Stream Enhancement and Freshwater Survival of Coho Salmon (*Oncorhynchus Kisutch*) in DeMamiel Creek, Sooke, B.C.

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SUMMARY

The directive of Fisheries and Oceans is to achieve a net gain of habitat for Canada's fisheries resource. DeMamiel Creek has decreased Coho salmon productivity due to a high fry to smolt mortality. Enhancement of rearing habitat has resulted in a 7.2% increase in fry to smolt survival (2.9% to 10.15%). This increase in survival shows up directly as an increase in returning spawners. This confirms the theory that Coho salmon production in DeMamiel Creek is limited by fry to smolt survival. When the number of smolts is known the resulting adult returns can be predicted several years in advance since 6.37% of smolts return as adults to spawn. Continued enhancement efforts should yield increasing returns of fish.

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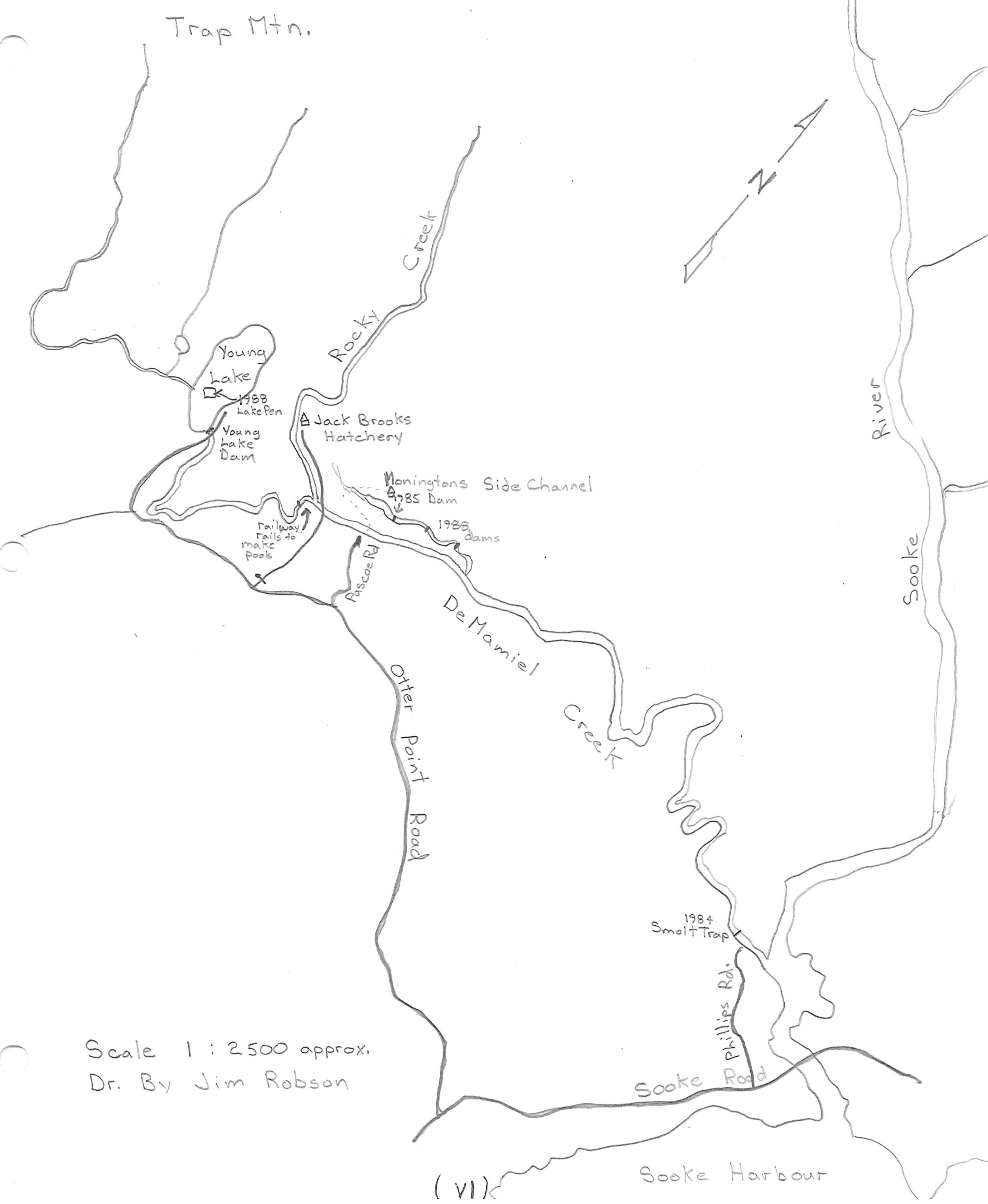
(VI) Projection conique conforme de Lambert Scale 1: 1 000 000

KEY MAP

Craig
Creek
Sooke
Lake
Bear Creek
Res.
Mt. Jack
Finlayson
Arm
Goldstream
River
Trap Mtn.
Sooke
River
Rocky Creek
Young
Lake
Muir Cr.
Cr
Tugwell
DeMamiel Creek
Otter Point Road
Sooke Rd.
Veitch Cr
My
House
Happy Valley Rd
Kangaroo
Rd.
Kemp
Lake
Sooke
Sooke Basin
Sooke Harbour
Matheson
Lake
Rocky Point Rd.
Orvea Bay
Sooke
Bay
Otter Pt.
Sooke Inlet
Possession Pt.
Becher
Bay
Beechey Hd
D.N.D.
Pedder Bay
N
Key Map of
Sooke Area
SCALE 1: 125000
Dr. By. Jim Robson

Enhancement Map



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INTRODUCTION

The destruction and loss of productive fish habitat is the greatest single factor offsetting the fisheries resources of Canada. The role of the resource manager is to minimize these losses and to rehabilitate damaged areas. This report examines the methods of enhancing and estimating fish habitat and survival. The purpose is to give the resource manager background information he or she can use for management decisions.

A. ENHANCEMENT POLICY

The Department of Fisheries and Oceans new policy on fish habitat management is designed to achieve a net gain of habitat for Canada's fisheries resources in a manner that benefits all users of Canada's aquatic renewable resources (Fisheries and Oceans 1986). It provides a comprehensive framework for the conservation, restoration and development of fish habitats. Under the Fisheries Act, "Fish Habitats" are defined as those parts of the environment "on which fish depend, directly or indirectly, in order to carry out their life process". Under this policy the Department of Fisheries and Oceans is empowered to initiate projects to restore and develop fish habitats in support of the net gain objective.

Following this mandate, the Sooke District Office of the Department of Fisheries and Oceans has invited me to work on a habitat enhancement project. DeMamiel Creek, a small coastal stream with decreased salmonid productivity, is the focus of the Sooke Salmonid Society's and Department's enhancement efforts. Over the years various enhancement strategies have been tried and much information collected. A smolt trap was constructed five years ago, in 1983, to assess the number of Coho going to sea and to estimate the percentage of Coho fry surviving to the smolt stage. The information collected from this stream forms the basis of this report.

B. STREAM DESCRIPTION

1. Reach Description

DeMamiel Creek (see key maps) is a third order coastal stream flowing from a large drainage basin into the estuary of the Sooke River. It drains from an elevation of 550 meters to sea level. It is a meandering stream approximately 15 kilometers in length with two small lakes along its course. Reach 1 is a broad part of the stream with large boulders and cobbles. Reach 2 is narrow and has a u-shaped gravel and cobble bottom. The upper third reach is steep with large rocks and mostly seasonal flow. All three reaches are known to be important in one or more of the life history phases of Coho Salmon, Oncorhynchus Kisutch, Chum Salmon, O. Keta, and Steelhead, Salmo Gairdneri. Rainbow and Cutthroat trout are resident species.

2. Streamside Vegetation

Riparian vegetation along DeMamiel Creek is dominated by Red Alder, with occasional Bigleaf Maple (Acer Macrophyllium), Western Red Cedar, (Thuja Plicata), and Douglas Fir (Pseudotsuga Menziesii). Shrub species include Salmon Berry, Devils Club, Salal and Bracken Fern.

The creek descends rapidly from a dry rocky hill down to a small level flood plain. The vegetation changes from dry scrub like trees to larger widely spaced trees to finally thick brush and Alder when the creek levels. Located on this small area are two small lakes (Young lake and a small pond). The creek descends from these lakes, less steeply then before, through a steep sided valley with large coniferous overstory and Red Alder Riparian Cever. The final descent to the Sooke River estuary is through farmland and populated areas. The vegetation varies from open field to thick streamside brush and Alder.

3. Stream Dynamics

DeMamiel Creek has large fluctuations in flow. The water levels vary drastically - floods occurring after most heavy rains. The spring and fall rains increase the flow to destructive levels. There is extensive erosion, debris and gravel transport, sedimentation and scouring. One day of moderate rain, at any time of year, can raise the creek level by several inches.

Summer flows are very diminished. The creek drys up except for the largest pools. The flow is almost negligible, except after heavy rains. The water temperature increases but because of deep shade seldom increases to fatal levels. Oxygen is somewhat limited due to low flow. The quality of water is generally excellent. It is cool, clear, well oxygenated and has low levels of polution. One possible problem is with malfunctioning septic tanks and agricultural runoff. There could be high levels of fecal chloroforms and possible eutrophication.

The large amount of debris moved during floods causes numerous dams and piles of debris. Two sites in the lower reach have to be cleared yearly. These dams can block adult migration upstream and limit downstream fry and smolt movement.

C. <u>STREAM FISHERIES</u>

1. <u>Coho Salmon</u>

In order to manage a fisheries effectivley one must have a good knowledge of the life history of the species in question. Coho Salmon have a rather unique life cycle. The adults return to the stream mouth in the early fall. Here they wait for the fall rains to signal their entrance to the stream. They swim up spawn and die. The eggs incubate and hatch in late December. the young alevins remain in the gravel until spring living off the yolk sac. The alevin swim up becoming fry. The fry migrate to larger pools and feed actively. They remain in these ponds until the following spring. Starting in mid April the fry undergo changes becoming smolt. They then migrate to the sea travelling mainly at night. The smolt enter the sea where they grow rapidly becoming grilse and then adults. After eighteen months at sea the adults return to spawn. Coho tend to spawn in the upper reaches of the river just above the limit of Chum migration (Stephen 1988).

2. Chum Salmon

Chum Salmon play an important role in DeMamiel Creek. The Chum Salmon spawns about the same time as the Coho. They tend to be slightly later but not substantially. The Chum remain in the lower portions of the stream because they have difficulty surmounting obstacles. They spawn and the eggs develop. In late December the eggs hatch. The young alevins remain in the gravel living off the yolk sac until spring. In May they swim up out of the gravel and immediately begin their downstream migration to the sea, travelling mainly at night. They spend three years at sea. They grow rapidly and return to spawn in the fall of their fourth year of life. Chum spawn in the lower reaches of the stream. They are the most numerous salmon in the DeMamiel Creek. Since the fry spend very little time in fresh water they are not subject to the harsh conditions of summer drought and winter flood. Their somewhat later spawning may dig up a small number of Coho eggs resulting in lower than normal survival (Scott 1973).

Other residents of the stream include Steelhead Trout, Cutthrout Trout, Sculpins, and otters. All are major predators on salmon fry and smolts.

3. The Fishery

The fisheries of a stream not only includes the fish present but the use of them by man. Historically the salmon of this stream were important in the native food fishery. Then the stocks were fished commercially. The numbers declined and the food fishery stopped. The terminal fishery (commercial) was also stopped. The main catch of adults was from the non-terminal net fishery in Juan de Fuca Strait. Sport fishermen and commercial trollers take the Coho while net fishermen can catch both Coho and Chum. In the recent past, surplus Chum have been removed by a native food fishery. Coho and Steelhead were recently open to sport fishing but have been closed for about 10-15 years. Hopes of re-opening the season and allowing other fisheries rest on enhancement.

D. HISTORY

1. Stream Production

DeMamiel Creek was historically a very productive salmonid stream with Coho and Chum returns much higher than today. From 1960 to 1972 the average returns were 3500 Coho and 10,000-15,000 Chum Salmon. Record high returns of Coho occurred in 1973 with 16,400 fish returning. With each large return of fish the overspawning results in a very low return three years later. For this reason the optimum number of Coho and Chum was calculated to give a maximum steady return. This is 5000 fish for Coho and 6000 for Chum. Chum is very close to the optimum level at present while Coho is still far away (Stephen 1988).

From 1972 onward the Coho stock has declined drastically. The lowest recorded return was in 1983 with only 230 Coho returning. Several years of weak returns previously to 1988 magnified by severe climatic conditions had caused a severe downward spiral that the stock is still trying to recover.

Chinook Salmon, Oncorhynchus Tshawytscha has been introduced to DeMamiel Creek due to escapes from Rocky Creek Hatchery. From 1974 to 1979 the average return was about 12 fish. A large release of Chinook in 1988, approximately 10,000 Chinook, should show up as a return in 1992-1993.

2. Enhancement

The Department of Fisheries and Oceans has tried several different approaches to enhancing Coho Salmon stocks in DeMamiel Creek. They in general have only shown moderate improvements until recently.

i) Water Flow Control

The first approach was to provide a more stable waterflow for summer fry. In 1967-68 the problem of low summer flows was identified. In 1970 a storage dam at Young Lake was constructed. This allowed storage of water during wet periods for use during times of shortage. This appeared to increase the stock considerably with returns in 1972 and 1973 of 3500 and 16,400 respectively. Unfortunately, the effect was short term and stocks quickly dropped to the 800 fish return average from 1974 on.

ii) Production of Fry

The next approach was to produce more fry to be released. Beginning in 1974, fish were stripped and the eggs placed in incubation boxes. The resulting egg to fry survival was increased to 90% from the 10% natural survival. In 1978 a hatchery was built at Rocky Creek (see enhancement map). The initial production capacity was 250,000 fry. The capacity was increased in 1981 to 500,000 fry. The production of more and more fry only increased the numbers of returning fish slightly.

iii) Production of Smolts

Even with the Young Lake Dam there were extremely low and fluctuating water flows. This resulted in a lack of suitable rearing habitat. In August 1985 a swampy side channel was excavated for Coho rearing and a cement dam with water flow control was constructed on the Monington property (see enhancement map). The next year a small dam was constructed in the headwaters of the creek for Coho rearing (James Dam). This work in conjunction with that previous showed a marked increase in fry survival and resulting increases in adult returns. In 1988 two further dams were constructed at Monington's to create two new pools for Coho rearing. The result was a steplike system of three 100 meter pools capable of rearing at least 120,000 fry to the smolt stage. In addition to providing more habitat a feeding and fry rescue program was initiated. Stranded fry were retrieved from smaller disappearing pools and moved to larger more permanent pools. Also every day the fish in the more accessable pools were fed with pelleted food from the hatchery. In 1988 20,000 to 30,000 fry should be rescued from certain death.

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E. THE PROBLEMS

Fry to smolt survival appears to be the limiting factor for Coho Salmon production in DeMamiel Creek. This theory was proposed by examining the stages of the lifecycle of Coho and Chum and the results of enhancement.

By comparing Coho and Chum we can get an idea where the problem lies. The only significant difference in freshwater life is that Chum leave immediately for the sea after emerging from the gravel. The Coho wait one year in the creek. The eggs of both species are spawned and hatch at the same time. They are subject to the same hazards and thus have very similar survival. Since the saltwater life of both species is also very similar the only real difference between the species is the one year Coho spend in fresh water. In DeMamiel Creek the numbers of Chum have remained relatively constant while Coho have dropped drastically. the one year Coho spend in the natal stream is the only difference so it leads one to believe the drop is a result of low survival in that stage.

This hypothesis is supported by the results of enhancement. Any work done that improves the rearing habitat, food source and water requirements of fry has shown favorable increases in Coho numbers. Other enhancement not affecting fry survival has had only minor success alone. So when you look at the supporting evidence you get a very strong argument the fry survival is the limiting factor in the production of Coho Salmon in DeMamiel Creek.

The fishery manager faces the symptom of the problem-declining fish populations. He or she must be able to halt this decline and produce more fish for people to use. In order to do this they need to have as much information on the stock as possible. What is especially needed is a formula to predict the numbers of returning adults you will get in any year. Also needed, in order to assess your enhancement efforts, is a method to quantify what the increased survivals of different stages are. The most important is to be able to see increased survival in the limiting stage of production.

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F. <u>PURPOSE</u>

The objectives of this report are three fold. It will attempt to evaluate the enhancement efforts, evaluate the theory of fry survival as a limiting factor and to formulate methods to make predictions about the stock.

1. Evaluating Enhancement

The purpose is to identify the fry smolt survival for years before and during enhancement and judge if the enhancement is showing significant increases in fish numbers. It will show what enhancement method is having the greatest effect on the fish stock. In addition the numbers of smolts leaving the stream will be related to the number of adults returning.

2. Evaluating the Theory

If the evaluation of enhancement proves that work done improving fry to smolt survival shows the greatest increase in fish numbers then we can prove it is the limiting factor.

3. Making Predictions

By examining survival percentages of fry to smolt and smolts to returning adults I hope to work out a method to apply these figures to forecasting. A forecast of number of smolts leaving and number of adults returning in any one year would be very valuable. By knowing what size of return to expect for several years in advance you can make informed management decisions for DeMamiel Creek.

G. LIMITATIONS OF REPORT

This can only be considered a preliminary report because of the limited number of years for which data is available. Smolt data was collected for the past six years. All calculations are based on smolt data so only three complete fish cycles were tracked. This limited data could introduce error into the conclusions drawn and the estimates of population size.

H. METHODS

1. Data Collection

i) Escapement Reports

All data pertaining to number of spawners, eggs stripped and stream enhancement completed was collected from yearly escapement reports prepared by the Department of Fisheries and Oceans Fishery Officer. The method used for determining the number of spawners was a stream walk. The number of fish were directly counted by walking the entire spawning area of the stream. Other data reflects yearly enhancement efforts.

ii) Smolt Trap

The number of smolts play an important role in all calculations and results. The numbers were determined by operation of a funnel entrance inclined plane smolt trap. This trap was constructed in 1984. It catches hundreds of Coho smolts migrating downstream. It was checked daily and a complete count of all smolts was recorded (Fisheries and Oceans 1980).

2. Calculations

i) Total Fry Number

Total Fry = Hatchery Fry + Wild Fry

a) Hatchery Fry

Calculated from eggs collected from stripped spawners at 90% egg to fry survival. e.g. 1986 190,800 eggs x 90% survival = 171,720 hatchery fry.

b) Natural Fry

The first step is finding the number of natural spawners. You then need to subtract the number of eggs stripped divided by the fecundity of 2600 eggs/female. Gives the number of females stripped e.g. 1986 862 spawners (male and female) x 50% female = 431 females 190,800 eggs take divided by 2600 eggs/female = 74 females stripped 431 total females - 74 females stripped = 357 female natural spawners

The second step is to find out how many fry the female natural spawners can produce. To do this you multiply by the fecundity and then multiply by survival of egg to fry in the wild 10% e.g. 357 females x 2600 eggs/female = 928,000 eggs x 10% survival = 92,800 natural fry + 171,720 hatchery fry

c) = 264,540 total fry 1987 from 1986 spawn

ii) Fry Smolt Survival

Calculated by dividing smolt number for current year by number of fry from previous year times 100%. e.g. 26,000 smolt 1988 divided by 264,540 fry from 1987 x 100%

9.8% fry to smolt survival

iii) Smolt Adult Survival

Calculated by dividing adult returns for that year by the number of smolts the previous calendar year times 100%. e.g 1987 1400 returning adults divided by 18,011 smolts in 1986 x 100% = 7.8%

iv) Making Estimates and Predictions

The estimates are all make by applying the calculated mean survivals of fry to smolt and smolt to adult. This is applied to calculated fry numbers. An assumption fo 200,000 eggs taken yearly is made.

I. <u>RESULTS</u>

1. <u>Fry to Smolt Survival</u>

The mean fry to smolt survival prior to 1984 was 2.92% . This represents the survival with no enhancement other than production of greater numbers of fry and the Young Lake Dam. This enhancement did very little to improve fry to smolt survival. With the construction of the Monington rearing ponds, the James Dam and fry rescue and feeding the percentage survival tripled to a mean of 10.15% +/- 0.311 at 95% confidence limits. The increase reflects the change in emphasis to directly enhance fry smolt survival by providing safe stable rearing habitat. See table 1 for detailed breakdown of fry survival.

TABLE 1 FRY TO SMOLT SURVIVAL

NOTE	YEAR	FRY NUMBER	YEAR	SMOLT NUMBER	% SURVIVAL	MEAN
	1979	211,980	1980	12,559e	5.9	
A	1980	370,420	1981	10,989e	3.0	2.9%
	1981	323,040	1982	3,610e	1.1	
	1982	339,220	1983	5,730e	1.7	
	1983	402,000	1984	11,801	2.9	
	1984	153,800	1985	15,885	10.3	
B	1985	171,220	1986	18,011	10.5	10.15 %
	1986	243,660	1987	24,394	10.0	
	1987	264,540	1988	26,000	9.8	
	1988	341,980e	1989	34,710e		
	1989	362,780e	1990	36,822e		
C	1990	376,300e	1991	38,194e		
	1991	447,280e	1992	45,398e		
	1992	465,220e	1993	47,219e		

Notes:

A Smolt numbers estimate from back calculation from actual returns i.e. deivide by 6.37% survival.

B Actual data from smolt trap.
Mean

C Estimated data for use in adult return predictions.

2. Smolt to Adult Survival

The mean smolt to returning adult survival based on the limited data is 6.37%. This means that for every 1000 smolts 63.7 adults will return. This makes it very easy to predict future returns by simply knowing the smolt number. For complete details on smolt to adult survival consult table 2.

TABLE 2 SMOLT TO RETURNING ADULT SURVIVAL

YEAR	SMOLT NUMBER	RETURNING YEAR	ADULTS	% SURVIVAL	MEAN
1984	11,801	1985	700	5.9	
1985	15,885	1986	862	5.4	6.37 %
1986	18,011	1987	1400	7.8	

3. Estimates and Predictions

The summary of estimated returns for the next seen years is shown in table 3. The returns increase from an estimated 1561

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fish in 1988 to 3007 spawners in 1994 provided current enhancement levels are maintained.

TABLE 3 PREDICTIONS OF YEARLY RETURNS

YEAR	SMOLT NUMBER	RETURNING YEAR	NUMBER OF ADULTS
1987	24,394	1988	1561e
1988	26,000	1989	1664e
1989	34,710e	1990	2211e
1990	36,882e	1991	2349e
1991	38,194e	1992	2432e
1992	45,398e	1993	2891e
1993	47,219e	1994	3007e

Notes
e estimated production

CONCLUSIONS

1. Fry Survival

The increase in fry survival from 2.9% to 10.15% is a result of enhancement actions directly affecting fry survival. The creation of suitable year round rearing habitat that is protected from extreme factors has created a three fold increase in the percentage of fry surviving. Seven percent more fry survive with this enhancement than without. This increase in the number of smolts produced shows up positively in the numbers of returning fish. The fact that the increase in fry survival directly affects the numbers of returning fish supports the theory that fry survival is the limiting factor in salmonid productivity in DeMamiel Creek.

2. Predictions

When the number of Coho smolts is know it is easy to calculate the estimate number of returning fish. To find this number you multiply the number of smolts counted or estimated by the 6.37% survival factor. The resulting returns will then be known and management decisions can be made. For details on the predictions made. See table 3 in Results.

RECOMMENDATIONS

1. Continue current enhancement efforts concentrating on increasing fry smolt survival.
2. Construction of more suitable rearing habitat is necessary to more rapidly increase stocks.
3. Continue operating smolt trap because of the wealth of information it produces.
4. Examine predicted returns and forecast the number of eggs needed to supply next year's required smolts. If you can use hatchery production in surplus these needs there may be a chance of a fishery to harvest the excess fish.

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