TCTR 8703

April 1987

# THE PACIFIC SALMON COMMISSION
# THE TRANSBOUNDARY TECHNICAL COMMITTEE

## REPORT TCTR (87)-3

# ENHANCEMENT OPPORTUNITIES FOR THE TRANSBOUNDARY RIVERS

April 28-30, 1987

## Summary


1. Surveys to assess Transboundary Rivers enhancement potential that have been undertaken to date have been done in a cursory manner. Some information on enhancement potentials has been acquired incidentally while conducting investigations for other purposes.

2. The information available suggests that sockeye enhancement would provide the greatest immediate benefits but that chinook and coho enhancement may also be beneficial in some areas. More investigation is needed to confirm these preliminary indications and to assess costs and benefits.

3. Three enhancement approaches for sockeye appear to have the greatest potential: lake stocking of fry, lake enrichment and obstruction removal. Of these, fry stocking may have the most widespread application.

4. Eleven lakes in the Taku, Stikine and Alsek watersheds were rated for enhancement potential on the basis of available information; Tahltan ranked highest followed by Klukshu and Tatsamenie lakes.

5. On the basis of this preliminary rating the Committee divided the lakes into two categories and recommends that the highest ranking lakes be considered for feasibility studies in 1987. If funding is available it is recommended that surveys be conducted on all lakes in 1987. These studies are needed to identify factors limiting production and thus what specific enhancement tool may be appropriate.

6. The general approach recommended is to conduct a broad survey of a number of lakes and a detailed survey of Tatsamenie lake which has been identified as the best potential for sockeye production in the Taku River drainage.

7. Investigations to assess the prevalence of fish disease in potential sockeye broodstocks and of the quality of returning adults for commercial use are also recommended.

8. As the harvest pattern for enhanced sockeye stocks will be mainly determined by harvest rates that can be applied to wild stocks, substantial surpluses may be available in terminal areas.

9. Slightly over 50% of enhanced Taku River sockeye would enter the river on average given the existing allocation formula while in the Stikine about 75% would enter the river.

10. The practicality of conducting terminal harvest on excess enhanced sockeye should be considered during project selection as much of the Canadian catch for some enhanced stocks may have to be taken in new terminal fishing areas.

11. Time separation of Tahltan sockeye from other Stikine stocks could allow additional harvests of enhanced fish in both U.S. and Canadian fisheries.

12. Because wild and enhanced stocks are mixed in the fishing areas it may not be possible to assign a separate formula for sharing of enhanced fish for certain projects.

13. Evaluation of the success of projects should be undertaken through the application of techniques such as biological markers analysis and coded-wire tagging to identify individual stocks. Stock separation information will also be needed to ensure that management programs can protect natural stocks.

14. Two potential chinook enhancement projects identified are rehabilitation of Alsek chinook through use of the Whitehorse hatchery to incubate Klukshu chinook eggs and fry planting above the barrier on the Tuya River.

15. No specific projects for coho enhancement were identified but system-wide surveys are recommended.

16. Pink and chum salmon enhancement was not considered to be viable at this time because of the comparatively low value of these species.

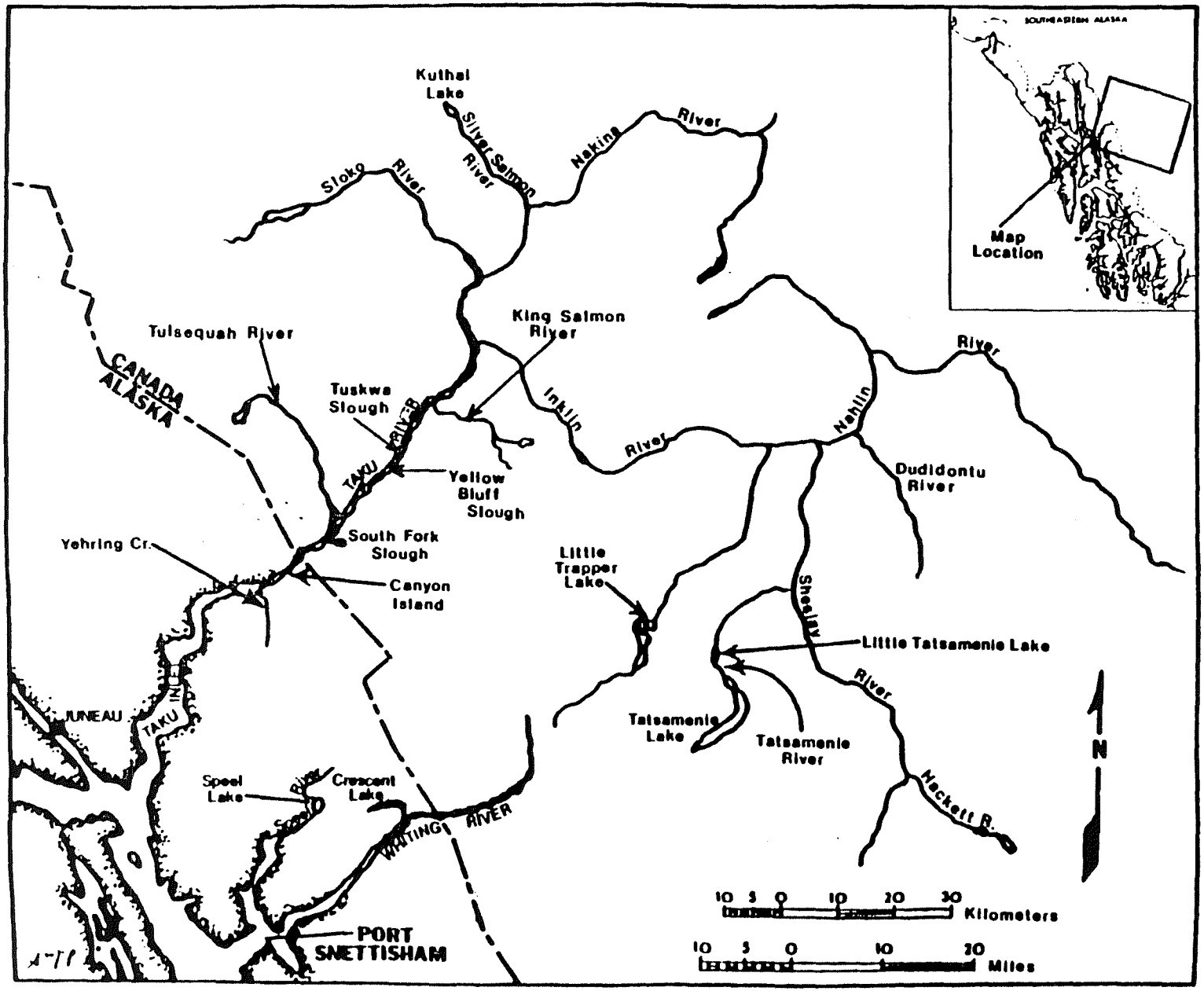


Figure 1. Taku River and Port Snettisham drainages.

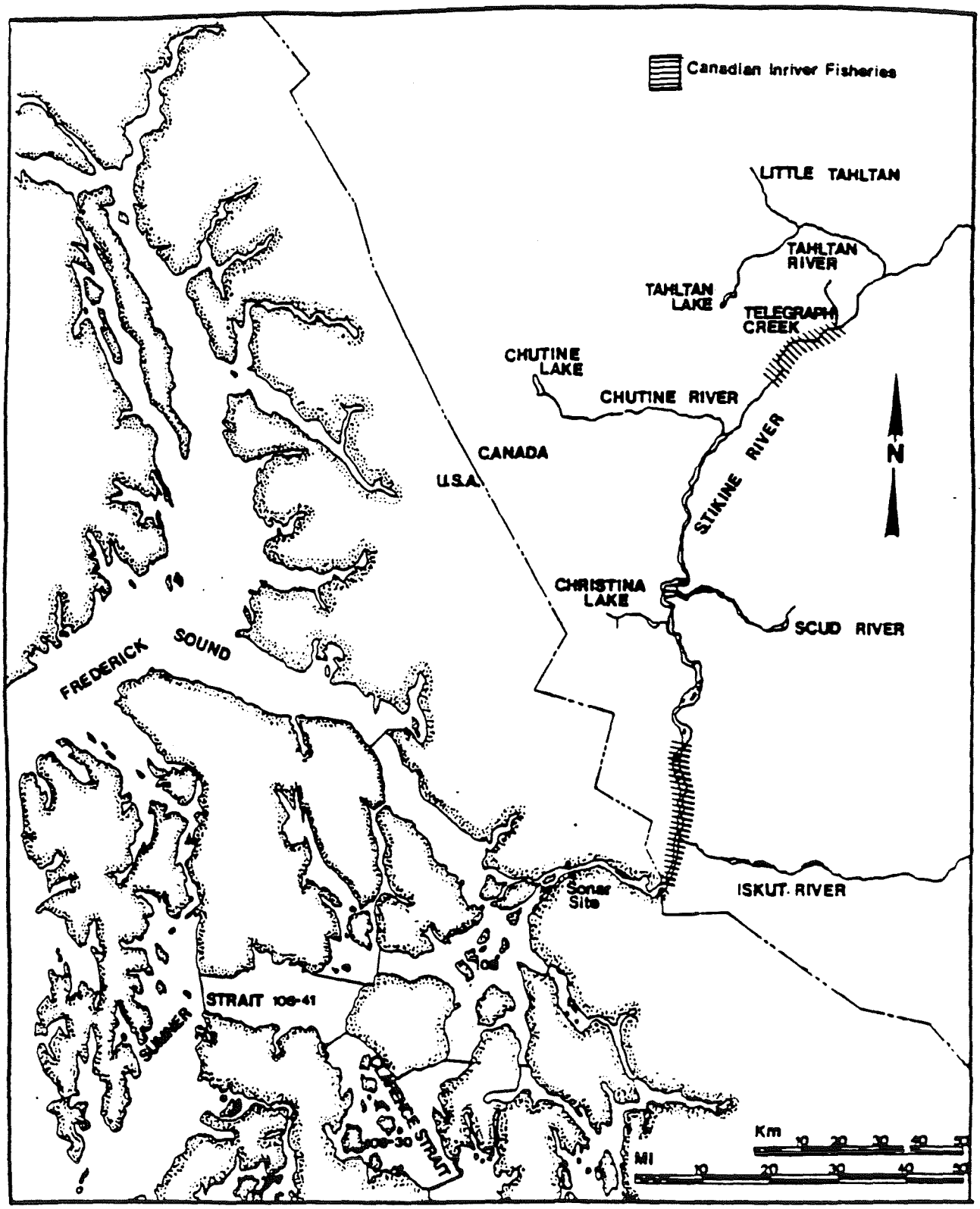


Figure 2. Stikine River drainages.

# PROPOSALS FOR TRANSBOUNDARY RIVER SALMON ENHANCEMENT FEASIBILITY STUDIES

## INTRODUCTION

The Pacific Salmon Treaty provided a mechanism for formalizing arrangements for cooperative enhancement on the transboundary rivers including sharing of the resultant benefits. Annex IV, Chapter 1, Section 6 of Treaty encourages the parties to undertake feasibility studies on enhancement potentials of the rivers and to consider cooperative enhancement possibilities. At the March 1987 negotiations the parties agreed to begin feasibility studies in 1987 to assess potential benefits from enhancement on the Stikine, Taku and Alsek rivers. The Transboundary Technical Committee was charged with undertaking by June 1987, a preliminary evaluation, based on existing information, of the feasibility, costs and benefits of alternative projects. The recommendations of the Committee would be reviewed by the Parties with a view to making a commitment to project initiation, schedule for implementation and harvest sharing arrangements.

This report summarizes enhancement opportunities recognized by the Committee along with recommendations for feasibility studies to be initiated in 1987. These studies would provide additional information of value in selecting enhancement projects for implementation. The Committee did a preliminary ranking of projects based on several criteria to identify projects for further study.

Because of their importance to the fisheries of both countries and the potential for creating significant increases in production through available techniques, sockeye were believed to be the species with the greatest potential for increasing mutual benefits in the short term. Consequently, the report tends to emphasize this species. However, the committee believes that significant potentials for increasing chinook and coho may also exist and preliminary discussions concerning these species are also included.

### Review of Previous Studies

Limited information is available in the Transboundary rivers to assess the enhancement potential for salmon. Except for Tahltan Lake, available information does not provide a basis for initiating specific enhancement projects. The data are sufficient however, to give an indication of where the greatest potentials are located.

Two surveys to assess enhancement opportunities have been conducted: a brief survey of several lakes was made in the late 1970's to determine their suitability for fertilization; second, the feasibility of providing access to the upper Tuya River was investigated. The lake enrichment survey did identify several lakes with potential while the Tuya River survey indicated that this system has a great capacity to support salmonids but that providing access would be very expensive. Appendix I lists specific enhancement opportunities that have been identified by previous research.

In general, the work to date suggests that enhancement of sockeye salmon would provide the greatest immediate benefits but that chinook and coho enhancement may also be feasible in some areas. More investigation is needed to fully confirm these preliminary indications and assess the costs and benefits and technical considerations of specific projects. A commitment should be made for a systematic survey of the transboundary river drainages to identify enhancement opportunities for all five species of Pacific salmon and steelhead. Such a program should include compilation and evaluation, from an enhancement prospective, of all relevant information now held by both countries as well as relevant field investigations.

## SOCKEYE SALMON

### Overview

Sockeye salmon are moderately abundant in the Taku and Stikine rivers with a smaller run occurring in the Alsek River. They form the basis of important fisheries in both the United States and Canada with combined catches averaging about 85,000 in the Taku, 35,000 in the Stikine and 25,000 in the Alsek. Historical catch records dating back to the late 1800's suggest that the sockeye runs to these rivers were always smaller than those occurring in most other large sockeye producing rivers. The smaller sockeye runs to the transboundary rivers are thought to be largely limited by natural barriers which restrict access to much of the watersheds. Providing access to the unutilized portions of the watersheds could potentially lead to substantial increases in production.

In both the Taku and Stikine rivers two basic life history strategies for sockeye have been identified. Some stocks spawn in streams associated with lakes or within lakes and rear for one or more years within the lakes before migrating to sea. Other stocks spawn in the mainstem of the rivers or in side sloughs and rear in these areas for a period of time before migrating to sea. Details of the life history of river rearing sockeye are poorly understood. Before embarking on any major enhancement projects involving existing stocks it is important to identify factors limiting production in order to develop the most appropriate enhancement strategy. For example, stocks limited by spawning habitat might benefit through fry planting, where lake productivity is low, nutrient addition may be beneficial. Also, improved access to rearing areas may increase production for some stocks.

### Sockeye Salmon Potential Opportunities

The Committee recognizes that opportunities do exist for the enhancement of transboundary river sockeye salmon stocks. This determination is based upon existing information and current technology. Three enhancement strategies (lake stocking, lake enrichment, and obstruction removal or modification) appear to provide the greatest opportunity for providing benefits over the short term.

In reviewing the existing database, it appears as if the delivery of sockeye salmon fry into barren or underutilized lake systems within the transboundary river drainages has the most widespread application for sockeye salmon enhancement. This strategy is dependent upon the operation of a centralized incubation facility and is only applicable to lake systems where sockeye fry recruitment (too few spawners or too little spawning area) is the limiting factor. Combining the fry delivery strategy with lake enrichment may increase sockeye salmon production well beyond natural production levels. These strategies have been successful in other areas (see Appendix V). While results from neither technique can be guaranteed, given appropriate conditions, both hold promise for substantially increasing sockeye production.

Candidate enhancement opportunities for sockeye salmon fry plants were identified by the Transboundary Technical Committee and listed in a comparative matrix (Appendix II). The matrix is made up of critical parameters that potentially could identify limiting factors for fry planting. Included in the matrix is a list of candidate lakes and their respective values in terms of lake size, broodstock considerations, turbidity, stock identification potential, quantity of background information available, and their potential for lake fertilization. A simplified value system was established for each parameter to provide a preliminary ranking of the candidate lake systems. Based on their overall ranking the lakes were divided into two categories. The first consisted of lakes showing the greatest promise and where the Committee is recommending that feasibility studies be implemented in 1987 to better define the enhancement potential. The second consisted of lakes that appeared to have less potential and which should be considered as possible long range future opportunities. Lakes deserving immediate consideration include Tahltan, Tatsamenie, Klukshu, upper and little Trapper, King Salmon, Kuthai, and Tuya. Lakes that warrant future consideration include Chutine, Christina, and Kennicott. However, should adequate funding be available in 1987 the Committee recommends that surveys be conducted on all the lakes listed in Appendix II.

## Feasibility Studies

Using the comparative matrix (Appendix II) candidate lakes were selected for additional feasibility studies in 1987-88. The objective of these studies is to tentatively identify the factor(s) limiting natural production in each lake system and thus what specific enhancement tool would provide the best opportunity for increasing production. Expected benefits from the proposed enhancement activities can then be better defined. The general approach recommended is to conduct a broad survey of several of the lakes and a more detailed investigation of Tatsamenie Lake. Investigations to assess the prevalence of fish diseases and the quality of returning adults for commercial use are also recommended.

Tahltan Lake, Klukshu Lake and Tatsamenie Lake were identified by the matrix as the candidate lakes with the best enhancement potential. Of these lakes, Tahltan rated highest partially due to the higher level of past research on Tahltan sockeye and the ongoing lake fertilization work by CDFO. Tatsamenie Lake is recommended for detailed feasibility work in 1987 because it represents a large potential due to its size (15.8 $Km^2$)

and the amount of data relating to fry planting potential collected in the past is limited. Also, Tatsamenie lake is the only large candidate lake system identified in the Taku drainage.

Specific field activities proposed for the 1987-88 season and their associated estimated operational costs are contained in Appendix III.

The data collection methodologies and analysis of the field work conducted in 1987-88 will be standardized between the American and Canadian teams to facilitate data comparison. Cost estimates are very preliminary and are not agency budget allocations.

Harvest and Sharing Considerations

Natural stock Protection:

It should be recognized that the harvest pattern for enhancement sockeye originating from lakes located in the Transboundary Rivers will be mainly determined by the harvest rates that can be applied to natural sockeye stocks produced in the drainages. U.S. marine fisheries and lower river Canadian fisheries will have to maintain existing effort patterns unless a unique targeting opportunity on the enhanced stock can be identified through stock identification and timing information. Because an enhanced stock will be able to withstand a higher harvest rate than the natural stocks in a drainage, the practicality of conducting a terminal harvest on excess enhanced fish should be a consideration during project selection. Such a terminal harvest may occur in an existing upriver fishery or a new fishing opportunity may have to be created.

Assessment of Enhancement Projects:

For major enhancement projects an evaluation of the success of each project will be necessary to provide information to allow for natural stock protection, to identify the distribution of the enhanced fish in the fisheries of both countries (sharing) and to determine project effectiveness. In order to accomplish such evaluations, biological stock identification markers and/or micro-wire smolt tagging as well as in-lake rearing sockeye measurements will be required.

The level of evaluation work required for each project will vary and could represent a significant annual operational cost for some projects. During detailed planning for a project, technical personnel will be able to determine the level of work required to assess production and to provide for natural stock protection.

Sharing of Enhanced Sockeye:

Fisheries on enhanced transboundary river sockeye will usually harvest a mix of wild and enhanced stocks. Exceptions to this could occur if special in-river terminal fisheries are established on enhanced returns, or if unique timing of an enhanced stock allowed for a directed harvest in a lower river or marine fishery. In formulating sharing arrangements it must be recognized that it will not be possible to simply assign a separate formula for sharing the enhanced fish. Overall benefits in terms of

the total harvest of mixed wild and enhanced stocks will have to be considered including any additional terminal area harvests required to fully utilize enhanced stocks.

Recent research indicates that wild transboundary river sockeye stocks will support a harvest rate ranging from 40% - 60% unless an exceptionally good or poor return occurs. In mixed stock marine and lower river fisheries the harvest rate that the wild stocks can sustain will have to be maintained. The additional harvest rate that an enhanced stock can be expected to withstand will probably have to be realized in terminal harvest opportunities.

Based on average harvest rates and using the 1985-1986 sharing arrangement for sockeye, examples of the expected distribution of the benefits of sockeye enhancement are provided in Appendix IV.

In our example of fry planting in a large lake in the Taku drainage slightly over 50% of the return is projected to enter the river under average conditions. The majority of the fish entering the Taku River would reach the lake unless a specific targeting opportunity could be developed without negatively impacting natural salmon stocks. This example points out the importance of carefully evaluating all aspects of the terminal harvest opportunity.

Sockeye enhancement on the Stikine River (Tahltan Lake) will result in the majority of the adult returns reaching an upriver terminal area under current fishing patterns. However, time separations of the Tahltan fish from other Stikine stocks should allow additional harvests of the enhanced fish in the lower river Canadian and terminal U.S. fisheries. Additional harvests in up-river Stikine fisheries near Telegraph Creek, where the Tahltan sockeye are geographically separated from the other Stikine Stocks may provide an additional harvest opportunity.

The distribution of benefits and terminal harvest potentials will vary with each new project that is evaluated.

## CHINOOK SALMON

The enhancement potential for chinook salmon in the Transboundary Rivers has not been examined in detail. The chinook salmon stocks in the rivers are currently depressed and regulations designed to rebuild them are currently in effect. While the rebuilding program is in effect, the potential to utilize enhanced chinook produced in the rivers will be limited.

Based on existing information, the following two projects have been identified as having the best potential of those known.

1. The Klukshu River tributary of the Alsek River supports a significant portion of the Alsek drainage chinook production. Attempts to micro-wire tag chinook salmon smolts in the Alsek drainage to determine their distribution and harvest rate in ocean fisheries have not been successful due to the small numbers of smolts captured for tagging .

By obtaining chinook eggs from the Klukshu system, rearing them to smolts in the Whitehorse Hatchery and tagging and releasing them back into the Klukshu system, the study could be conducted. Adults returning as a result of these releases would contribute to the rebuilding effort as well as provide useful information on distribution and harvest rate through tag returns. This activity would require expansion of the existing facility at Whitehorse.

2. The Tuya River, a tributary to the Stikine River, contains approximately 535 kilometers of potential chinook rearing habitat. A major block located near the confluence of the Tuya and Stikine prevents access to this habitat by natural chinook stocks. Chinook fry planting in the Tuya River may provide an opportunity to significantly increase production. During the completion of the rebuilding program, limited harvest of this production in existing fisheries can be expected. That portion of the Tuya River below the block should be surveyed to determine if a terminal harvest opportunity exists and if natural chinook stocks are utilizing this area.

## COHO SALMON

Coho salmon are known to be extensively distributed throughout the Transboundary River drainages. Natural coho stocks are found throughout most accessible rearing habitats. Past efforts to identify potentials for coho enhancement by the Committee have resulted in general references to opening up access to rearing habitat in small lakes and behind beaver dams, possibly combined with fry plants. Projects that would result in major measurable benefits have not been identified. Further system-wide surveys to identify potentials should be considered.

### Pink and Chum Salmon

The identification of enhancement opportunities for these species in Transboundary River drainages has received little attention. In-river fisheries have not focused on utilizing these species because of their low value and/or poor quality after they have entered the river. In the Taku River, an overlap of pink run timing with that of sockeye presents management conflicts. To date these have been resolved by treating the pink harvest as an incidental catch and by altering fishing techniques and mesh sizes to minimize the catch of pinks. In recent years, Taku pink salmon have also not been extensively targeted on and this has resulted in a substantial underharvest on years of large returns.

Appendix I

Review of Previous Studies and Potential Enhancement Opportunities

In selecting enhancement opportunities the Committee undertook a brief review of previous enhancement studies that has been conducted on the transboundary rivers. The bulk of the information used in the following list was extracted from a Canadian SEP Report on Enhancement Opportunities in British Columbia and the Yukon, and from Stockner's and Shortreeds's report (1978) on limnological surveys of lakes in the transboundary river areas.

Alsek River

1. Klukshu

    a. Stockner and Shortreed (1978) selected this lake as a possible candidate for lake enrichment.

    b. Potential incubation facility and stream habitat improvement sites have been located.

    c. There is a preliminary proposal to incubate and rear Klukshu chinook salmon, coded-wire tag the juveniles, and release the juveniles back into the Klukshu.

    d. Health Check - positive for IHN from samples collected September 1983.

2. Neskataheen

    a. Stockner and Shortreed (1978) rejected this lake as a candidate for lake enrichment because it had extensive growths of rooted marophytes and was very productive at the time of the survey.

3. Dezadeash

    a. The possibility of transplanting 30,000 Klukshu sockeye salmon smolts to Dezadeash Lake for colonization and release was discussed by DFO in 1982. Adult returns would indicate whether the fish could negotiate the lower reaches of the outlet stream.

4. Blanchard Headwaters

    a. A potential hatchery site has been located in the headwaters of this system which would utilize an abandoned pumping station. The site is questionable from both a technical and cost standpoint.

5. Estuary Productivity Studies

    a. American biologists (NMFS and ADF&G) have conducted preliminary studies on the productivity of the estuary (Dry Bay) of the Alsek River and its potential affect on survival of emigrating salmonid

smolt. The results are not encouraging; very low productivity and rearing capability are indicated.

Taku River

1. Kuthai

   a. Stockner and Shortreed (1978) selected this lake as a possible candidate for lake enrichment. DFO operated a sockeye enumeration weir in 1980 and 1981

2. Silver Salmon

   a. Canada conducted a basic engineering reconnaissance on an obstruction in the river. Construction of a fishpass was rated as difficult.

3. Upper Trapper

   a. Stockner and Shortreed (1978) rejected this lake as a candidate for lake enrichment due to the glacial silt in the water.

   b. A basic aerial reconnaissance of the system was conducted by SEP engineers.

4. Little Trapper

   a. Stockner and Shortreed (1978) gave tentative approval for this lake as a candidate for lake enrichment.

5. King Salmon

   a. Stockner and Shortreed (1978) selected this lake as a candidate for lake enrichment.

6. Tatsamenie

   a. Stockner and Shortreed (1978) selected this lake as a candidate for lake enrichment.

7. Inklin

   a. Bio-engineering report on the mud slide. Basic water quality sample reports available.

8. Annual Access Maintenance

   a. Beaver dam removal.

   b. Open side rearing ponds for coho enhancement.

Stikine River:

1. Tuya

    a. Detailed engineering surveys and cost estimates on the fishway and downstream area were done in 1984 and 1985.

    b. The Northwest Enhancement Society was contracted in 1983 and 1984 to investigate water conditions (temperatures, ice and snow conditions, freeze-up, thaw, and the location of upwelling and open water areas) and determine the location and height of any obstructions in the system.

    c. B.C. Hydro conducted basic inventory and assessment studies in support of their proposal to dam the Stikine Grand Canyon for hydro-electric power.

2. Tahltan

    a. The Northwest Enhancement Society conducted the same contract work in 1983-84 on the Tahltan as on the Tuya.

    b. A flow control structure was constructed in 1959 and renovated in 1983 and 1984.

    c. Lake enrichment was implemented along with sockeye smolt enumeration studies in 1984.

3. Iskut

    a. Underutilized coho and sockeye habitat identified on the Craig and Jekill systems. Data source unknown.

4. Chutine

    a. Stockner and Shortreed (1978) rejected this lake as a candidate for lake fertilization due to the glacial silt in the water.

    b. Stockner identified a potential incubation site.

5. Annual Access Maintenance

    a. Beaver dam removal.

    b. Opening of side rearing areas for coho enhancement.

6. IHN Virus Surveys

    a. Some sockeye broods along the Stikine River were sampled for IHN virus by CDFO in 1986.

## Literature Cited

Lill, A.F., B. Shepherd, J. Wild, J.W.C. McNally and D. Marshall. 1985 Opportunities for salmonid enhancement projects in British Columbia and the Yukon. A revised version of the preliminary report by the Enhancement Opportunities Subcommittee to the Salmonid Enhancement Phase II Planning Committee.

Stockner, J.G. and K.C. Shortreed. 1978. Limnological survey of 35 sockeye salmon (Onchorynchus nerka) nursery lakes in British Columbia and Yukon Territory, Fisheries and Marine Service Tech. Report 827. 47pp.

Appendix II Transboundary River Lake Potential Evaluation Matrix

Comparative matrix of potential sockeye salmon fry planting opportunities on the Alsek, Taku, and Stikine Transboundary River Systems (Legend follows).

| River/ Lake | Size in $Km^2$ | -------Broodstock------- Availability | Ease of Collection | Turbidity | Terminal Harvestability | Stock I.D. Potential | Background Data Availability | Lake Fertilization Candidates |
|---|---|---|---|---|---|---|---|---|
| Alsek | | | | | | | | |
| Klukshu | 1.6 | Yes | Good | C | G 1 | ? | 4 | Yes |
| Taku | | | | | | | | |
| Tatsamenie | 15.8 | Yes | Med. | S | G 2 | ? | 3 | Yes |
| Upper Trapper | 6.8 | N/A | ---- | G | G 2 | ? | 1 | No |
| Little Trapper | 2.3 | Yes | Good | S | G 2 | ? | 3 | No |
| Kuthai | 2.4 | No | Good | C | G 2 | Yes | 3 | Yes |
| King Salmon | 1.6 | No | Poor | C | G 2 | ? | 2 | Yes |
| Kennicott | 1.2 | N/A (Hackett) | ---- | C | G 2 | ? | 1 | No |
| Stikine | | | | | | | | |
| Tahltan | 4.0 | Yes | Good | C | G 1 | Yes | 5 | Yes |
| Tuya | 30.6 | N/A | ---- | C | Med. | ? | 1 | Unknown |
| Chutine | 6.5 | No | Med. | G | Med. | Poor | 1 | No |
| Christina | 2.4 | No | Med. | G | Med. | Poor | 1 | No |

Appendix II Legend

For comparative matrix of potential sockeye salmon fry planting opportunities on the Alsek, Taku, and Stikine Transboundary River Systems.

Size - Defined in square kilometers

Broodstock:

Availability

Yes - Existing natural return to support an egg take of 5 million (2,000 females @ 2,500 eggs/female).

No - Existing natural return will not support an egg take of 5 million eggs.

N/A - Not available, lake system does not support an existing sockeye run.

Ease of Collection

Good - Site available to collect ripe sockeye spawners.

Med. - Medium, collection of ripe sockeye spawner not as readily accessible as previous ranking.

Poor - Collection of ripe sockeye spawners will be difficult.

---- - Collection of ripe sockeye spawners non existent.

Turbidity

C - Clear water lake system (highest priority)

S - Semi-glacial lake system.

G - Glacial lake system (lowest priority)

Terminal Harvestability

G 1 - Good 1, Existing terminal area fishery to harvest the enhanced stocks.

G 2 - Good 2, A new terminal area fishery would have to be created to harvest the enhanced stocks, but the opportunity exists and the fish are harvestable.

Med. - Medium, terminal area fishery is possible, but full utilization of the enhanced stocks is questionable.

Stock I.D. Potential

Yes - There is an existing biological marker to separate this stock from other natural or enhanced stocks.

No - There presently is no existing biological marker to separate this stock from other natural or enhanced stocks.

? - Presently unknown whether a biological marker exists to separate this stock from other natural or enhanced stocks.

Background Data Availability

1 - No existing salmon runs, or the available information is limited to the presence of fish of unknown magnitude.

2 - Lake fertilization survey conducted, limited escapement records.

3 - lake fertilization survey conducted, escapement levels documented by weir.

4 - Lake fertilization survey conducted, and escapement levels documented by a weir for a long period of time.

5 - lake fertilization survey conducted, lake enrichment occurred, long term escapement levels by a weir, and smolt emigration documented.

Lake Fertilization Candidate

Yes - This lake was surveyed by Stockner and Shortreed in 1977 and selected as a potential candidate for lake fertilization based on that information.

No - This lake was surveyed by Stockner and Shortreed in 1977 an rejected as a potential candidate for lake fertilization based on that information.

Unknown - This lake has not been surveyed and it is unknown whether it is a candidate for lake fertilization.

Appendix III Details on Proposed 1987 Feasibility Investigations

1. Tatsamenie Lake (U.S. tentatively planning to conduct this investigation)

   a. Detailed limnological survey - $43,600

      1) First trip (June 1987)

         a) Establish four sampling stations in the lake.

         b) Collect water quality samples from the surface (1m) and at two thirds of the depth at each station.

         c) Collect water samples for nutrient chemistries at each station.

         d) Take temperature, light, and dissolved oxygen profiles at each station.

         e) Take vertical hauls to each station to determine the density, species composition, etc. of the zooplankton community.

         f) Carry out hydroacoustic survey to estimate juvenile rearing densities and to develop a morphometric map of the lake.

         g) Obtain a grab sample of migrant sockeye salmon smolts to provide biological information.

      2) Second trip (early August 1987)

         a) Replicate the sampling of the first trip, with the exception of the hydroacoustic work and the smolt sampling.

      3) Third trip (mid-September 1987)

         a) Replicate the sampling conducted on the second trip.

         b) Carry out hydroacoustic survey, plus tow netting to determine species composition rearing fry densities, the depth (and temperature) at which the fry are rearing, and sizes and ages of the sockeye juveniles.

      4) Fourth trip (late October-early November 1987)

         a) Replicate the sampling conducted on the second trip.

      5) Fifth trip (late April 1988) included to complete the sampling for one full season cycle.

         a) Through-the-ice sampling to determine any pre-iceout production.

b) Replicate the sampling of the second and fourth trips.

b. Pathological screening of sockeye salmon brood (Fall 1987) $2,000.

c. Small sockeye egg-take (10,000 eggs) to develop a fish cultural history of the Tatsamenie sockeye salmon brood in the ambient water temperature of the Snettisham Hatchery (Fall 1987-Spring 1988) - $5,000.

d. Determination of fish quality returning to the fish weir for harvest considerations. (DFO fish inspection team) - $_____.

2. Kuthai, King Salmon, Upper and Little Trapper, Tahltan, Klukshu and Tuya Lakes. (Canada tentatively planning to conduct these investigations).

a. Basic limnological survey - $ 155,000.

1) Bathymetric survey (July 1987).

2) Hydroacoustic and trawl surveys (July-September 1987).

3) Zooplankton assessment (July-September 1987).

4) Water analysis (Fall overturn 1987).

5) Smolt emigration samples (May 1988).

b. Fish quality of adult returns at applicable sites. - $_____.

c. Collect and analyze disease samples from sockeye salmon broodstocks to develop a disease history. - $_____.

Appendix IV.

Effect of Stock Enhancement on U.S. and Canadian Transboundary Sockeye Catches. 1/

Taku River

example - sockeye fry planting of Tatsamenie Lake

assumptions: 1) return of 100,000 adults
2) exploitation rates of enhanced and unenhanced scenarios are equal (no opportunities exist to selectively harvest enhanced stocks at a higher rate than natural stocks in the traditional U.S. and Canadian mixed-stock fisheries)

| | Natural | Enhanced | Total |
|---|---|---|---|
| Total Run (1984-1986 mean) | 183,000 | 100,000 | 283,000 |
| Less Escapement Goal (wild stock) | 80,000 | | 80,000 |
| Total TAC | 103,000 | 100,000 | 203,000 |
| U.S. TAC (85%) | 87,500 | 47,800 | 135,300 |
| Canadian TAC (15%) | 15,500 | 8,500 | 24,000 |
| Additional Fish Available for Terminal Harvest and Egg Take | | 43,700 | 43,700 |

Stikine River

example - sockeye enhancement of Tahltan Lake

assumptions: 1) return of 50,000 adults
2) exploitation rates of enhanced and unenhanced scenarios are equal (no opportunities exist to selectively harvest enhanced stocks at a higher rate than natural stocks in the traditional U.S. and Canadian mixed-stock fisheries)

| | Natural | Enhanced | Total |
|---|---|---|---|
| Total Run (1982-1986 mean) | 101,500 | 50,000 | 151,500 |
| Less Escapement Goal (wild stock) | 62,000 | | 62,000 |
| Total TAC | 39,500 | 50,000 | 89,500 |
| U.S. TAC (65%) | 25,700 | 12,700 | 38,400 |
| Canadian TAC (35%) | 13,800 | 6,800 | 20,600 |
| Additional Fish Available for Terminal Harvest and Egg Take | | 30,500 | 30,500 |

1/ The scenarios used to illustrate effects of enhancement are based on the average total run sizes to the Taku River from 1984-1986 and the Stikine River from 1982-1986. The total TAC for each river represents all fish in excess of the escapement goal. U.S. and Canadian portions of the TAC represent 1985-1986 treaty harvest sharing ratios and differ slightly from the number of fish actually harvested by each fishery.

Appendix V

Sockeye salmon rehabilitation and enhancement in Alaska has proceeded along two fronts. The first is stocking or out-planting of juveniles (0.2 - 0.3 g) into lakes to take advantage of existing surplus natural forage production. The second is application of nitrogen and phosphorus fertilizer to increase the forage base for existing juvenile populations.

Out-plants of fry into three different lake systems located in Southcentral and Southeast Alaska (Table 1) since 1978 has resulted in significant returns of adult fish.

Fertilization of two lakes (Table 2) located in Southcentral Alaska was designed to produce larger and younger smolts so that freshwater and hopefully marine survival will be increased. Success is evident for Leisure Lake where more, younger and larger smolts were produced. At Packers Lake, younger and larger smolts were also produced. However, because no direct estimate of fry abundance in the spring was available, survival during freshwater residence is unknown.

In summary, available information from Alaska indicates that both fry outplanting and lake fertilization may be successful enhancement strategies. The combination of the two technologies also offers great promise. However, the key to success of either technology depends upon matching the appropriate technology to the individual situation.

The lake fertilization program has been active in British Columbia for a number of years concentrating mainly on coastal lakes, such as Great Central, Kennedy, Long and Morice. Increased sockeye production as a result of fertilization is difficult to demonstrate directly due to variability in sockeye growth rates and mortality and the complication of allocating catch by stock. However, larger adult returns can be inferred through increased primary and secondary production and through increased lake growth and/or survival of juvenile sockeye. The available evidence suggests that increases in smolt size will lead to increases in marine survival and consequently harvestable surpluses.

Table 1. Results of fry out-plants in Alaska.

| Facility | Lake | Release Years | Mean Number of Juvenile Released (0.2-0.3g) | Mean Number of Smolts Produced | Mean Number of Adults Produced |
|---|---|---|---|---|---|
| Kasilof | Tustumena | 79-86 | 12,700,000 | 2,540,000 | 390,000 |
| | Leisure | 80-84 | 1,420,000 | 277,000 | 95,400 |
| | Chenik-1 | 78-81 | 450,000 | --- | 46,000 |
| Trail L. | Hidden | 83-86 | 1,032,000 | 475,333 | 40,000 |
| Beaver F. | Bakewell/ Badger | 85-86 | 500,000 | 120,000 | --- |

1 - 839,000 fry released in 1986 not included.

Table 2. Results of lake fertilization experiments.

| Lake | Smolt Year | Fry Density (millions) | Smolts --- Age 1 --- Size | Age 1 Age (%) | Smolts --- Age 2 --- Size | Age 2 Age (%) | Total |
|---|---|---|---|---|---|---|---|
| Lesiure | Pre-fert. | 2.1 | 62 mm; 1.8 g | 26 | 75 mm; 3.4 g | 74 | 178,000 |
| | Post-fert. | 2.1 | 84 mm; 4.8 g | 60 | 110 mm; 11.5 g | 40 | 376,000 |
| Packers | Pre-fert. 1983 | 13,000[1] | 96 mm; 7.0 g | 5 | 104 mm; 9.4 g | 92 | 246,000 |
| | Post-fert. 1986 | 18,400[1] | 120 mm; 16.0 g | 63 | 140 mm; 26.0 g | 33 | 167,000 |

[1] Estimated number of adults spawning the previous year.