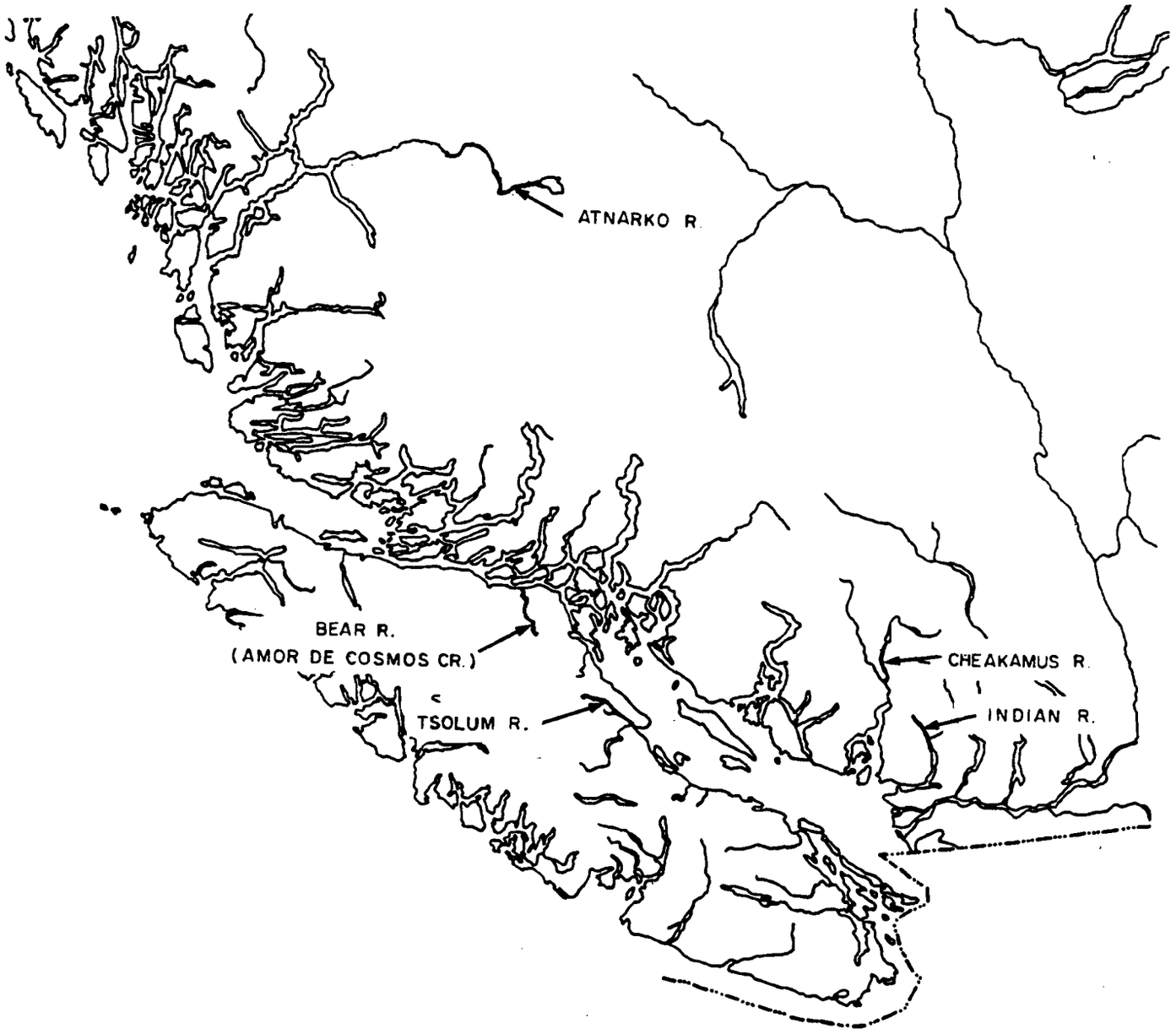
SPAWNING CHANNEL DESCRIPTION

The Robertson Creek spawning channel was 1280 metres long with 775 metres of actual spawning area which was 10 metres wide. Gravel size ranged from 2 to 10 centimetres with a total content of approximately 6750 square metres of graded gravel. Normal water flow was 3 cubic metres per second. The project was very elaborate with drop structures, rearing facilities, and flow control mechanisms. A full description is given by Lucas (1960).

METHODS

Between 1959 and 1964 pink salmon eggs were collected from various native pink streams in British Columbia: the Indian, Atnarko, Tsolum, Cheakamus, and Bear Rivers (Figure 2). Eggs were stripped from spawning females in the fall, fertilized by males of the same donor stream, then were generally shipped by air to Puntledge River or Robertson Creek

FIGURE 2: DONOR STREAMS



on Vancouver Island. In 1959, 1960, and 1961 eggs were incubated at the Puntledge Hatchery; in subsequent years incubation was at Robertson Creek. Eyed eggs were planted in troughs dug in the spawning channel at roughly 4000 per lineal metre and buried with around 5 centimetres of gravel. Planting time varied from year to year, ranging from mid-October to mid-January (Table 1). Several removable baskets of eggs were interspersed in the channel for periodic checks of mortality and development.

Each year monitoring consisted of collecting data on incubation mortality, egg to fry survival, timing of downstream migration, and adult return. Total enumeration was made of migrating fry in the early years; later only subsampling was done. Besides this basic information, in 1962 a simple experiment was done to test the effects of pulp mill effluent on pink fry survival. In 1964 comparative data was collected on the length and weight of pink fry from Robertson Creek, Fraser River, and Indian River.

A detailed account of the first eyed transplant is given by MacKinnon (1960). Methods did not vary significantly from year to year. Donor stream, incubation location, and monitoring techniques were the main variants; the data presented defines the variations.

RESULTS

Existing Information

Lucas (1960) gives a thorough engineering description of the channel covering all aspects of history, theory, design, and construction. Objectives of the channel were multiple with one of its primary aims to build up substantial runs of pink, coho, and chinook salmon in Robertson Creek.

TABLE 1. Incubation and Planting Schedule of Transplanted Pink Salmon Eggs at Robertson Creek, 1959-1964.

Year	Donor Stream	Incubation	Incubation Temperature °C	Planting Time	Planting Temperature °C
1959	Indian Tsolum	Puntledge	0.55-10.6	Nov. 18-Dec. 3	6.1- 6.7
1960	Tsolum	Puntledge	12.2-15.6	N/A	N/A
1961	Indian	Puntledge	2.8-13.3 9.4-15.6	Oct. 24-Nov. 23	7.2-11.7
1962	Atnarko	Robertson Cr.	12.2-18.3	Oct. 12-Nov. 5	N/A
1963	Indian Cheakamus	Robertson Cr.	10.0-19.2	Oct. 16-30	9.2-16.4
1964	Atnarko Bear	Robertson Cr.	N/A	Jan. 12-15	3.9

MacKinnon (1960) reports the first eyed transplant to Robertson Creek using fertilized eggs from the Indian River pink salmon escapement. Methods are recounted in detail. Survival from egg to migrating fry was 91 percent, an excellent result unduplicated by any artificial spawning channel technique to date.

Boyd (1964) presents a short report documenting adult pink salmon returns to Robertson Creek from 1959, 1960 and 1961 egg plantings. The 1963 return of 4,700 adults from a 4.8 million egg plant was encouraging from several aspects. Fry to adult survival (0.1 percent) was the best recorded, and fish were spawning in parts of the Somass River system other than Robertson Creek. These results suggested hope for fulfilling the objective of establishing pinks.

Neave (1965) shows Robertson Creek data previously reported by Boyd plus results of the disappointing 1964 adult return (0.02 percent fry to adult survival). The two important observations are that: no substantial self-sustaining population of pink salmon resulted from an egg transplant, and it is possible for pinks to complete their life cycle in a place other than their native stream.

Fraser and Halsey (1969) attempted to lower water temperatures in Robertson Creek spawning channel with two air percolation systems. Robertson Creek water temperatures during salmon migration and spawning were reported to range from 20° to 23° C. These higher temperatures are associated with infectious fish diseases which were linked with high pre-spawning mortality in Robertson Creek adult salmon.

Withler (1982) cites Robertson Creek as the most ambitious attempt to introduce pink salmon into a British Columbia stream. Since adult returns were inadequate to replace eggs, the project was considered a failure and transplant attempts abandoned. No explanation for lack of success is given, but Withler points out that no more attempts to establish off-year pinks should be made as the population controls in this case are not understood.

Current Analysis

The overall results from six years of pink salmon egg transplants to Robertson Creek spawning channel are summarized in Table 2. Obviously, the project failed to establish pink salmon in the Somass River system. Adult returns were never nearly large enough to replace the eggs originally planted. Individual segments of the experiment were very successful though, especially egg to fry survival rates. These were greater than 85 percent in all years, far better than previously recorded for incubation in gravel or for natural egg deposition of pink salmon eggs (usually accepted to be $\sim$10 percent).

Egg survival in the hatchery varied from year to year. Unfortunately, records of methods used are incomplete, so comparisons cannot be made. Some of the reasons suspected to contribute to incubation mortality include excessive transport time, overcrowding of eggs in trays, elevated temperatures during transport and incubation, and collection of immature (green) eggs. Fungus did not seem to be a problem as incubating eggs were regularly treated with malachite green.

Although survival to the migrating fry stage was excellent, there is some question as to the quality of fry produced. Length and weight data show Robertson Creek pink fry to be shorter and smaller than those from the Indian and Fraser Rivers (Table 3). This could have affected survival to the adult stage. A relatively normal proportion of misformed fry was also recorded: albinos, Siamese twins, spinal column defects, and cyclops. In natural situations such fry usually do not survive to maturity (Petersen, pers. comm.). Condition of the Robertson Creek fry was further aggravated in early years by the enumeration technique. A total enumeration system was used which meant all fry were handled during their downstream migration. The large number of fry migrating meant that sampling boxes were very crowded with fish. If processing was delayed, fry would suffer from the stress of being confined and be released in a weaker state than if left to migrate naturally.

TABLE 2. History of Pink Salmon Egg Transplants at Robertson Creek, 1959-1964.

Source	Year	No. Eggs Collected x 10^6	% Incubation Mortality	No. Eggs Planted x 10^6	% Survival Eggs to Fry	Fry Migration x 10^6	Adult Return	% Survival Egg to Adult	% Survival Fry to Adult
Indian & Tsolum	1959	1.7	3.5	1.6	95	1.6	130	.008	.008
Indian & Tsolum	1961	5.1	5.3	4.8	93	4.4	4200	.09	.1
Indian & Cheakamus	1963			9.8	88	8.6	1650	.02	.02
Natural Deposition	1965			1.5	73	1.1			
Tsolum	1960	0.9	19.6	0.8	89	0.7	240	.03	.03
Atnarko	1962	5.7	18.7	5.4	89	4.7	78	.001	.002
	1964	7.9	25.4	6.7	83		1400	.02	
Bear	1964	3.7	8.0	3.4	91	3.1	4	.0001	

TABLE 3. Comparative Length-Weight Data for Pink Salmon Fry, 1964.

Statistic	Area		
	Robertson Creek	Indian River	Fraser River
Mean Weight (g)	0.24	0.27	0.26
Mean Length (mm)	32.1	34.5	33.6
S.D.	1.25	1.21	1.33
N.	3532	2397	203

Unfortunately, such factors were secondary to gathering statistics on numbers of migrating fry which were the first indicators of the spawning channel success. The effect of this initial handling of the newly emerged fry was not measured.

Timing of downstream migration varied each year. Figure 3 shows the difference between three odd-year egg plants. There was a general trend for transplanted fry to migrate earlier than donor stream fry.

Pulp mill effluent was regularly found in fish traps on the Somass River. In the early 1960's effluent was discharged untreated directly into Alberni Harbour. A test with several different concentrations of the raw effluent showed no mortality of pink fry. Fish were exposed to concentrations ranging from 1:70 to 1:14 (effluent:water). This crude test did not evaluate sublethal effects which could have affected pink fry survival.

High pre-spawning mortality of around 30 percent of spawning females was noted in 1963. One of the major causes was suspected to be columnaris, a bacterial fish disease. Pathological tests in 1965 showed low incidence of disease with less than 2 percent prespawning mortality. In that year, water temperatures were 1° to 3° C. colder than in 1963, a factor accounting for the lower incidence of disease. Relatively high water temperatures characteristic of Robertson Creek during the salmon spawning period increases the probability of occurrence of bacterial fish diseases (Figure 4). But even if prespawning mortality could have been minimized, adult returns were still not adequate to replace eggs planted two years earlier at Robertson Creek. This fact alone demonstrates the failure of the project.

FIGURE : 3

DAILY DOWNSTREAM MIGRATION OF PINK SALMON FRY AT ROBERTSON CREEK : 1960 , 1962, 1964

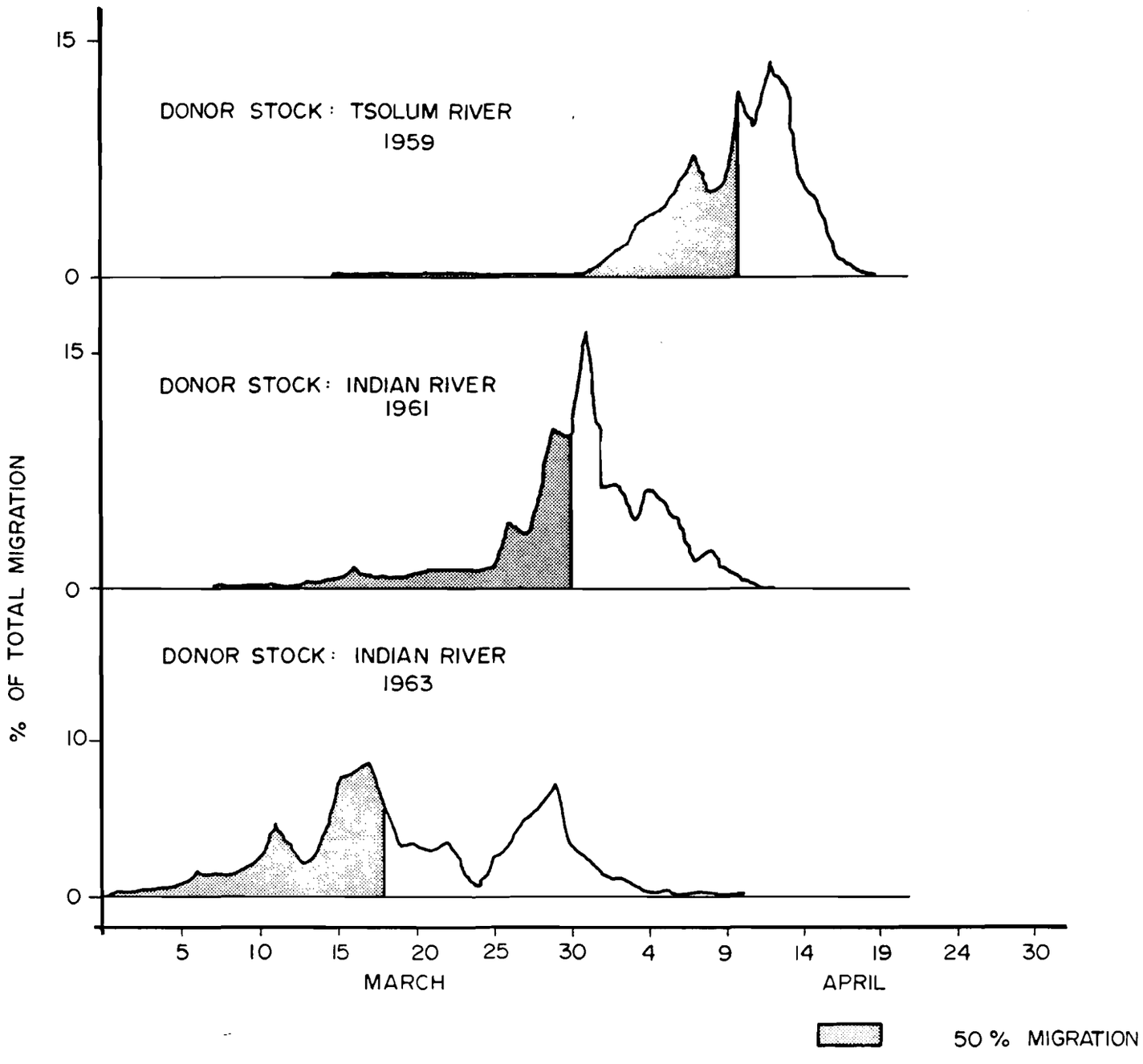
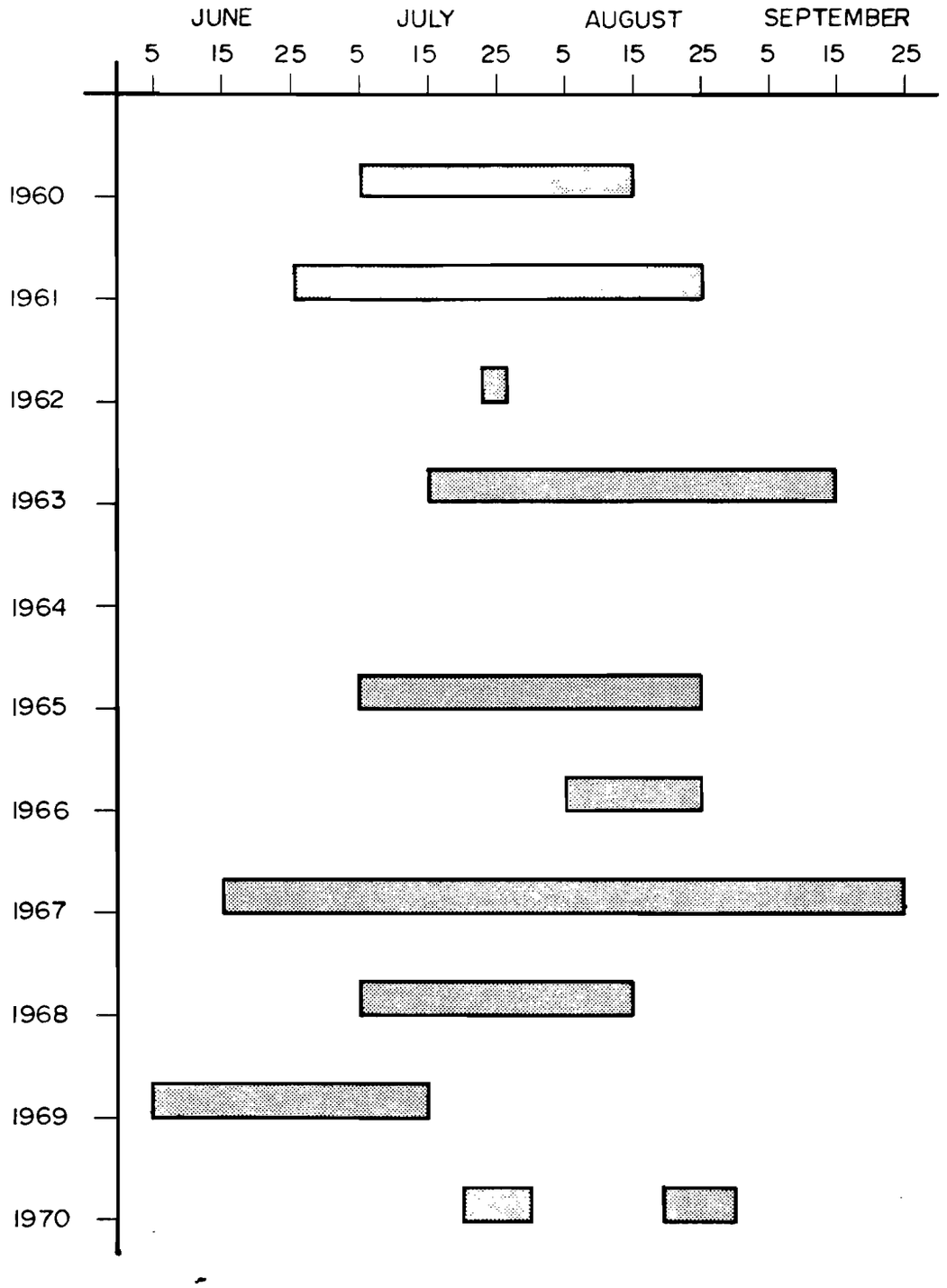


FIGURE: 4

PERIODS IN WHICH TEMPERATURES EXCEED 20°c IN ROBERTSON CR. SPAWNING CHANNEL



DISCUSSION

At Robertson Creek three main points emerge as possible reasons for failure. These are technique, dissimilarities of donor and recipient streams, and the basic biological problem of transplanting a species to an environment previously not supporting it. A development of these points provides forum for the ideas accumulated through the years in the minds of these people who had been actively involved or interested in the project.

Technique

Walker (MS 1960) first criticized the technique used in incubation of transplanted eggs because it was not totally done in the receiving waters. Although this did not affect the survival to emergent fry, Walker questions the possible effects on homing mechanisms. He also emphasized the probable mishandling of fry through enumeration techniques as previously mentioned. Petersen (pers. comm.) aptly notes that, in fact, the best return was from a year when total enumeration was done and incubation took place off-site.

During the early 1960's it was vogue to transplant an excess of eggs to maximize the probability of success of the transplant. The general theory was to exceed a threshold density which would overcome density related mortality, particularly during downstream migration. Unfortunately, the data clearly shows this to be an unreliable method; the largest egg plants did not result in the largest adult returns. Kearns (1964) suggested a better approach was to make more detailed comparisons between donor and recipient streams and to find ones which were as physically similar as possible. Environmental differences were seen to inhibit successful transplants.

The most startling omission in technique used at Robertson Creek was that of monitoring after downstream migration. Only scant information was collected on the fish after they left Robertson Creek

until adults returned two years later. Adult straying was not adequately measured as fry were not marked. This represents a serious lack of information and consequently, only guesses can be made on the fate of the fry. Boyd (pers. comm.) pointed out that study of estuarial life of the fry would have been beneficial. In general, there was not enough projection of the probable whole life cycle of the transplanted pinks. If there had been, monitoring of suspected critical stages could have been done and estimates made of associated mortality.

Differences Between Donor and Recipient Streams

The majority of pink salmon eggs transplanted to Robertson Creek came from areas considerably more pristine than the Somass River, i.e., the Atnarko/Bella Coola and Indian Rivers. Although both places had logging activity in the watershed, their estuaries have no industrial development. The Somass River estuary, in stark contrast, is heavily used by a pulp and paper mill, sawmills, and supports a populated settlement. Therefore, it is subject to heavy domestic and industrial effluent. Conditions have improved since the time of the spawning channel though. Where once raw pulp mill effluent was discharged directly into Alberni Harbour, now treatment precedes discharge.

Different orientation of the rivers is a factor which has been suggested as a reason for low adult returns to Robertson Creek (Walker and Lister, 1971). The Somass River flows generally south and eggs from the river with the most similar direction of flow, the Indian, resulted in the best adult returns. The Atnarko, with some of the lowest survivals, flows west. Though distance to the sea of the rivers varied, it is difficult to judge any effect the differences made to the transplanted fish. It is known, however, that loss of migrating fry to predation is an important part of pink salmon life history (Hunter, 1959; Neave, 1965; Parker, 1971). Presumably, the longer the trip, the more predatory pressure exerted on the migrating fish population.

The Somass River system is the only one supporting all five species of salmon and steelhead trout. Coho, chinook, and steelhead are all known predators of pink and, therefore,heavy predation can be assumed to have taken place in the transplanted population of fish. Heavy predation during downstream migration, combined with unfavourable conditions in the estuary, could easily have set the transplanted populations back enough to explain the poor adult returns. Once again, an example of neglected monitoring which could have helped planning of subsequent transplants.

Temperature differences between the donor and recipient waters caused the most recorded problems with the transplants. As mentioned before, relatively high temperatures characteristic of Robertson Creek in the fall caused fish disease problems and high pre-spawning mortality. In the spring, temperatures higher than those of the donor stream triggered earlier than normal downstream migration, causing transplanted fish to enter estuarial and oceanic life earlier than they would have in their native streams. The effects of this mistiming are unclear, but generally thought to be undesirable (Sheridan, 1962).

Basic Biological Problem of Transplants

At Robertson Creek no pinks had naturally established themselves in any significant numbers. Absence of a species is safe indication that some factors exist which limit its presence. Isolation of such population limiting factors is a difficult task, one not answered by Robertson Creek transplant operations. Explanation of distribution of Pacific salmon evades biologists in spite of long and intense study (Withler, 1982). It is known that pink salmon can live and reproduce away from its normal range as shown by U.S.S.R. and Great Lakes examples (Withler, 1982). Once again, only vague explanations can be used for these 'transplant' successes.

CLOSING COMMENTS AND RECOMMENDATIONS

The failure of the Robertson Creek project to establish a commercial run of pink salmon in the Somass River system has become part of the history of unsuccessful transplants in British Columbia. It is not often that a project receives renewed interest after 20 years have passed by. But by reviewing this case, the pioneering work on spawning channels on Vancouver Island, valuable lessons in planning can be learned. Unfortunately, transplants are still being attempted with not much greater success in British Columbia. Clearly, some limiting factors within pink populations need to be identified before self-sustaining transplants can be hoped for.

This project amply shows that although methods exist to greatly increase on natural egg to fry survival, unless further information is gained on subsequent life, adult returns cannot approach economically practical levels. Future transplants must be accompanied by plans to follow migrating fry as accurately as possible to returning adult. Marking of fry would be an important first step. A careful comparison of donor and recipient streams plus more observations on straying habits could help identify some of the physical limits of tolerance and homing cues of the species. Most importantly, more accurate monitoring techniques should be developed and used to estimate survival at various life stages.

ACKNOWLEDGMENTS

Roger Kearns and Karl Petersen are gratefully acknowledged for their informative discussion of this project. Chuck Walker is thanked for sharing his own unpublished work on the project. Final review was done by F.K. Sandercock.

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