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JOINT TRANSBOUNDARY TECHNICAL COMMITTEE

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PROGRESS REPORT AND RECOMMENDATIONS FOR JOINT  
CANADA/U.S. SOCKEYE SALMON ENHANCEMENT PROJECTS  
IN THE STIKINE AND TAKU RIVER DRAINAGES

PREPARED BY:

The Transboundary Enhancement Subcommittee  
of the  
Transboundary Technical Committee

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## EXECUTIVE SUMMARY

This report is a summary of studies undertaken to determine the feasibility of sockeye salmon enhancement projects proposed for the transboundary rivers. All projects discussed involve the collection of eggs from broodstock sources in the transboundary river systems, incubation of the eggs at an Alaskan hatchery, and outplanting of resulting fry into lakes having underutilized rearing capacity. In the Taku system, outplanting is proposed for Trapper and Tatsamenie Lakes; proposed sources of broodstock are Little Trapper and Little Tatsamenie Lakes, respectively (Figure 1). In the Stikine system, it is proposed to outplant fry into Tuya Lake and/or Tahltan Lake, using Tahltan Lake as a source of broodstock for both (Figure 2).

Results of field activities conducted during 1988, relevant to the feasibility of the proposed projects, are presented. Tests of capture and holding of broodstock at the proposed broodstock source lakes indicate it is feasible to collect the required number of eggs at each site, providing run strength is sufficient. Pathological surveys of the proposed broodstocks detected very high prevalences of both Infectious Hematopoietic Necrosis Virus (IHNV) and Bacterial Kidney Disease (BKD) in Tahltan Lake spawners, raising serious concerns regarding the outplanting of Tahltan origin fry into Tuya Lake. Results of limnology and juvenile fish population surveys of Tuya and Tatsamenie lakes support earlier conclusions on their enhancement potential. Additional limnological and juvenile fish studies conducted during the summer and fall of 1988 are discussed. The Phase I construction of a central incubation facility (CIF) was completed at Port Snettisham, Alaska. Studies involving the mass-marking of sockeye fry by thermal banding of otoliths and delaying of fry emergence through coldwater incubation, to ensure fry do not emerge before ice has left the outplant sites, were undertaken at this facility using 1988 brood sockeye. Both techniques are essential to the projects as presently planned. Success of the otolith marking technique has been demonstrated. Delay of emergence also appears successful, although this can not be stated conclusively until fry emerge in mid-June.

Enhancement projects were analyzed in detail, incorporating results of the field activities. Issues examined include procedures for evaluation, fisheries management requirements, technical feasibility, likelihood of success, schedules for implementation and production forecasts, and benefit/cost analyses.

Evaluation. Evaluation and fisheries management require a practical method of marking enhanced fish. The recommended technique of thermally induced banding of the otoliths is described in detail and reasons for its selection are given. Evaluation of outplanting success would require hydroacoustic and

trawl sampling to provide estimates of population size and growth and survival of juveniles in freshwater, as well as information on possible early outmigration. Migrating smolts should be sampled to determine total freshwater growth, age composition, and the ratio of wild to enhanced production. Limnological surveys should be conducted to monitor changes in lake productivity. Survival to the adult stage should be evaluated through enumeration and sampling of both the fishery and escapement.

Fisheries Management. In the U.S. District 106 fishery, enhanced returns to the Stikine River would likely commingle with wild stocks. Management would be based on maintaining optimal yield from wild stocks; thus, an in-season method of distinguishing enhanced fish from wild fish would be required. This would also be required for monitoring compliance with any U.S./Canada sharing arrangements for enhanced returns. Fisheries targeting on enhanced returns would probably not be possible and harvest rates of from 2 to 35 percent could be expected. Fisheries targeting on a mix of enhanced Tuya Lake sockeye and Tahltan Lake sockeye in the U.S. District 108 fishery should be possible because of their early run timing; however, exploitation rates of enhanced Tuya fish could be limited to those appropriate for Tahltan Lake, unless this stock was also enhanced. Possible conservation problems with chinook, chum and pink stocks are discussed. Steelhead are unlikely to be affected because of their late run timing. Enhanced Taku stocks could be expected to commingle with wild sockeye stocks in the U.S. District 111 fishery; as in District 106, management would be based on maintaining optimum yield from wild stocks and an in-season method of identifying enhanced fish would be required. Harvest rates averaging about 30 percent (15%-40%) could be expected unless enhanced fish could be targeted. It would perhaps be feasible to target to some extent on Trapper Lake fish, but not on Tatsamenie Lake fish, based on the run timing of donor stocks.

In the Canadian lower Stikine River fishery it would probably be possible to target on an enhanced Tahltan sockeye run or on a mixture of wild Tahltan Lake sockeye and enhanced Tuya sockeye (using Tahltan fish as donor stock), because of their early run timing. However, enhancement of Tahltan Lake sockeye would likely be required to permit any increases in harvest rate. Chinook stocks could also be affected by the higher harvest rate and their enhancement should be considered. Harvest rates of steelhead are unlikely to be affected because of their late run timing. Expansion of Indian food fisheries and/or the commercial fishery located further up-river is discussed. On the Taku, there appears to be little opportunity for targeted fisheries in the lower river, because of expected overlaps in run timing with wild stocks. Since sockeye management would continue to be based on maintaining wild stocks, it is unlikely that harvest rates on other species would be affected by the sockeye enhancement

projects. The possibility of initiating new terminal fisheries on both systems, including weir fisheries at Tahltan, Little Trapper and Little Tatsamenie lakes, and some type of fishery in the vicinity of the Tuya River obstruction, is discussed.

Feasibility. The proposed enhancement activities appear to be technically feasible based on the results of studies to date and should have a high likelihood of success. Thermal banding of otoliths has been successfully tested and delay of emergence through low temperature incubation appears successful, subject to confirmation in mid-June. Retention of the otolith mark to the adult stage will still not have been demonstrated at that time; however, the use of an otolith mark is recommended based on results of studies elsewhere. If delay of emergence proves unsuccessful, an alternative strategy will have to be identified prior to implementation of the projects. This could alter decisions regarding feasibility, or delay implementation. Other unanswered issues affecting feasibility include that of introducing Tahltan Lake sockeye, with high prevalences of IHNV and BKD, into Tuya Lake and the possibility of gas pressure problems in fry during transport.

Schedule for Implementation. A schedule for implementation is recommended. In an Understanding reached during the Pacific Salmon Commission meeting at Portland, Oregon, in February, 1989 (Appendix 2), the parties agreed to an egg-take of 3 to 6 million eggs at Tahltan Lake in 1989. The resulting fry would be planted into Tahltan Lake or distributed between Tahltan and Tuya lakes, dependent on the magnitude of the 1989 Tahltan Lake adult escapement. Enhancement operations on the Taku River are discussed, but under the agreement would not begin until 1990, unless hatchery space and funding issues are resolved in time to permit an egg-take of 2.4 million in 1989.

Benefit/Cost. A favourable, but preliminary, benefit/cost ratio of 1.56 to 1 was calculated based on 20-year production forecasts and cost schedules. Further analysis by economists from both countries, using transboundary fishery-specific information, is warranted.

Several areas requiring immediate action are identified. These include:

1. direction from the Northern Panel on whether joint enhancement should proceed or be delayed, if the strategy for delaying emergence of incubated fry to coincide with ice departure from target lakes does not work;
2. a decision from Alaska regarding availability of additional space in the Port Snettisham CIF in 1989 and a decision from

Canada on whether funding is available to take advantage of such space;

3. the need for disease surveys of Tuya River system fish populations (in regard to introduction of disease carrying Tahltan sockeye);
4. a decision from Canada on whether outplants of Tahltan sockeye into Tuya Lake will be permitted;
5. approvals from transplant authorities in both countries;
6. completion of field tests to determine the possibility of gas pressure problems in fry during aerial transport to the outplant lakes; and
7. formation of a Work Group to examine issues surrounding harvest and cost sharing on the Taku River, as agreed to at the February, 1989, Portland meeting (Appendix 2).

Areas identified as requiring further study, but not felt to be of sufficient importance to delay implementation of projects, are:

1. additional knowledge on the availability of spawning habitat in Tatsamenie, Tahltan, and Little Trapper lakes;
2. examination of the feasibility of capturing and marketing sockeye in non-traditional terminal areas;
3. more detailed examination of the productivity of Little Trapper Lake, in regard to its potential for lake enrichment;
4. studies to determine whether sockeye in Tatsamenie and Little Tatsamenie lakes represent two discrete stocks;
5. the feasibility of larger egg-takes and economy of scale (i.e. improved benefit/cost ratios at higher levels of production); and
6. intensified enhancement studies on Tuya Lake.

## INTRODUCTION

In accordance with the February, 1988, "Understanding Between The United States And Canadian Sections Of The Pacific Salmon Commission Concerning Joint Enhancement Of Transboundary Salmon Stocks" (Appendix 1), an Enhancement Subcommittee of the Transboundary Technical Committee was established on May 5, 1988. The terms of reference of the Subcommittee include:

- a) developing a preliminary summary of various projects meeting enhancement goals established by the Northern Panel;
- b) developing detailed feasibility studies for projects selected by the Northern Panel; and
- c) monitoring the implementation of projects and reporting progress to the Northern Panel.

The enhancement goal established by the Northern Panel for the period 1988-1992 is to embark on a program designed to annually produce 100,000 returning sockeye to both the Taku and Stikine rivers, for a total of 200,000 sockeye salmon per year. Based largely on studies conducted in 1987 (Transboundary Technical Committee 1988) several potential enhancement projects were selected by the Northern Panel. All involve the collection of sockeye eggs from broodstock sources in the transboundary river systems, incubation of the eggs at the Port Snettisham central incubation facility (CIF) located near Juneau, Alaska, and outplanting the resulting fry into lakes with underutilized rearing capacity. In the Taku system, two outplant candidates were selected: Trapper Lake, using Little Trapper Lake as a source of broodstock, and Tatsamenie Lake, using broodstock taken from the natural run occurring there (Figure 1). In the Stikine system, Tuya Lake was selected as a prime candidate for outplanting, using Tahltan Lake as a source of broodstock (Figure 2). The target date to initiate egg-takes of 5 million eggs per system (i.e., sufficient eggs to provide adult returns of approximately 100,000 to each system) was initially established as 1989. However, in an Understanding reached in Portland, Oregon in February, 1989 (Appendix 2), the parties agreed to a reduced effort in 1989 involving the taking of 3 to 6 million Tahltan sockeye eggs. Taku River sockeye enhancement will likely be delayed until 1990; however, there is a provision in the Understanding that up to 2.4 million eggs could be taken in 1989 if considered practical.

With the preceding enhancement strategy in mind, the Enhancement Subcommittee agreed to conduct a number of enhancement related field activities in 1988 (Appendix 3). These activities included broodstock capture and holding experiments, pathological screening of samples from potential broodstocks for Infectious Hematopoietic Necrosis Virus (IHNV) and Bacterial Kidney Disease

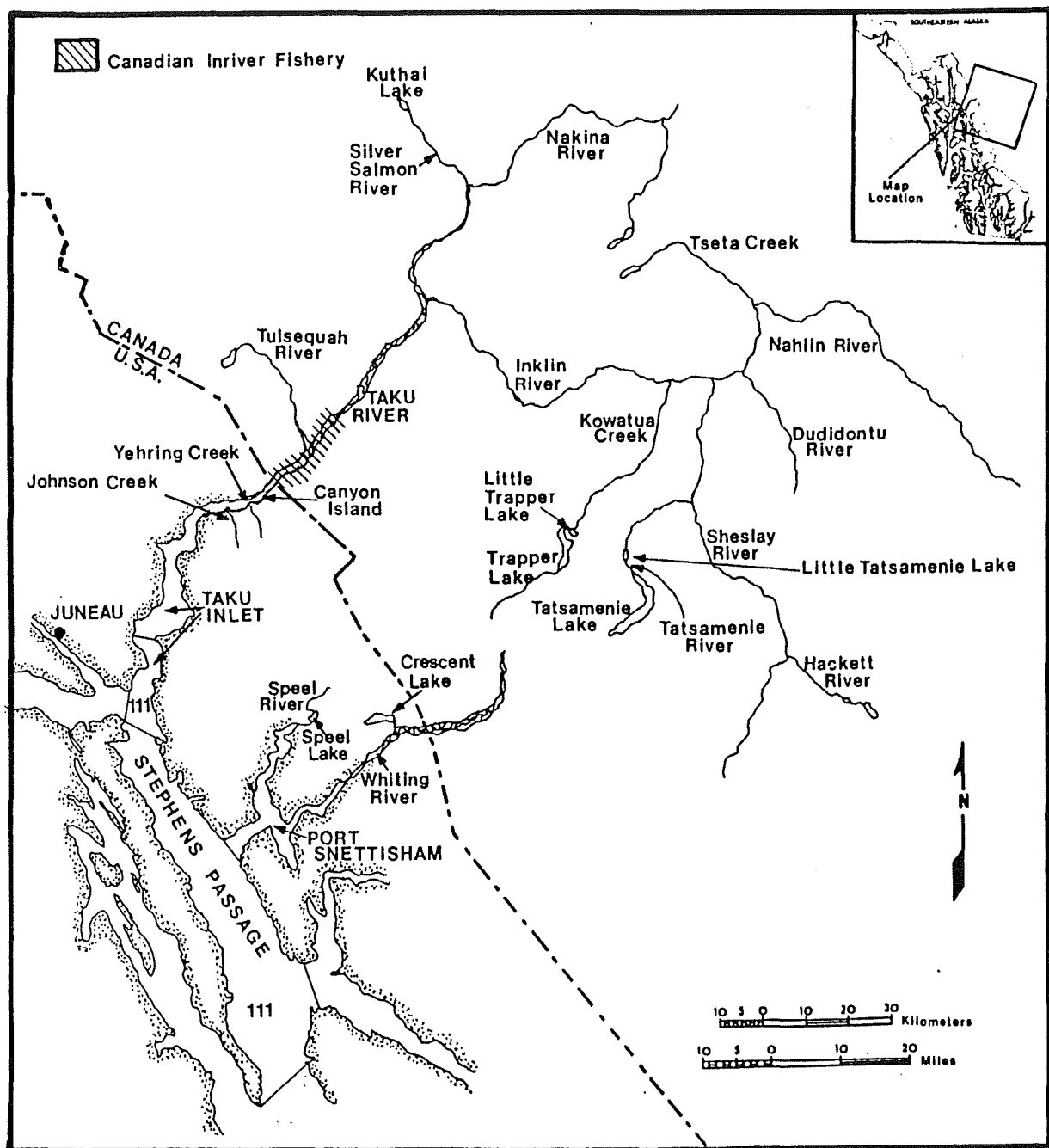


Figure 1. Taku River drainages.

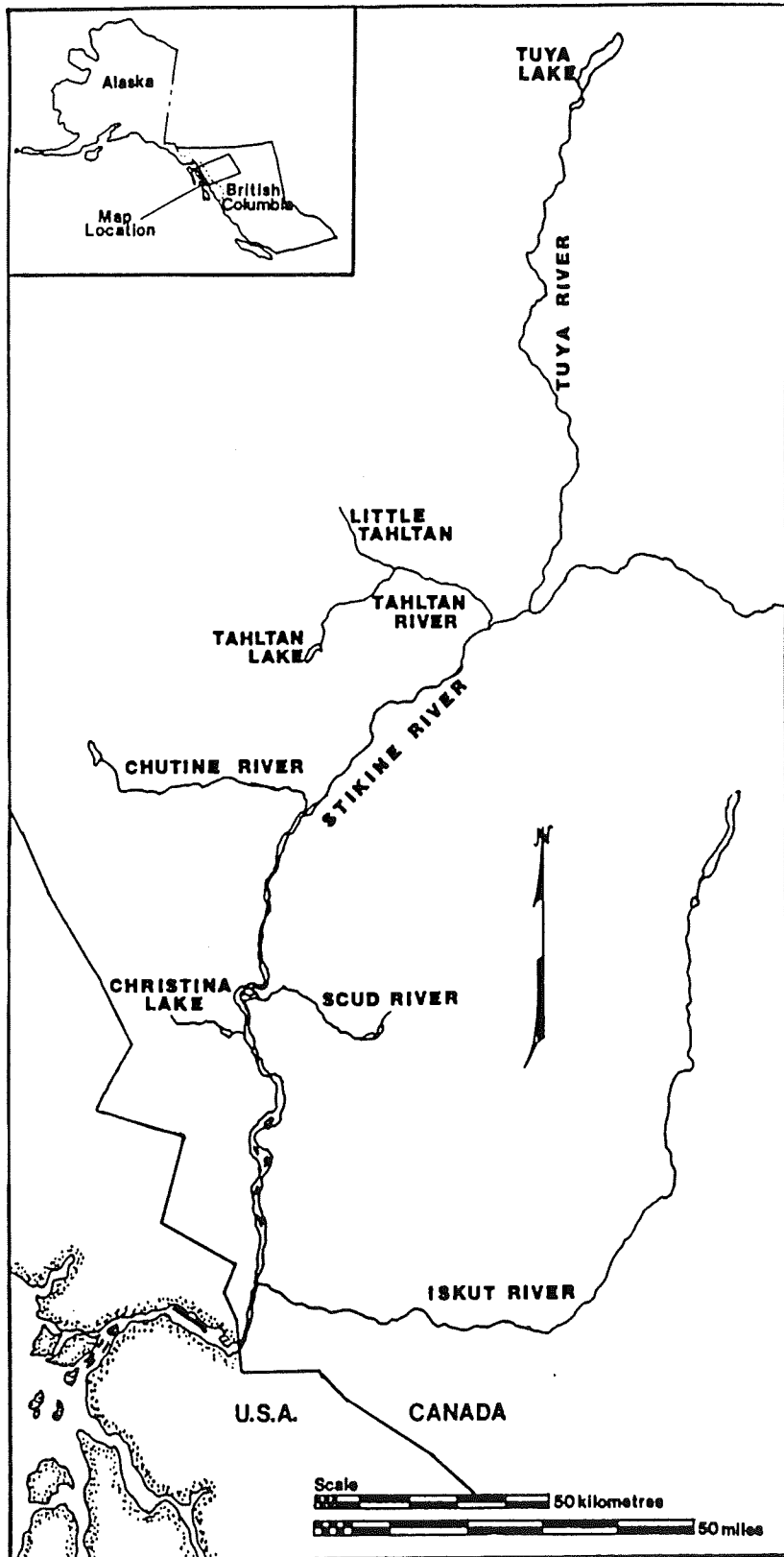


Figure 2. Stikine River drainages.

(BKD), assessment of available spawning habitat at Tatsamenie Lake and testing of the Port Snettisham CIF and fish culture procedures.

Part A of this report summarizes results of field activities conducted during the summer of 1988. The implications of these activities are discussed. Part B of the report presents detailed feasibility studies of the proposed projects, which incorporate the results of the field activities. Areas examined include procedures for evaluation, management requirements, technical feasibility and likelihood of success, and benefit/cost. Recommendations for future transboundary river sockeye salmon enhancement activities are presented.

## PART A. 1988 ENHANCEMENT RELATED FIELD ACTIVITIES

### 1.0 FEASIBILITY OF BROODSTOCK COLLECTION

Long-term holding of broodstock for ripening (2-6 weeks) was conducted at Little Trapper, Little Tatsamenie, and Tahltan lakes. Fish were captured at existing weirs and by beach seining. Male and female sockeye were held in separate net pens for the experiments. Results are summarized as follows:

Little Trapper Lake - Holding mortality for females was negligible; 1/30, or 3%. Mortality for males was comparable to that for females. Seining from the creek was not difficult.

Little Tatsamenie Lake - Holding mortality was not excessive, 8/62 females (13%) and 3/38 males (8%). Seining broodstock from the creek was very difficult due to access problems and low spawner density.

Tahltan Lake - Twenty-five fish of each sex were placed into holding pens; however, 15 of the females escaped early in the trial, making it impossible to accurately assess female mortality. Of the remaining 9 females, 6 were dead at the time of final examination; a minimum estimate of mortality would therefore be 6/25, or 24%. Two of the dead females had already spawned; if these are excluded from the mortalities (fish could be expected to die shortly after spawning) the minimum estimate of mortality becomes 4/25, or 16%. Male mortality was 6/25, or 24%. Seining from the beach-spawning areas was not difficult.

In the Tatsamenie system, consideration was also given to using Tatsamenie Lake (the outplant lake) as a source of broodstock. Fish used in the holding studies were obtained at an existing weir at Little Tatsamenie Lake and could have been destined for either lake; the little information available suggests the majority pass through Little Tatsamenie Lake and enter Tatsamenie Lake. Although it has not been demonstrated, there is a possibility of two genetically distinct populations, each adapted

to a particular environment. If this were true, broodstock collected from Tatsamenie Lake could conceivably perform better in the outplants. However, there is no weir at Tatsamenie Lake and the extra expense of operating a weir at this location (approximately \$30,000 to \$35,000 in the first year due to cost of construction materials and \$25,000 to \$30,000 in subsequent years) in addition to that already being operated at Little Tatsamenie Lake, which would still be needed for management purposes, is probably not justified. Capture of sufficient broodstock from spawning grounds in Tatsamenie Lake itself does not appear to be feasible and Little Tatsamenie is, therefore, recommended as the source of broodstock, at least until the existence of two distinct stocks has been demonstrated.

In summary, it appears feasible to capture and hold sufficient adults at each of the three donor sites, providing run strength is sufficient. For reference, Table 1 provides annual weir counts of sockeye salmon at Tahltan Lake on the Stikine River and Little Trapper and Little Tatsamenie lakes on the Taku River. Holding in net pens for two or more weeks will be necessary at Little Tatsamenie Lake, but good holding locations are available and attention can be given to reducing the holding mortality. At Little Trapper and Tahltan Lakes, broodstock will be seined from spawning areas and held for short periods prior to spawning, minimizing holding mortality.

If removal of 30% of the escapement for broodstock is accepted as the maximum permissible limit (Canadian policy), then run strength could prove limiting in some years, particularly at Tahltan and Little Tatsamenie Lakes, where marked fluctuations in escapement can occur (Table 1). Logistical constraints associated with weather conditions and the remoteness of the broodstock sites present significant risk factors. Egg-take and transport cost estimates should, therefore, reflect worst-case scenarios.

## 2.0 PATHOLOGICAL SCREENING

Pathological samples were collected from potential sockeye salmon broodstocks on the Taku and Stikine rivers. The samples were analyzed by Alaska's Fish Pathology Laboratory in Juneau for IHN virus and BKD. The analysis determined the prevalence (percentage occurrence) and titer (concentration) of the two pathogens. Results of the pathological sampling are summarized in Table 2.

The Tahltan Lake samples had a 90.0% prevalence of IHNV, with 52.0% of the positive samples having a sufficiently high concentration of the virus to be of concern. The Little Trapper Lake samples had 86.7% prevalence and 44.2% of the positive samples contained a high titer. Little Tatsamenie Lake samples

Table 1. Annual weir counts of sockeye salmon at Tahltan Lake on the Stikine River and Little Trapper and Little Tatsamenie Lakes on the Taku River.

Year	Tahltan	Little Trapper	Little Tatsamenie
1959	4,311		
1960	6,387		
1961	16,619		
1962	14,508		
1963	1,780		
1964	18,353		
1965	1,471 <sup>a</sup>		
1966	21,580		
1967	38,801		
1968	19,726		
1969	11,805		
1970	8,419		
1971	18,523		
1972	52,545		
1973	2,877		
1974	8,101		
1975	8,159		
1976	24,111		
1977	42,960		
1978	22,788		
1979	10,211		
1980	11,018		
1981	50,790		
1982	28,257		
1983	21,256	7,402	
1984	32,777	13,084	
1985	67,326	14,889	13,015
1986	20,280	13,820	11,368
1987	6,958	12,007	2,794
1988	2,523	10,629	2,063

<sup>a</sup>A land slide occurred, blocking the stream for a period.

Table 2. Prevalence and titer of BKD and IHNV among transboundary river sockeye salmon broodstocks sampled in 1988.

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Little Trapper Lake (Taku River)

Pathogen	prevalence	% prevalence	Titer *
IHNV	52/60	86.7%	44.2% (23/52) $\geq 10^4$ pfu
BKD	2/60	3.3%	(1 - 1+ ; 1 - 3+)

Little Tatsamenie Lake (Taku River)

Pathogen	prevalence	% prevalence	Titer *
IHNV	25/65	38.5%	16.0% (4/25) $\geq 10^4$ pfu
BKD	0/67	0.0%	

Tahltan Lake (Stikine River)

Pathogen	prevalence	% prevalence	Titer *
IHNV	54/60	90.0%	52.0% (28/54) $\geq 10^4$ pfu
BKD	28/60	47.0%	(14 - 1+ ; 8 - 2+ ; 4 - 3+ ; 2 - 5+)

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\* For IHNV the likelihood of vertical transmission (parent to offspring) greatly increases when the titer is greater than, or equal to,  $10^4$  pfu (plaque forming units). Positive IHNV samples containing a titer of less than  $10^4$  pfu are considered a minor pathological concern.

For BKD the higher the number (1+,2+,3+,etc) the more severe the case. BKD is a primary pathological concern for outplanting activities whenever a donor stock is introduced, or planted, into a system in which the indigenous stocks have no prevalence of BKD, or have a prevalence lower than that of the introduced stock.

had 38.5% prevalence and 16.0% of the positive samples contained a high titer.

The high prevalence and titer of IHN in the Tahltan and Little Trapper stocks does not preclude the culture and resultant planting of sockeye fry back into the system of origin, providing stringent sockeye culture protocol developed by the Fisheries Rehabilitation, Enhancement and Development (FRED) Division of the Alaska Department of Fish and Game (ADF&G) are followed to minimize the risk associated with the culturing of sockeye salmon containing IHN. The below average prevalence of IHN observed in the Little Tatsamenie samples suggests this would be an excellent broodstock for enhancement purposes.

The BKD prevalence for the Tahltan Lake samples was 47.0% (Table 2). Prevalences for the Little Trapper and Little Tatsamenie Lake samples were 3.3% and 0.0%, respectively. While the prevalence observed in the Tahltan Lake samples is very high, hatchery problems with BKD in Alaska usually occur only when intensive rearing exceeds one year, which would not apply to the proposed transboundary river projects.

The high prevalence of IHN and BKD in Tahltan sockeye salmon does raise questions on the advisability of planting fry from this source into systems with either no history of, or a lower prevalence of, IHN or BKD. Although devoid of anadromous species, Tuya Lake does contain resident populations of Arctic grayling, Dolly Varden (charr), and lake trout (charr), all of which have high recreational value. Longnose suckers are also present. There have been anecdotal reports of the presence of kokanee in Tuya Lake, but the hydroacoustic and trawl surveys in 1987 and 1988 have failed to substantiate this. It is not known if the resident species presently harbor either IHN or BKD. If they do, the introduction of Tahltan sockeye may be of little consequence; however, the impact might be difficult to assess. While BKD occurs in many fish species, including those indigenous to Tuya Lake, the effect of introducing this pathogen to a stock which may not presently harbor the disease is unknown. There is very little information available on the susceptibility of the indigenous species to IHN.

Tuya River and Stikine River fish populations residing downstream of the Tuya barrier will also have to be considered if enhancement activities are implemented in Tuya Lake. These include chinook and coho salmon, which have been considered for future transboundary river enhancement projects. Chinook salmon are susceptible to both IHN and BKD. Coho salmon are susceptible to BKD and possibly IHN. Introducing stocks carrying either pathogen into Tuya Lake may adversely impact the downstream stocks if they do not presently harbor the pathogens. Presently, no disease history exists from stocks below Tuya Lake.

### 3.0 LIMNOLOGICAL AND JUVENILE FISH POPULATION SURVEYS

Canada conducted a limnological and juvenile fish population survey of Tuya Lake, the prime enhancement candidate lake on the Stikine River. The methodology and timing of this survey were similar to those of a 1987 survey (T.T.C. 1988) and the information collected provides additional pre-enhancement baseline data, including information on annual variability. Observations included temperature profiles, water chemistry (Phosphorous and Total Dissolved Solids), Secchi depths, zooplankton density and composition, and hydroacoustic surveys combined with trawling to obtain fish population estimates. Large predator species were sampled by angling and gillnetting.

There were no obvious major differences between the 1987 and 1988 surveys in physical, chemical, or biological characters. Very few fish were detected in the hydroacoustic surveys and the only fish captured in trawls were a few pelagic sculpins. Predator species observed (none were observed in 1987) included Dolly Varden (charr) and Arctic grayling; the latter appear to be quite numerous. Lake trout (charr), although reported in the literature (Lindsey 1957), were not observed, nor were Longnose suckers, which are also reported in the literature (Coombes and Grant, 1986). Kokanee were not observed in either year and anecdotal reports of this species remain unconfirmed.

Several additional projects involving some of the eleven lakes surveyed for enhancement potential in 1987 were also conducted and include:

- a) Sampling of smolts emigrating from those lakes found to contain juvenile anadromous sockeye in 1987 (all but Tuya, Trapper, and Kennicott). This was done to examine growth over the winter period following the surveys conducted in the fall of 1987.
- b) Monthly sampling of plankton in Tuya, Trapper, and Tatsamenie lakes (the three prime enhancement candidates) from July to September.
- c) Limnological and fish population surveys of Tahltan Lake and Kluksu Lake (Alsek River system) to observe conditions in a year when sockeye juvenile densities in both were lower than in 1987. It was also desired to examine Tahltan Lake in the first unfertilized year following several consecutive years of enrichment.

Analysis of the smolt sampling and limnological and fish population surveys is not complete; however, preliminary results corroborate conclusions on enhancement potential determined from the 1987 surveys.

Alaska conducted limnological and hydroacoustic surveys on Tatsamenie Lake to evaluate the rearing capacity for juvenile sockeye salmon. The scheduled frequency of sampling for the 1988 surveys was June, early August, October, and mid-November; however, the mid-November survey was cancelled in-route due to poor weather conditions. Work accomplished included:

- a) collecting, processing, and analyzing of water quality samples (e.g., nitrogen and phosphorous), as well as determining light, temperature, and dissolved oxygen (D.O.) profiles;
- b) assessing algal biomass (chlorophyll a) and zooplankton species composition and density; and
- c) enumeration of juvenile sockeye salmon.

Limnological surveys by Alaska were completed at either two or three mid-lake stations, depending on suitability of weather conditions. The water samples were processed (e.g., filtered), preserved, and sent to the Limnology Laboratory in Soldotna, Alaska, for analysis. Analysis of general water quality parameters from the 1988 surveys and from similar surveys conducted in 1987 have been completed; nutrient, chlorophyll a, and zooplankton analyses from the 1987 surveys have also been completed. With completion of analyses of the 1988 survey data, the lake will have been characterized on a seasonal basis covering the ice-off to ice-on period.

Access to Tatsamenie Lake is limited to float plane and helicopter. The hydroacoustic survey in 1987 was postponed until October because of adverse weather conditions. The 1988 hydroacoustic survey was also done in October and included a long night of tow netting. However, processing of the hydroacoustic data is not yet complete. The captured juvenile sockeye were robust and their stomachs are currently being analyzed. Processing of the nutrient, chlorophyll a, and zooplankton samples from the 1988 field season is nearly completed. Although a final report cannot be submitted at this time, the data in hand support the earlier conclusion that Tatsamenie Lake has strong enhancement potential.

#### 4.0 SURVEYS OF POTENTIAL SPAWNING AREAS IN OUTPLANT CANDIDATE LAKES

Preliminary surveys of Tatsamenie Lake were conducted by Canada during the period September 24 to October 17, 1988. Sockeye were observed spawning at depths of 5-7 m in three locations and carcasses were located in two additional areas. All of the spawning sites were associated with gravel fans located at the mouths of tributary creeks. Many of these creeks have no surface flow and enter by subterranean upwelling in the gravel fan. This

was evidenced by benthic temperatures of 0.5 C to 1.5 C in these areas, compared to a lake water temperature (isothermal) of 6.0 C. Previous investigators have observed sockeye spawning in gravel lined crater-like depressions in the lake bottom. These are presumed to be upwelling areas which have repelled the deposition of sediment. Due to limited visibility and the extreme depth of Tatsamenie Lake, a more systematic approach is required to quantify spawning habitat. This should possibly involve the use of divers and hydroacoustics.

The margin of Tuya Lake and one significant inlet stream located on the S.E. side of the lake were examined in a cursory fashion during the limnological survey. Several areas located along the lake margin have gravel substrate which may be suitable for spawning. The substrate in the short portion (200 m) of the inlet stream examined appeared to be unsuitable for spawning, although the gravel fan at its mouth may provide some spawning area. A 1986 survey, conducted by the Province of British Columbia, indicated limited spawning habitat in several other inlet streams and in Tuya River, the outlet stream (Coombes and Grant, 1986).

Trapper Lake was not examined in 1988. However, observations made during the 1987 limnological survey and anecdotal information suggest suitable spawning habitat occurs in at least one of the two major inlet streams, as well as in the outlet stream.

Tuya Lake and Trapper Lake are currently inaccessible to anadromous sockeye and the availability of spawning habitat is not an issue unless barrier removal or adult transfer are considered as enhancement options. The survey of Tatsamenie Lake suggests spawning habitat may be sufficient to support enhanced runs, but further study is required. A more important consideration may be the amount of spawning area available in Little Trapper Lake and its associated streams. Adults returning from outplants to Trapper Lake will utilize the same spawning grounds as natural stocks returning to Little Trapper Lake, unless access to Trapper Lake is provided through barrier removal. If Trapper Lake remains inaccessible, enhanced returns will result in increased spawning densities in Little Trapper Lake. Therefore, spawning capacity limits should be assessed and spawning populations regulated, perhaps through a terminal fishery at the weir if necessary.

It is also important to note that progeny of naturally spawning hatchery-origin adults would rear as juveniles in Little Trapper Lake. When surveyed in 1987, the rearing capacity of Little Trapper Lake was considered to be fully utilized by a juvenile population resulting from an average escapement of 11,000 adults. Both nutrient and plankton levels were low and this lake was identified as a possible candidate for lake fertilization. If

the combined population of wild plus enhanced juveniles overutilize the rearing capacity of the lake, then fish productivity may decline. The possibility of fertilizing Little Trapper should be given further consideration. This would serve to increase production of the wild stock as well as offer protection against the possible harmful effects of high returns resulting from the outplants into Trapper Lake.

## 5.0 DEVELOPMENT AND CONSTRUCTION OF THE PORT SNETTISHAM CENTRAL INCUBATION FACILITY (CIF)

The FRED Division of the Alaska Department of Fish and Game (ADF&G) completed Phase I construction of a CIF at Port Snettisham in September, 1988. Plans are in progress to complete the Phase II construction by 1990, one year later than originally scheduled. ADF&G is working closely with the Alaska Department of Transportation and Public Facilities (ADOT/PF) to secure the necessary authority to "force account" construct Phase II of the CIF. The latest series of meetings between ADF&G and ADOT/PF were positive and every indication is that the construction will be completed in 1990, though considerable work remains.

The Phase I CIF is an interim facility with a capacity of 10.8 million eggs. Physically, the interim CIF consists of two isolation modules having a capacity of 3.0 million eggs each and two isolation modules with a capacity of 2.4 million eggs each. Technically, it is recommended that a maximum of four stocks be incubated because of isolation measures required for the culture of sockeye salmon. The Phase II CIF will replace the Phase I facility and will have a total capacity of 25 million eggs consisting of five isolation modules, each capable of incubating 5 million eggs. There will be four production modules and one rehabilitation module. Each production module will be capable of incubating eggs from one stock, while the rehabilitation module will be designed with the flexibility to incubate eggs from multiple stocks. The possibility of expanding the Snettisham CIF to a capacity of 40 million eggs (eight modules of 5 million eggs each) is being considered.

Operational design of the Port Snettisham CIF includes mechanical refrigeration of the process water to retard the rate of development of the incubating sockeye in order to coincide fry emergence with ice departure from the target lakes, as well as water heating units to thermally induce bands on the otoliths of the enhancement fish as a means of mass-marking. Success of the proposed joint enhancement projects is dependent upon these two operational strategies. Tests of otolith marking at Port Snettisham using 1988 brood sockeye from Speel Lake in Southeast Alaska have been successful, as discussed below in section B 1.1. Low temperature incubation to delay emergence also appears successful, although this cannot be stated conclusively until fry actually emerge in mid-June.

Mechanically, the Phase I CIF was limited to 1.8 million eggs in 1988. Sufficient mechanical systems will be in place by 1989 to incubate 10.8 million eggs.

The allocation of space within the CIF is an ADF&G policy decision and beyond the purview of the Enhancement Subcommittee. Commitments for space within the Phase I CIF were made for Alaskan sockeye salmon enhancement projects prior to the Northern Panel recommending joint enhancement projects on the transboundary rivers. Unallocated space does exist for 3.0 million eggs for joint transboundary river enhancement in 1989. There is also some possibility additional space may become available. Technically, it is recommended that one stock be used within the available sub-module. The space constraint for joint sockeye enhancement on the transboundary rivers should only be a limiting factor in 1989 and will be removed once the Phase II construction of the CIF is complete in 1990.

## PART B. DETAILED ANALYSES OF THE PROPOSED ENHANCEMENT PROJECTS

### 1.0 PROCEDURES FOR EVALUATION

Stock productivity should be monitored for both the freshwater and marine stages, as this information is necessary to properly evaluate the success of the outplants and identify problems that may be encountered. A practical method of marking the outplanted fry is essential for each stage of evaluation. Performance of outplanted fish in freshwater would require hydroacoustic and trawl sampling in lakes. This would provide estimates of population size, growth, and survival, as well as information on premature outmigration. Migrating smolts should be sampled to determine total freshwater growth, age composition, and wild to enhanced ratios. Limnological surveys should be conducted two (minimal) to five (optimal) times annually to monitor changes in lake productivity. Additional evaluation information required would include survival to the adult stage through enumeration and sampling of both the fishery and escapement.

#### 1.1 Otolith Thermal Mass-Marking Technique

A practical means of mass-marking fry prior to outplanting would provide a mechanism for distinguishing outplanted from wild fish and would be essential for evaluation and management of the proposed enhancement projects. We recommend thermal banding of otoliths. This is a mass-mark that is induced during incubation at the hatchery. The technique is described in more detail below; the rationale and the decision making process that led to the selection of the otolith thermal mark is discussed in Appendix 4.

Otoliths are small bony structures located in the inner ear. As with scales, calcium is deposited in layers as the fish grows, resulting in the daily formation of circuli (Wilson and Larkin 1980.). The otoliths are fairly easily extracted and when cross-sectioned, spacing of the circuli can be used to determine the age and growth patterns of the fish. Otoliths begin developing well before hatching and daily circuli formation is extremely sensitive to temperature. Thus, by varying water temperature during incubation, a specific "pattern" of circuli can be induced, which serves as a permanent mark. Testing of the otolith-marking technique at Port Snettisham CIF, utilizing 1988 brood Speel Lake sockeye, was successful. All banding codes were recognizable through the egg and alevin stages and it is presumed, but not definitely known, that the marks will be identifiable in adults. In support of this, induced otolith marks have been detected in returning coho jacks in Washington State studies (Eric C. Volk, Washington Department of Fisheries, personal communication). Returns of otolith marked chinook, coho, and chum adults from these studies are expected in the fall of 1989.

Processing of samples to detect otolith marked fish would require hiring lab personnel, purchasing equipment, and examining baseline data on wild stocks.

## 1.2 Evaluation at the Juvenile Stage

Sections 1.2.1 to 1.2.4 describe proposed hydroacoustic and trawl surveys and limnological studies. The two study areas are closely related. The U.S. and Canadian sides differ in their approaches to this work and proposals from both sides are presented. Cost estimates for each are discussed in section B 4.3. The agreement reached in Portland, Oregon in February, 1989 (Appendix 2) states Canada will pay for and carry out its proposal for the Tahltan project, which is to begin in 1989. Section 1.2.5 describes a joint proposal for assessment of smolt production.

### *Canadian Proposals, Hydroacoustic/Trawl Surveys and Limnology:*

The Canadian proposals are designed to assess:

1. short term survival of fry immediately after outplanting;
2. extent of migration of outplanted fry from upper outplant lakes into lower lakes which may be fully utilized by wild stocks; and
3. optimal fry-stocking density by monitoring long term survival and growth of fry and changes in the zooplankton community.

### 1.2.1 Hydroacoustic and Trawl Surveys (Canadian)

Annual hydroacoustic and trawl surveys are proposed for spring (late June) and fall (late September). The timing of the spring surveys would be approximately one month after fry outplanting had occurred. This would allow for dispersion of fry offshore where they would be detectable to the sonar equipment. Some beach seining, or side-scanning hydroacoustic surveys, should be conducted to confirm that this had occurred. The spring surveys would provide baseline size and population estimates; growth and survival over the summer would be calculated using these and similar estimates obtained in the fall. The fall surveys would occur at the end of the period of rapid summer growth, but before deteriorating weather conditions created access problems. Timing of the late survey is crucial to enable an accurate determination of seasonal fry growth. The fall population estimates would also provide a good estimate of smolt production the following spring, since overwinter mortality is generally low. Sampling of smolts is discussed fully in section B 1.2.5.

The Tatsamenie and Trapper Lake systems (Figure 1) both contain large upper lakes, to which the outplants will be made, and smaller lower lakes. The two lakes in each system are connected by short streams. Hydroacoustic surveys are proposed for the upper and lower lakes in both systems. Anadromous sockeye utilize both lakes in the Tatsamenie system. In the Trapper system anadromous sockeye apparently utilize the lower lake only, due to falls located in the connecting stream. However, it is possible these falls may not be completely impassable, since low numbers of juvenile sockeye are present in the upper lake (it is not possible to say whether these are progeny of anadromous sockeye or of kokanee, the non-anadromous form). Trawl surveys of the lower lakes would provide a measure of the extent of possible migration of outplanted fry from the upper lakes to the lower lakes prior to smolt migration, since outplanted fish taken in trawls would be distinguishable from wild fish by presence of the otolith mark. This information on outmigration is essential since success of the outplants depends upon the introduced fry exploiting the underutilized food supply in the upper outplant lakes. The migration of outplanted juveniles could also have detrimental effects on wild stocks in the lower lakes as a result of competition for both food and space. This is especially true in the Trapper system, since the rearing capacity of Little Trapper Lake appears to be fully utilized at present. If fry were found to outmigrate from the upper lakes into the lower lakes it may be advisable to investigate whether they leave the lower lakes as well and displace wild sockeye juveniles

rearing in riverine habitat in the lower Taku River, which currently supports significant wild production.

Spring and fall hydroacoustic and trawl surveys would be conducted on Tuya Lake also. Since the Tuya River drains directly into the Stikine, outmigration prior to the smolt stage would have to be estimated by some other method; however, this is not being proposed at present. Limnological and hydroacoustic effort would be transferred from Tuya Lake to Tahltan Lake if fry from egg-takes at Tahltan Lake are planted back into Tahltan rather than outplanted into Tuya Lake.

#### 1.2.2 Limnology (Canadian)

Chemical observations would include measurements of total phosphorous, total dissolved solids (TDS), and chlorophyll a. Samples would be taken at two to three sites in each lake from near the surface and at depth (above and below the thermocline in stratified systems). These samples would provide a good measure of lake productivity, do not require immediate processing or special storage techniques, and are relatively inexpensive to analyze. Physical characters measured would include Secchi depth and water temperature profiles at each sampling site.

Zooplankton samples would also be collected at each sampling site in conjunction with the water sampling. Zooplankton biomass, size, and species composition are the best indicators of the extent to which the carrying capacity of a lake is being utilized. Changes in this forage base would be monitored to assess the impact of the fry outplants and to determine optimal fry stocking density.

Two sampling plans are proposed:

Plan a) At a minimum, sampling should be conducted in conjunction with the spring and fall hydroacoustic surveys in Tuya Lake (or Tahltan Lake) and in both the upper and lower lakes in the Trapper and Tatsamenie systems. Cost of sampling would be minimal since no extra aircraft costs would be incurred.

Plan b) For the outplant lakes only, three additional samples would be taken; one at the time of fry outplanting (late May) and two at points intermediate to the hydroacoustic surveys (July and August). This would incur additional expenses but would provide better and more reliable information, especially on seasonal changes.

The recommendation is to follow plan b); however, it is questionable whether sampling at this level would be

necessary on a continued basis. The possibility of operating at the plan b) level initially (for a period of approximately 4 years) then reducing effort to that of plan a) is a consideration.

*U.S. Proposals, Hydroacoustic/Trawl Surveys and Limnology:*

1.2.3 Hydroacoustic and Trawl Surveys (U.S.)

Numbers of juvenile sockeye rearing in the lakes would be determined using hydroacoustic counts accompanied by tow-netting to estimate both species composition of targets and wild to enhanced ratios of sockeye juveniles (using the otolith mark to identify outplanted fish). Surveys would be conducted in the spring (post-smolting, but pre-outplant, dependent on the timing of lake ice-out relative to outplanting time) to estimate natural production, in mid-to-late October to estimate fall populations, and in the subsequent spring (pre-smolting) to estimate numbers of emigrating smolts. Estimates of freshwater survival and growth of both wild and enhanced fish would be made using these population estimates and size measurements of the juveniles captured by tow-net. Stomachs of the captured juveniles would be examined to determine food items relative to the forage base of the lake.

The hydroacoustic surveys would be conducted only on lakes actually receiving fry outplants; the objective would vary based upon the presence or absence of natural fry. The surveys would be done at specific periods and hopefully provide the following:

1. May - This survey would provide an estimate of the pre-smolt population prior to smolting (not required in the initial year of planting in lakes not accessible to anadromous fish).
2. July - This survey would provide an estimate of age-1 fish that held over, age-0 fish which entered the lake in May and June, and the number of planted fry. Combining data from the May and July surveys would determine the number and age composition of smolts that left the lake.
3. Late October - This survey (combined with data from the above surveys) would provide survival and growth rates of age-0 and age-1 fish over the major portion of the growing season and could serve as an estimate of the number of smolts the next spring if survey number 1 is not accomplished.

Note that a tow-net survey would be conducted with each hydroacoustic survey. This would provide a sample from which age composition, size, and species composition (to apportion the hydroacoustic estimate of numbers) could be determined. The stomachs of captured juveniles would be excised and the contents preserved for diet analysis.

#### 1.2.4 Limnology (U.S.)

Limnological surveys would accompany the three hydroacoustic surveys and would also be conducted once (minimal) or twice (preferred) between the second and third hydroacoustic surveys. At least two stations per lake would be included (possibly three at Tatsamenie Lake because of its large size) with the sampling of zooplankton being a priority. Changes in zooplankton species composition and body-sizes would be used to gauge the impact of sockeye predation. In addition, changes in the density of specific zooplankters would accompany increased numbers of outplanted juveniles and would be compared to changes in smolt characteristics to assess cause and effect. With such information (fish + zooplankton), it would be possible to determine for future projects juvenile densities appropriate for specific zooplankton populations to attain production of an optimal size 80-90 mm smolt.

Since a large part of the cost of sampling would be incurred in getting people to the lakes to do the hydroacoustic surveys, we propose taking detailed limnological data as well. This would include the zooplankton work plus light profiles with an underwater photometer, temperature profiles, and 8-10 liter water samples. The bulk water samples would be used to determine a complete nutrient profile including chlorophyll a levels. This would be necessary to isolate the effects of rearing sockeye predation pressure on zooplankton populations from environmental changes. The sampling protocol would follow that used to survey lakes for enrichment potential. This would serve only to insure a uniform data base for all sockeye nursery lakes and is not intended to pre-stage an enrichment project.

### *Joint U.S./Canada Proposal for Assessment of Smolt Production:*

#### 1.2.5 Smolt Enumeration and Sampling

Assessment of smolt production would require estimates of numbers to determine freshwater survival and qualitative sampling of migrating smolts to determine size and age structure.

Methods considered for estimating numbers include complete fence counts, indexed trapping, mark recovery programs, and hydroacoustic lake surveys. The expense of total fence counts is probably not justifiable, except at Tahltan Lake, where there is already an ongoing annual smolt program. Also, fences may be physically impracticable in some locations because of stream size and spring water conditions, e.g. Little Trapper and possibly Tatsamenie lakes. With the exception of total fence counts, estimates of smolt production based on juvenile population estimates obtained in fall and spring hydroacoustic lake surveys (as described previously in Sections 1.2.1 and 1.2.3) are considered more accurate than those of other methods. It is therefore recommended that smolt numbers be estimated using data from the hydroacoustic lake surveys. At Tahltan Lake, fence counts could be used to validate the hydroacoustic technique.

Smolts would be sampled for size and age distribution at the lake outlets during the migration period. This would be done using fyke-nets and/or inclined plane traps. Sampling in the Trapper and Tatsamenie systems would have to be conducted in both the upper and lower lakes to determine the origin of the migrating smolts (as a check on migration over the winter), with effort concentrated on the lower lakes.

In the Trapper and Tatsamenie systems, smolt sampling is proposed for the early, mid, and late parts of the migration period. Each sampling trip would involve flying a crew into one of the systems where they would sample both lakes over a 3-day period; the crew would then be flown directly to the next system for another three day period.

For Tuya Lake, more intensive smolt sampling is proposed, at least for the first 3 years following the first fry outplant, for the following reasons: 1) it is not known when smolt migration may occur because of the absence of natural stocks to observe and 2) the outlet streams of the donor and recipient lakes are oriented in opposing directions and smolts may experience difficulty in finding the lake outlet. Although Alaskan experiences with analogous situations indicate this is not likely to be a concern, some Canadian experiences have shown such problems can occur. With intermittent sampling there is always a possibility of missing the migration period completely; if this were to occur at Tuya Lake it would be highly uncertain whether the run had been missed or whether the smolts had failed to migrate. It is therefore proposed that a temporary field camp be maintained at the lake outlet throughout the expected period of smolt migration (approximately four weeks). Daily sampling with inclined plane traps and/or fyke nets would be conducted and it may also be possible to

derive a population estimate with little additional effort. Preliminary observations indicate it may be relatively easy to install a simple, inexpensive weir at the outlet and this possibility should be further examined.

In the case of backplants of Tahltan fry into Tahltan Lake, smolts would be enumerated and sampled using the existing weir. Total counts would be obtained and could be used to validate the hydroacoustic techniques. As confidence in the hydroacoustic techniques increased, the need to operate the weir would diminish. Operational costs would be slightly higher during the validation process as both enumeration techniques would be conducted simultaneously.

Studies to assess the smolt production of the candidate lakes would be an expensive, but necessary, process. Recent successes in Alaskan sockeye enhancement programs are a result of well planned, carefully evaluated programs. Sockeye enhancement technology is not far enough along in its development to be applied to all sockeye enhancement projects, but we are getting close. The proposed transboundary river projects would serve to increase our knowledge on sockeye enhancement if carefully evaluated.

### 1.3 Evaluation at the Adult Stage

Separation of wild and enhanced adult returns would require sampling for otolith-marked fish, in both the fisheries and escapements. Estimates of numbers taken in the commercial fisheries (U.S. and Canadian) would be obtained in conjunction with sampling and catch estimates required for management purposes. Sampling of any Indian food fishery catches (such as that at Telegraph Creek on the Stikine) should also be conducted.

Enhanced sockeye returns to Tahltan Lake could be assessed at the existing weir. There currently is no way of accurately assessing the adult return to the Tuya system. There would, however, be harvest rate information available from the lower Stikine commercial and test fisheries and additional information could become available if a terminal fishery was undertaken in the vicinity of the Tuya blockage.

Enhanced sockeye returns to the Trapper Lake system could be monitored at the existing Little Trapper Lake weir through an expanded sampling program that would include the collection and examination of otolith samples.

Enhanced sockeye returns to the Tatsamenie Lake system could be monitored at the existing weir at Little Tatsamenie Lake (the lower lake) through an expanded sampling program which would include the collection and examination of both scale and otolith samples. Adult counts made at this weir would include enhanced

stocks bound for Tatsamenie Lake (the upper, outplant lake) as well as natural stocks bound for both Tatsamenie Lake and the stream connecting Tatsamenie and Little Tatsamenie lakes. If it is important to closely examine the escapement to Tatsamenie Lake, it would be necessary to construct a weir at the outlet. This is not being recommended at this point. Cost of operation of such a weir is estimated to be \$30,000 to \$35,000 in the first year (due to expenditures for construction materials) and \$25,000 to \$30,000 in subsequent years.

## 2.0 FISHERIES MANAGEMENT REQUIREMENTS

### 2.1 U.S. Fisheries

Stikine River: Presuming that migratory timing of outplants to Tuya Lake, or backplants to Tahltan Lake from the parent Tahltan stock, would be preserved and that the number of returning adults would be about 100,000, the following management synopsis was developed.

To evaluate the strength of Alaskan sockeye stocks which would commingle with enhanced runs in District 106, a method of separating catches into stock of origin would be required. Evaluation of Alaskan run strength is necessary to assure conservation in years of poor returns. Evaluations would have to be made available to managers in season.

If harvest sharing of enhanced returns was based on percentages of production or numeric limits, a method of separating catches in Alaska's mixed stock fisheries would be required to monitor compliance.

Management of District 106 would be based on maintaining optimal yield from the mix of wild stocks present. Harvest rates of from 2 to 35 percent could be expected in District 106. The actual harvest rate each year would depend upon the strength of the wild runs. Targeting of enhanced sockeye returns in District 106 would probably not be possible. Extensive test fishing coupled with stock identification studies would be needed to verify this conclusion.

Targeting a mix of enhanced sockeye and wild Tahltan Lake sockeye in District 108 would be possible. However, exploitation rates of enhanced Tuya fish could not be increased beyond those appropriate for the Tahltan Lake wild stock unless this stock was also enhanced.

Targeting enhanced sockeye early in the season would likely increase catches of chinook salmon. However, it is presumed that by the time adults return this would not present a conservation problem. Targeting in District 108 during the

peak of the enhanced return would probably increase exploitation rates on local pink and chum salmon stocks. A conservation problem for these stocks may emerge. Steelhead stocks are unlikely to be affected because of their later run timing.

Taku: Enhancement of two stocks, Tatsamenie and Trapper, has been discussed. Management issues common to these sites are discussed first, then issues unique to each site are presented.

#### Common Issues.

To evaluate the strength of other Taku River sockeye stocks which would commingle with enhanced runs in District 111, a method of separating catches into stock of origin would be required. Evaluation of run strength for the wild stocks would be necessary to assure conservation in years of poor returns. Evaluations would have to be made available to managers in-season.

If harvest sharing of enhanced returns was based on percentages of production or numeric limits, a method of separating catches in Alaska's mixed stock fisheries would be required to monitor compliance.

Management of District 111 would be based on maintaining optimal yield from the mix of wild stocks present. In recent years, harvest rates for Taku sockeye in District 111 have ranged from 15 to 40 percent and have averaged about 30 percent. Harvest rates in this range could be expected in the foreseeable future, but the actual harvest rate each year would depend upon the strength of the wild runs.

Targeting of enhanced sockeye returns in District 111 would probably not be possible. Extensive test fishing coupled with stock identification studies would be needed to verify this conclusion.

#### Tatsamenie Lake Issues.

Targeting of enhanced sockeye returns in District 111 would probably not be possible because of overlap in run timing with wild stocks.

#### Trapper Lake Issues.

Limited targeting of enhanced sockeye returns in District 111 may be possible early in the season, based on run timing of the Little Trapper Lake donor stock.

However, opportunities could be restricted by the need to protect early migrating Kuthai Lake sockeye and early run coho, such as the Nahlin River stock. Steelhead are unlikely to be affected by a targeted early sockeye fishery because of their later run timing. Extensive test fishing, coupled with stock identification studies, would be needed to determine any targeting opportunities.

## 2.2 Canadian Fisheries

Enhanced stocks moving through the Canadian in-river fisheries would present potential mixed-stock fishery problems, since migration timing of enhanced fish would be similar to timing of natural returns of some sockeye stocks, as well as to returns of other species. This would tend to limit the extent to which enhanced sockeye could be taken in traditional fisheries. Harvest rate increases directed specifically at enhanced fish would have to be developed for Canada to obtain the full benefit from enhancement, unless greater than optimal exploitation of natural stocks was to be accepted.

In the Stikine River, Tahltan sockeye predominate early in the season and Tuya outplants would presumably have similar timing. The opportunity would therefore exist to selectively fish the enhanced returns in the lower river; however, enhancement of Tahltan stocks would likely be required also, to allow for increased exploitation of fish from that source. Increased harvest of chinook stocks could also be expected; this could be offset by enhancement of that species. Timing of steelhead is considerably later than that of Tahltan sockeye and harvest rates on this species would not be expected to change. Expansion of the existing Indian food fishery and/or the commercial fishery at Telegraph Creek would provide another opportunity to target on sockeye returns to Tahltan and Tuya Lakes, since this location is beyond the limit of migration for other sockeye stocks.

On the Taku River, there appears to be little opportunity for targeted fisheries in the lower river, since the run timing of both Little Trapper and Tatsamenie sockeye stocks overlap considerably with those of other stocks. Sockeye management would therefore continue to be based on maintaining production from wild stocks, with any surplus enhanced fish to be taken in terminal areas by weirs or other means (see discussion below). Because of this management approach, enhancement is expected to have no impact on harvest rates of other species, including steelhead.

The practicality of initiating terminal fisheries has not been properly explored. Fish could be harvested at the Little Trapper and Little Tatsamenie weirs located on the Taku system and at the Tahltan Lake weir on the Stikine system (if fry are backplanted

to that location instead of, or in conjunction with, outplants to Tuya Lake). There are no similar opportunities for fish returning to Tuya Lake and the possibility of a fishery in the vicinity of the Tuya River obstruction should be examined, since fish would presumably accumulate there. Quality and marketability of fish taken in close proximity to the spawning areas should be examined. Fish would probably be of canning and smoking quality, but the terminal areas are remote and cost of transport (aircraft in many cases) would be high. Aircraft transport to Atlin of sockeye taken in the Canadian fishery in the lower Taku River has proved economically viable. The distance being flown in that operation is similar to that from Little Tatsamenie or Little Trapper lake to Atlin and costs should therefore be similar; however, the quality of fish taken at these sites would presumably be poorer than that of fish taken in the lower river. A licensing or permit system which would allow participation in any new terminal fisheries should also be considered.

### 3.0 FEASIBILITY OF THE PROPOSED PROJECTS AND LIKELIHOOD OF SUCCESS

The proposed enhancement activities appear to be technically feasible based on results of studies to date and should have a high likelihood of success. Tests of the otolith marking technique at the Port Snettisham CIF have been successful. Incubation at low temperature to delay emergence also appears to be successful; this will be confirmed when fry emerge in mid-June. It should be noted that although thermal banding of otoliths in the fry has been demonstrated, it must still be assumed that the mark will remain detectable at the adult stage. This assumption will be proved or disproved in the fall of 1989, when the first adult returns of marked chinook, coho, and chum salmon from a Washington State study are expected (Eric C. Volk, Washington Dept. of Fisheries, personal communication). Based upon results of research to date and examination of natural banding on adult otoliths, it appears extremely unlikely the mark would not be visible in the adults; the Subcommittee therefore recommends acceptance of the otolith thermal banding technique.

Although it is improbable, if delay of emergence proves unsuccessful an alternative strategy will have to be identified prior to implementation of the projects. This could effect benefit/cost analyses, delay implementation, or alter decisions regarding the feasibility or utility of the projects.

Another important issue affecting feasibility is that of introducing Tahltan Lake sockeye, with high prevalences of IHNV and BKD, into Tuya Lake, which may presently be free of these diseases. A disease survey should be done on resident Tuya Lake fish stocks. The outcome of this survey may affect the decision of whether to proceed with the Tuya outplants. Additionally,

both countries have fish health regulations controlling the import and export of live fish and eggs and approvals must be obtained from the appropriate authorities before proceeding with any of the proposed projects. Applications have been submitted and were being processed at the time of preparation of this report.

Transporting fry from the Port Snettisham CIF at sea level to the target lakes, at elevations of approximately 700 meters, could cause gas pressure problems in the fish, similar to those of a SCUBA diver who decompresses too quickly. The consensus of experience and research suggests this is not likely to be a problem, but there is no first-hand experience with this specific scenario. Studies are being conducted this spring to test the susceptibility of emergent sockeye fry to the expected gas pressure changes. Methods could be developed to prevent gas pressure problems (if they are found to occur), but would complicate the transportation process considerably.

Other issues relating to the feasibility and likelihood of success of the projects, but of less immediate importance or less technical in nature, are discussed in Section B 5.0.

#### 4.0 RECOMMENDED SCHEDULE FOR IMPLEMENTATION, PRODUCTION FORECASTS, AND BENEFIT/COST ANALYSIS

##### 4.1 Schedule for Implementation

The following schedule assumes success of the incubation technique currently being tested at Port Snettisham Hatchery and approvals from fish health regulatory bodies in both countries. It is based upon the Portland, February 1989 Understanding (Appendix 2) in which the parties agreed to restrict 1989 enhancement activities to an egg-take at Tahltan Lake, largely due to space constraints in the Port Snettisham Hatchery. Up to 3 million eggs would be taken. If the escapement through the Tahltan weir is less than 15,000 sockeye in 1989, all fry are to be backplanted to Tahltan Lake; if this escapement figure is exceeded fry would be distributed between Tahltan and Tuya lakes in a manner to be agreed upon. There is a provision in the Understanding that, if additional space becomes available in the Port Snettisham Hatchery in 1989, up to 3 million more eggs would be taken from Tahltan Lake and, if considered practical, up to 2.4 million eggs from the Taku River system (sufficient lead time and further funding would be required).

##### Tahltan/Tuya plants:

The predicted sockeye escapement to Tahltan Lake in 1989 is 16,200 fish, sufficient to permit the planned egg-take of 3 million (plus some additional if more space becomes available in Port Snettisham Hatchery). Given a successful

1989 brood operation, egg-takes may be scaled up to 6 million for subsequent years, stock strength permitting. Transplanting to Tuya Lake may not be feasible because of the high prevalence of BKD and IHNV; this is still under investigation. However, limnological data suggests Tahltan Lake is underutilized and could support large backplants of fry. Continued enhancement of Tahltan stocks in conjunction with Tuya Lake outplants (if the Tuya Lake project proceeds) would be desirable for management purposes - since adults from both systems would be expected to have similar run timing, it may be impossible to target on Tuya origin fish in the existing fisheries; simultaneous enhancement of the Tahltan Lake stock would help prevent overharvesting of Tahltan fish and would allow higher exploitation rates on both stocks.

#### Little Tatsamenie/Tatsamenie outplant:

Enhancement operations can begin when space and funding allocations are resolved. The start-up year of operations should have the production level egg-take target of 2.5 million and egg-takes would continue thereafter at this level (one-half of the desired production level total of 5 million for the Taku system), escapements permitting. Two recent years of poor escapements suggest that stock abundance may be limiting in some years. In the event of a low escapement, enhancement should still be considered to build up stock levels.

#### Little Trapper/Trapper outplant:

As above, operations can start when space and funding allocations are resolved. Enhancement operations would be scaled to the production level egg-take target of 2.5 million (one half of the desired production level total of 5 million for the Taku system) and continued at that level. Strong (10,000+) escapements since 1984 suggest that spawner abundance will not limit broodstock availability for this egg-take target.

### 4.2 Production Forecasts

Adult production, with and without enhancement, was forecasted from 1989 to 2008. The twenty-year time frame used is appropriate for assessing a permanent installation such as the Port Snettisham CIF. Enhancement plans for 1989 had not been finalized at the time of preparation of this report; the Subcommittee therefore decided to prepare forecasts for all systems assuming an egg-take on each river system in 1989. The forecasts for the Little Tatsamenie/Tatsamenie and Little Trapper/Trapper systems assume egg-takes of 2.5 million at both Little Trapper and Little Tatsamenie lakes in 1989. This is the

production level target (a total of 5 million eggs for the Taku system) and is used throughout the forecasts. Tahltan/Tuya system forecasts are based on an egg-take of 2.5 million at Tahltan Lake in 1989 (one-half of the production level target of 5 million eggs for the Stikine) with an increase to 5 million eggs in subsequent years. Incremental harvests, by lake system, are summarized in Table 3; detailed forecasts are presented in Appendices 5 to 10.

The production forecasts for enhanced fish were based on standard Alaskan survival expectations. Production from the naturally spawning fish was estimated by lowering the egg-to-fry survival rate to give realistic observed wild stock return rates.

The forecasts assume unharvested adults of hatchery origin will spawn along with wild fish and thus contribute to natural production. Limits on natural production were estimated from observed return data and used to constrain the estimates of natural production. Estimates of added natural production resulting from the enhancement activities were not made for Tuya Lake, which is inaccessible to returning adults. Adult returns from the Trapper Lake outplants are assumed to spawn in Little Trapper Lake due to the presence of a barrier in the interconnecting stream.

In most cases the factors that limit natural production are not obvious, and their nature may, or may not, affect the success of an enhancement program. Systems with unutilized rearing capacity, such as Tuya or Trapper Lake, and systems that appear to have underutilized rearing capacity because of spawning area limitations, such as Tatsamenie Lake, are well suited to fry outplant strategies. The Little Trapper Lake stock, however, appears to be limited by lake productivity and may be a candidate for lake fertilization. The limiting factor for Tahltan Lake is unknown. These differences indicate the need for investigation of limiting factors, e.g. spawning and rearing habitat surveys, to attain the full potential of some systems.

It is important to note that the enhancement strategy for the Tahltan stock would be to backplant fry to Tahltan Lake, if the escapement to Tahltan Lake was less than that required to optimize natural production (estimated to be approximately 15,000 adults). Outplants to Tuya Lake or simultaneous plants to both Tuya and Tahltan lakes would be considered when this escapement goal was exceeded.

#### 4.3 Cost Estimates

Cost estimates were determined for the period 1989-1992 and projected for subsequent years to 2008. These estimates were calculated using the same schedule for implementation used for production forecasts in the previous section; i.e. for the Little

Table 3. Summary of incremental sockeye harvests resulting from enhancement of the Tahltan/Tuya, Tatsamenie and Trapper lake systems. Harvest rates are assumed to be constant at 45 percent and all egg-takes are assumed to begin in 1989; egg-take levels are given in the text.

BROOD YEAR	TAHLTAN/ TUYA	TATSAMENIE	TRAPPER	TOTAL
1989	0	0	0	0
1990	0	0	0	0
1991	0	0	0	0
1992	0	0	0	0
1993	2780	1778	3218	7776
1994	21593	17331	19591	58516
1995	41062	21217	21600	83879
1996	39157	20783	21600	81540
1997	39425	20034	21600	81059
1998	41571	21497	21600	84668
1999	37877	21631	21600	81108
2000	42093	21600	21600	85293
2001	38074	22383	21600	82057
2002	34423	25687	21600	81711
2003	37008	25478	21600	84086
2004	40651	22190	21600	84442
2005	42654	21600	21600	85854
2006	38785	21600	21600	81985
2007	28219	21682	21600	71501
2008	31986	21949	21600	75536

Tatsamenie/Tatsamenie and Little Trapper/Trapper systems an egg-take of 2.5 million on each in 1989 and in all subsequent years; for the Tahltan/Tuya system an egg-take of 2.5 million in 1989 with an increase to 5 million in all subsequent years. Table 4 presents a summary of costs, by lake system, up to 1995; costs become constant after this date. All costs are in 1988 U.S. dollars.

Table 4. Summary of costs associated with the proposed transboundary river sockeye salmon enhancement projects. Cost projections are in 1988 \$US (thousands) and are constant after 1995. All projects are assumed to begin in 1989; egg-take levels are given in the text.

BROOD YEAR	TAHLTAN	TATSAMENIE	TRAPPER	TOTAL
1989	100.5	116.5	80.7	297.7
1990	156.8	115.8	106.9	379.4
1991	269.2	169.0	160.1	598.3
1992	212.7	142.7	133.8	489.2
1993	232.1	153.0	144.1	529.2
1994	305.4	189.6	180.7	675.7
1995	287.8	180.9	172.0	640.7

Detailed costs are presented in Appendix 11. These are divided into three major categories: enhancement, management, and evaluation. Each of these is further divided into sub-categories. Enhancement costs include egg-take, egg-transport, incubation, fry transport, and disease sampling. Management costs consist mostly of the otolith mark assessment program. Evaluation costs include hydroacoustics and limnology, smolt sampling, growth and survival studies, and outmigrant studies. Costs for both the U.S. and the Canadian hydroacoustic and limnology proposals are given, as well as an average value used in benefit/cost analysis (Canadian costs are based on limnology plan b, as described in Section B 1.2.2). Although evaluation costs are high, these are considered by the Subcommittee to be the minimum required to properly monitor and evaluate the enhancement projects. Division of labor and cost sharing are not considered in this report.

#### 4.4 Benefit/Cost Analysis

A preliminary benefit/cost ratio of 1.56 to 1 was calculated, using the estimated harvest increments and cost projections, and a 10% discount rate. For reference, a benefit/cost ratio of 1.5, at a discount rate of 10%, is considered desirable by the CDFO Salmonid Enhancement Program (SEP). Benefit/cost ratios using this and other discount rates are shown in Table 5. These estimates should be used with caution, however, for the following reasons:

1. Province-wide SEP standards for wholesale fish values and harvest costs were used because of a lack of specific information from the transboundary fisheries.
2. Canadian and U.S. methods of calculating benefit/cost ratios may vary. Only a cursory Canadian analysis has been done.

Further review by economists from both countries is warranted.

Table 5. Summary of benefit/cost analyses of the proposed transboundary river sockeye enhancement projects.

Discount Rate	Benefit/Cost Ratio
0%	2.11
5%	1.82
10%	1.56

#### 5.0 AREAS REQUIRING ACTION OR FURTHER STUDY

The Subcommittee has identified below a number of areas of concern. Some require immediate action since they affect planning and implementation of the projects. Others are of less importance, but should be addressed as soon as possible. The approximate costs associated with each item are given where applicable; these costs are not included in either the cost estimates or the benefit/cost analyses presented earlier in this report.

##### 5.1 Areas Requiring Immediate Action

###### 5.1.1 Mass-Marking and Delayed Development

The Subcommittee assumed that the mechanical refrigeration and heating units being tested at the Snettisham CIF would

serve their intended purpose (see section A 5.0). This assumption was correct in respect to the otolith thermal banding. However, the success of the delayed emergence technique has yet to be determined. If delay of emergence is not successful, the Northern Panel will have to provide direction on whether the enhancement projects should proceed or be postponed until a viable alternative strategy can be developed.

#### 5.1.2 Allocation of Space at the Snettisham CIF in 1989

Total incubation space in the Port Snettisham CIF is limited in 1989 because the Phase II construction is behind schedule. Sufficient space has been identified to incubate 3.0 million eggs for joint transboundary river enhancement, with the possibility of expansion to 8.4 million eggs if Alaska does not receive approval to proceed with a domestic project. It is imperative to receive timely notification of any possibility for expansion of 1989 transboundary river enhancement production beyond the 3.0 million egg level in order to allow for sufficient lead time to prepare for, and commit resources to, the activities associated with the expansion.

#### 5.1.3 Disease Profiles in the Tuya River System

The high prevalence of IHN and BKD in Tahltan sockeye raises questions on the advisability of outplanting sockeye fry from this source into Tuya Lake (see Section A 2.0). Tuya Lake contains resident populations of Arctic grayling, Dolly Varden (charr), and lake trout (charr) with potentially high recreational value. Longnose suckers are also present and there have been unconfirmed anecdotal reports of the presence of kokanee. Fish populations downstream of the Tuya barrier include chinook and coho salmon. It is not known if any of these populations presently harbor IHN or BKD. Disease surveys of all resident species should be conducted as a first step in deciding the advisability of the transplants. It is recommended that Tahltan origin chinook salmon be included in the surveys as well.

Estimated cost: \$ 5,000

#### 5.1.4 Consultation Concerning Introductions to Tuya Lake

A policy decision is required from Canada on whether sockeye enhancement will be permitted in Tuya Lake. This is in reference to internal jurisdictional matters involving the federal and provincial governments and Indian bands and the pathological concerns regarding the introduction of Tahltan sockeye into Tuya Lake.

#### 5.1.5 Transplant Committee Approvals

The transfer and introduction of eggs and fry associated with the enhancement should follow proper protocol procedures and be approved under each country's fish health regulations. Appropriate permits should be obtained from Alaskan and Canadian federal-provincial transplant committees, or other appropriate levels of authority, before proceeding.

Note: Permits for all projects have been applied for.

#### 5.1.6 Possible Gas Pressure Problems During Fry Transport

Fry will be incubated at sea level and flown at elevations in excess of 1,000 m to the outplant lakes. There is a possibility of transport mortality because of the formation of gas bubbles in the blood of the fish being transported, similar to that of the "bends", which SCUBA divers can experience. Because "gas bubble" disease is a possibility, tests are being done using 1988 brood sockeye fry. These tests will simulate the proposed fry transport schemes and should be completed in mid-June, 1989. Suitable methods must be developed for preventing gas pressure problems, if they are found to occur.

Estimated cost: \$ 1,000

#### 5.1.7 Formation of a Taku Enhancement Issue Work Group

As agreed to in the Portland, February 1989, Understanding (Appendix 2), a Working Group should be formed to examine issues surrounding harvest and cost sharing on the Taku River. Recommendations of this Working Group should be reported by December, 1989.

### 5.2 Areas For Further Study

#### 5.2.1 Additional Spawning Ground Surveys

More detailed information on the availability of spawning habitat in Tatsamenie, Tahltan, and Little Trapper Lakes is required. This information is of less concern in Tuya and Trapper Lakes, which are inaccessible to returning fish. The possibility of using divers should be considered.

Estimated cost: \$ 6,000

### 5.2.2 Productivity of Little Trapper Lake

As discussed in section A 4.0, Little Trapper Lake appears to be low in nutrients and zooplankton and additional fry production resulting from increased spawning escapements (a potential consequence of fry outplants to Trapper Lake) could conceivably overload the rearing capacity of Little Trapper. Fertilization of Little Trapper would help alleviate this problem and increase production of wild fish. Closer limnological examination of Little Trapper over a full spring-summer-fall period should be conducted, including measurement of nitrogen (not measured in the 1987 survey) and flushing rate, to examine more closely the potential for increased productivity through fertilization.

Estimated cost: \$ 25,000

Note: CDFO submitted a proposal to carry out this project in 1989 but did not receive funding.

### 5.2.3 Separation of Tatsamenie Lake and Little Tatsamenie Lake Wild Stocks.

As discussed in Section A 1.0, there is a possibility that sockeye in Tatsamenie and Little Tatsamenie lakes represent two distinct populations, each adapted to its particular environment. If true, it may be advantageous to ensure that only Tatsamenie Lake origin fish are used as broodstock. Adult scale samples taken at the Little Tatsamenie weir suggest that fish reared in the two lakes show differences in juvenile scale patterns; studies should be conducted to confirm this and to examine for genetic differences between the two types. If there are in fact two distinct populations, identifiable by scale characteristics, selection for Tatsamenie origin fish at the Little Tatsamenie weir could be considered.

Estimated cost: \$ 3,000

### 5.2.4 Terminal Fisheries and Marketability of Adult Fish

This report assumes the enhanced fish will be harvested only in existing fisheries. Terminal harvests may improve the benefit further. The feasibility of capturing and marketing sockeye in non-traditional areas after they have separated from other stocks should be investigated. Capture at the Tahltan, Little Tatsamenie and Little Trapper weirs is possible and a fishery near the Tuya obstruction should be investigated. However, fish quality and remoteness of the fishing areas will affect costs and benefits (this is discussed more fully in section B 2.2 of this report).

Prevalence of parasites, which might affect fish quality, should also be examined.

Estimated cost: \$ 10,000 (contract)

#### 5.2.5 Larger Egg-takes and Economy of Scale

Some costs are relatively independent of the scale of production and would remain fairly constant, even with substantial increases in production levels. Examples of such costs are the establishment and operation of field camps and evaluation and management expenses. Thus, increasing production (through larger egg-takes) is economically desirable, since the resulting increased benefits would be accompanied by improved benefit/cost ratios. The scale of operations, 5 million eggs from each river system, is sizeable for pilot operations, but increasing the production targets should be considered. In particular, the unutilized rearing capacity of Tuya Lake (euphotic volume limit = 764,000 adults) is a significant production opportunity. Increasing the production targets should be considered after operational experience is gained provided stock strength is sufficient to supply the required broodstock and if the returns indicate a successful program.

#### 5.2.6 Intensified Enhancement Studies on Tuya Lake

Tuya Lake is the "best" candidate identified for enhancement. If outplanting to this lake proceeds, the Subcommittee recommends intensified studies on this system over a period of several years. These should include increased juvenile outplants, if feasible. The purpose of these studies would be to determine to what extent zooplankters are reduced when the system is supporting sufficient juvenile growth to produce an optimal smolt size of 80-90 mm. This is crucial information for future enhancement work both on the Fraser system in Canada and on U.S. systems where sockeye outplants to fishless lakes are being conducted or considered. That is, how many fry are required, given a virgin zooplankton community, to produce an 80-90 mm smolt? If Tuya Lake proves to be as productive as is predicted, the planning considerations for hatchery capacities alone are staggering.

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ATTACHMENT 2

UNDERSTANDING BETWEEN  
THE UNITED STATES AND THE CANADIAN SECTIONS  
OF THE PACIFIC SALMON COMMISSION  
CONCERNING JOINT ENHANCEMENT OF  
TRANSBOUNDARY RIVER SALMON STOCKS

Recognizing the desire of the United States and Canada to embark upon a joint salmon enhancement program for the Transboundary Rivers that is carefully planned and coordinated:

I. The Parties agree:

- A. That for the period 1988 through 1992 the goal for enhancement activities on the Transboundary Rivers is to embark on a program designed to produce annually 100,000 returning sockeye salmon to the Taku River and to the Stikine River, for a total of 200,000 sockeye salmon per year;
- B. To develop strategies for management of the enhanced stocks prior to the return of adult fish;
- C. To determine harvest sharing arrangements for enhanced stocks prior to the time eggs are taken to initiate production level enhancement;
- D. That the target year to initiate the first production level egg takes of 5 million eggs per system for sockeye salmon on the Taku and Stikine Rivers is 1989;
- E. To develop an agreed process for conducting periodic review of implemented projects to identify and recommend action regarding, inter alia:
  - 1. Success or failure of a project in a given year or series of years,
  - 2. A distribution of benefits that is substantially different than expected,
  - 3. Costs which are substantially greater than expected;

- F. To recommend a plan for funding of projects including:
  - 1. Cost sharing arrangements between the Parties,
  - 2. Long term funding obligations,
  - 3. In carrying out joint enhancement projects, capital construction and on-site operating costs shall be borne by the country on whose soil project components are located.
- II. The Parties agree to establish an Enhancement Subcommittee of the Transboundary Rivers Technical Committee whose Terms of Reference shall be, inter alia, to:
  - A. Develop a preliminary summary of various projects which meet the enhancement goals established by the Northern Panel;
  - B. Develop detailed feasibility studies for projects selected by the Northern Panel, including:
    - 1. Estimation of costs and benefits,
    - 2. Likelihood of success,
    - 3. Schedules for implementation,
    - 4. Procedures for evaluation,
    - 5. A fisheries management plan for the enhanced stocks;
  - C. Monitor implementation of projects and report progress to the Northern Panel.
- III. In recognition of the Parties desire to embark upon a sockeye salmon enhancement program for the Stikine and Taku Rivers, the Parties agree to conduct the following activities in 1988:
  - A. The Enhancement Subcommittee shall:
    - 1. Determine the feasibility of obtaining sockeye salmon brood stock from Tatsamenie Lake, Little Trapper Lake and Tahltan Lake,
    - 2. Prepare a management cost analysis for enhancement activity that will be undertaken for Taku and Stikine River sockeye salmon.

B. The United States shall:

1. Conduct pathological screening of Tatsamenie Lake, Little Trapper Lake and Tahltan Lake sockeye salmon,
2. Develop fish culture profiles for Tatsamenie Lake, Little Trapper Lake and Tahltan Lake sockeye salmon.

C. Canada shall:

1. Conduct a detailed limnological survey of Tuya Lake,
2. Deliver about 20,000 eggs each from the Tahltan Lake, Little Trapper Lake and Tatsamenie Lake stocks of sockeye salmon to the central incubation facility at Port Snettisham in Alaska so that fish culture profiles can be developed,
3. Provide samples required to conduct pathological screening,
4. Assess the quantity and quality of sockeye salmon spawning habitat in the tributaries of Tatsamenie Lake, Upper Trapper Lake and Tuya Lake.

C. Wayne Shinnors  
Vice-Chair

S. Timothy Wapato  
Chair

ATTACHMENT 2

BILATERAL NORTHERN PANEL WORK-GROUP

UNDERSTANDING BETWEEN  
THE UNITED STATES AND THE CANADIAN SECTIONS OF THE  
PACIFIC SALMON COMMISSION  
CONCERNING JOINT ENHANCEMENT OF  
TRANSBOUNDARY RIVER SALMON STOCKS

In order to implement the understanding on joint enhancement dated February 19, 1988, the parties agree:

I. Project Selection

A. General Guidelines

1. If broodstock is not available to provide the agreed upon number of eggs, up to 30 percent of the available adults will be taken, provided that a minimum of 600, 000 eggs are available; if this minimum number is not available, no eggs will be taken.
2. A reasonable expectation that a stock identification technique will be available to estimate the contribution of enhanced sockeye in mixed stock fisheries is required in order for these projects to proceed. At present, thermal mass marking is being evaluated. The appropriate stock identification technique for each fishery will be determined by the Technical Committee.

B. Stikine River

The Tahltan Lake sockeye salmon stock will be used as the source for eggs. In 1989, up to 3 million eggs will be taken. In 1990, up to 6 million eggs will be taken. Eggs will be incubated at the Port Snettisham central incubation facility (CIF). Fry will be planted into Tahltan and Tuya lakes in the following manner, subject to review by the Transboundary Technical Committee:

1. When the sockeye escapement through the Tahltan Lake weir is less than 15,000 fish, all fry will be returned to Tahltan Lake;
2. When the sockeye escapement through the Tahltan Lake weir is greater than 15,000, the fry will be distributed to Tahltan and Tuya lakes in a manner which maximizes harvestable production and provides information on the potential production capacity of Tuya Lake.

C. Taku River

The Parties agree to establish an Ad Hoc Transboundary Enhancement Work Group to examine issues surrounding harvest and cost sharing on the Taku River. The Work Group will report its recommendations to the Northern Panel no later than December 1989.

Both Upper Trapper and Tatsamenie Lakes present good sockeye enhancement opportunities. Up to 6.0 million eggs will be taken in 1990 from Little Trapper Lake and/or Little Tatsamenie Lake. The selection of the appropriate stock will be determined by the Technical Committee.

II. Harvest and Cost Sharing

The Parties desire to maximize the harvest of Tahltan/Tuya sockeye salmon in their existing fisheries while considering the conservation needs of wild salmon runs. The Parties agree to manage the returns of Stikine River sockeye to ensure that each country obtains equal catches in their existing fisheries beginning in 1993. In 1993, 1994, and 1995, Canada may also utilize any fish surplus to escapement and broodstock requirements. In 1996, the Parties shall review this sharing arrangement.

The costs of producing these enhanced fish shall be shared as follows:

To be paid by Canada:

1. Egg take;
2. Egg transport;
3. Smolt sampling;
4. Sampling and analysis necessary to determine the contribution of enhanced transboundary river sockeye salmon to Canadian fisheries.
5. Limnology sampling and hydroacoustics.

To be paid by the United States:

1. Construction and operation of that portion of the Port Snettisham central incubation facility that is dedicated to enhancement projects on the transboundary rivers;
2. Transport of fry to the enhancement site;
3. Sampling and analysis necessary to determine the contribution of enhanced transboundary river sockeye salmon to United States fisheries.

Projects to be conducted jointly:

1. Disease sampling and analysis.

III. If additional space becomes available at Port Snettisham CIF in 1989:

- A. Up to 3 million more eggs will be taken from Tahltan Lake.
- B. If considered practical by the Parties, up to 2.4 million eggs will be taken from the Taku River system. Cost sharing for 1989 will be as agreed for the Stikine. For 1990 and beyond, harvest and cost sharing for enhanced Taku River sockeye will be negotiated by March 1990.

APPENDIX 3.      Summary of 1988 proposed salmon enhancement field activities as agreed to by the Co-chairs of the Enhancement Subcommittee of the Transboundary Technical Committee, August 9, 1988.

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PROPOSED SOCKEYE ENHANCEMENT ACTIVITIES FOR THE  
TRANSBOUNDARY RIVERS IN 1988

Prepared by:

The Enhancement Subcommittee  
of the  
Transboundary Technical Committee

August 9, 1988

In accordance with the Understanding between the United States and Canadian Sections of the Pacific Salmon Commission Concerning Joint Enhancement of Transboundary River Salmon Stocks (Attachment 2 of the letters to government from the Pacific Salmon Commission, February 19th, 1988), the following field activities will be carried out in 1988:

Re: Item III.A.1. of the Understanding

Canada shall, for the purpose of determining the feasibility and logistics of obtaining sockeye salmon broodstock from Tatsamenie, Little Trapper, and Tahltan Lakes:

1. Capture small numbers of broodstock (40 - 100 adults) at the existing Tahltan, Little Trapper, and Little Tatsamenie weirs and hold them in net pens at production level densities to determine the success of holding to maturity.
2. Carry out seining and tangle-net operations in Tahltan Lake and the Trapper River to determine the feasibility of broodstock capture.

Re: Item III.C.1 of the Understanding

Canada shall survey Tuya Lake, the prime outplant candidate, to determine whether the conditions observed in a 1987 survey were typical. Observations will include hydroacoustic population estimates of juvenile sockeye, trawls, water temperatures and chemistry, and plankton sampling.

Re: Items III.C.2 and III.B.2 of the Understanding

After consideration by all members of the Transboundary Enhancement Sub-committee, Canada will not deliver sockeye eggs to the United States in 1988. The Snettisham facilities will instead be tested with local stocks, and the temperature control capabilities and intended fish culture procedures will obviate the need to develop preliminary fish culture profiles.

Re: Items III.C.3 and III.B.1 of the Understanding

Canada shall obtain samples required for pathological screening from adult sockeye at Tahltan, Little Trapper, and Tatsamenie Lakes and deliver them to the ADF&G laboratory at Juneau, Alaska. Approximate timing of delivery will be:

Tahltan stock: 2nd or 3rd week of September  
Trapper stock: 1st week of September  
Tatsamenie stock: 1st week of September

The United States shall conduct pathological screening of the provided samples for infectious Hematopoietic Necrosis virus (IHNV) and bacterial kidney disease (BKD), to provide a baseline disease history of the donor stocks. This information will be used to determine the risk factor associated with the transportation of the donor stocks and will be considered in selecting specific transboundary river enhancement activities. The results will be summarized and distributed.

Re: Item III.C.4 of the Understanding

Canada shall assess the quality and quantity of salmon spawning habitat in Tatsamenie Lake and its tributaries, providing funds and manpower prove sufficient. This is the only outplant candidate where spawning area is of immediate importance, the others being presently inaccessible to returning adults. Information on abundance and availability of broodstock from existing spawning grounds would also be obtained.

Bradley B. Sele  
United States Co-Chairman

R. Bruce Morley  
Canadian Co-Chairman

#### APPENDIX 4.      Selection of the otolith thermal marking technique.

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##### SELECTION OF THE OTOLITH THERMAL MARKING TECHNIQUE

The need to differentiate enhanced transboundary river sockeye from co-migrating non-enhanced stocks depends on management and enhancement evaluation requirements and objectives. Precise estimates of enhanced stock contributions require techniques with a high level of resolution. In general, there is a greater requirement for a high resolution technique in U.S. fisheries than in Canadian fisheries.

Several options for differentiating enhanced from non-enhanced stocks were considered. They were evaluated on the basis of practicality, likelihood of success, precision, and cost. If the objective is to very accurately identify stocks in various fisheries and minimize impacts on wild stocks, then the otolith marking technique appears to be the most promising. The following is a summary of comments on the various techniques examined.

##### TEMPERATURE INDUCED OTOLITH BANDING

We recommend otolith marking for several reasons:

1. Sufficient otolith-banding variations are available to allow identification of each of several stocks, e.g. Trapper, Tatsamenie, Tahltan, and Tuya.
2. We believe that methods can be developed to rapidly recover and decode sufficient numbers of otoliths to allow in-season management.
3. All fish are marked at once with no handling required.
4. It does not cause increased mortality as do many of the other methods.
5. It works well between the eyed egg and hatching stage - a time when both water demand and requirements for refrigeration or heating of water are lowest.
6. This marking technique preserves our current capability to separate wild stocks based upon scale pattern analysis.

Although we recommend the otolith-banding technique, we recognize that there are still some questions that are only partially answered. First, research on this marking technique is so recent

that fish marked by otolith banding and released as juveniles have not yet had time to return as adults. The first adult returns of marked chum, chinook, and coho salmon, from a Washington State study, are expected in the fall of 1989 (Eric C. Volk, WDF, personal communication); however, coho jacks which returned in 1988 did still show the mark.

Second, a rapid otolith recovery and processing method is still under development. Although we anticipate its completion by the time of returns of adults from the proposed enhancement projects, we could accomplish the recovery and reading using present, more expensive methods, if necessary. Third, we will use a temperature cycle in which the ambient water temperature will be raised to induce specific banding patterns. This differs from most studies in which the temperature was lowered; however, some researchers have demonstrated successful otolith marking using temperature increases.

We anticipate that up to three transboundary river stocks of sockeye salmon would be incubated at the Snettisham CIF, each requiring a distinct otolith mark. Both the number and the spacing of induced bands would be varied by utilizing different thermal cycles among the stocks. By inducing two patterns per stock, we intend to alleviate problems caused when otoliths are not sectioned properly in the recovery process.

Sampling in the fishery would be concentrated in areas of highest expected harvest. Because all enhanced fish would be marked, far fewer fish would have to be sampled to make reasonably accurate stock proportion estimates than if coded-wire tags or some other method involving the marking of only a proportion of the enhanced stock is used. This is a major advantage of mass-marking techniques. Results of these sampling programs would have to be made available to managers in-season. Budgets prepared so far include sampling of catches made in Districts 106, 108, and 111.

#### DISCUSSION OF OTHER MARKING OPTIONS, BY RIVER SYSTEM.

##### Taku River

Option I, Rely on scale patterns: Estimation of the catch by stock for Taku sockeye is currently made by scale pattern analysis. This technology permits separation of Alaska District 111 catches into six groups; Kuthai, Tatsamenie, Main-stem, Little Trapper, Crescent and Speel. Separation of Canadian in-river catches can also be made into individual Taku stocks (the first four). We believe it unlikely that fry out-plants into Upper Trapper and/or Tatsamenie would exhibit scale patterns sufficiently different from these groups to estimate contributions given the broad range of patterns already observed in the Taku. Likewise, we would probably not be able to differentiate

natural from enhanced sockeye production in Tatsamenie Lake. Thus it is unlikely that direct estimates of contribution of enhanced stocks could be made using scale patterns.

Option II, Genetic and/or parasite marking: We concluded that neither a genetic mark (unless selectively bred into the stocks) or parasite mark would permit direct estimation of enhanced production from fry out-plants to Tatsamenie or Trapper. While selectively breeding a genetic mark may be possible, costs would be very high and discarding a significant portion of the brood stock was considered unacceptable.

Option III, Coded micro-wire tagging: While coded micro-wire tagging may permit direct estimation of enhanced production, several problems were identified. First, it is very expensive to tag and recover enough fish to obtain precise estimates. Second, estimating tagged to untagged ratios in stocks where natural production occurs ( e.g. Tatsamenie Lake) presents unresolved technical difficulties. Third, the probable inability to differentiate untagged enhanced fish from wild fish by scale patterns would compromise our ability to provide estimates of the contribution of individual Taku River stocks to the catches.

Option IV, Fin-clipping: Sockeye fry at the time of outplanting would be very small. Experience has shown that fin-clips applied at this stage are virtually useless in identifying adults due to fin regeneration (J. McDonald, Canadian Dept. of Fish Oceans, Nanaimo, B. C., personal communication). One consideration would be to rear fry for several weeks to attain a size at which they could be more easily marked. This would result in better quality marks with less regeneration, although it would still remain a problem. However, the Snettisham hatchery does not have the facilities for rearing of sockeye fry and disease outbreaks would be a concern. The possibility of pen-rearing fry at the outplant sites to achieve larger size for marking was also considered, however, this would be expensive, contains many risks, and the cost of conducting large scale marking operations at these remote sites would be high. As with coded-wire tags, it would probably only be feasible to mark a portion of the fish, which increases the complexity of attaining adequate samples. Fin-clipping of migrating smolts is also a consideration, however, this would again be very expensive and in some systems (e.g. Tatsamenie) there would be difficulties separating enhanced from wild smolts at the time of marking. Other arguments against fin-clipping include its effect on survival and limitations on the number of available marks.

Option V. Other mass-marking techniques: Other promising mass-marking techniques considered include use of oxytetracycline or rare elements to "label" bone or other tissues. However, research on these techniques is less advanced than that on thermal banding of otoliths and recovery costs would again be high. A major problem with these techniques is that the marker substance is applied through the diet and fairly long term rearing of the fish is required; arguments against rearing were discussed under Option IV, above. Spray marking of juveniles using fluorescent grits is another method of mass-marking considered but there are many uncertainties regarding the technique at this time.

Option VI, No mark: No direct estimate of contribution of enhanced fish could be made without some mark. However, we could infer the contribution by: 1) assuming that harvest rates are the same for all stocks, 2) obtaining accurate counts of escapement at both Trapper and Tatsamenie and 3) assuming some fraction of the Tatsamenie escapement is of wild stock origin. Such inferences would be of uncertain accuracy and precision. In addition, introduction of enhanced fish could alter the baseline scale patterns of the groups for which estimates of stock contribution are currently made using scale analysis. Lack of a mark would probably not jeopardize our ability to provide estimates of Taku and Port Snettisham origin fish in the District 111 fishery but could jeopardize wild stock conservation.

#### Stikine River

Option I, Rely on scale patterns: Estimates of the catch of Stikine sockeye in Alaska's District 106 and 108 fisheries are also made using scale pattern analysis. In these districts, estimates are made for five groups; Tahltan, Non-Tahltan Stikine, Alaska Type I, Alaska Type II and Canadian Nass-Skeena. At the current target enhancement level, we believe that fry out-plants to Tuya Lake would probably grow rapidly and smolt at a large size. The scale patterns of these fish would likely be similar to those of the Tahltan, Nass and/or Skeena Rivers. If we could not differentiate Tahltan, Nass and/or Skeena fish, we would not be able to directly estimate the enhanced contribution in District 106. In District 108, where Stikine stocks predominate, the only potential problem would be in differentiating Tahltan and mainstem fish from Tuya. While this is less problematic, we have no way of predicting the accuracy and precision of estimates that we would be able to generate.

If fry were planted back into Tahltan Lake, the scale patterns of smolts would probably be within the range

observed in recent years. Thus, identification capabilities in District 106 and 108 would probably continue. However, direct estimation of the fraction of the total production which was attributable to enhancement activities versus natural spawning would probably not be possible.

Option II, Genetic or parasite marking: Analysis of gene frequency data could probably provide a basis for estimating the contribution of Tahltan Lake stock fish in District 106 and 108. However, this technology would not permit us to estimate the fraction that is enhanced versus wild. Also, the cost to provide genetic based estimates to managers is high. Estimates based on parasite prevalence do not appear to be possible.

Option III, Coded micro-wire tagging: Our conclusions regarding coded micro-wire tagging of enhanced production from the Stikine are essentially the same as for the Taku.

Option IV, Fin-clipping: The conclusions are the same as those for the Taku.

Option V, Other mass-marking techniques: The conclusions are the same as for the Taku.

Option VI, No mark: No direct estimates of enhanced production could be made without a mark. The highly mixed stock nature of the District 106 fishery and management based on CPUE makes the application of simplifying assumptions using historic harvest rates very risky to conservation of commingled stocks. While very crude estimates of contribution could be inferred from historic harvest rate data for the Tahltan stock, such inferences were considered too unreliable to monitor success of enhancement or to monitor harvest sharing. Application of terminal harvest rate estimates of the Tahltan stock could be used to infer contributions of Tuya out-plants in the District 108 and in-river fisheries. If fry were planted back into Tahltan Lake without a mark, we would be unable to estimate enhanced contribution to any fishery or to monitor the success of enhancement.

APPENDIX 5 : FORECAST OF ADULT SOCKEYE RETURNS TO TAHLTAN LAKE, WITHOUT ENHANCEMENT.

BROOD YEAR	SPAWN ESCAPE	ADULT RETURNS TO TAHLTAN LAKE (from wild spawners)																				TOTAL
		1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	
1983	21256	3396																				53055
1984	32777	22838	1843																		*	28800
1985	67326	10010	55510	4480																		70000
1986	20280		7238	40141	3240																	50619
1987	6958			2484	13772	1111																17367
1988	2536				905	5020	405															6330
1989	19934					7115	39457	3184														49756
1990	35525						10010	55510	4480													70000
1991	25908							9247	51279	4139												64665
1992	9854								3517	19505	1574											24597
1993	7285									2600	14420	1164										18184
1994	27430										9790	54293	4382									68465
1995	37368											10010	55510	4480								70000
1996	32602												10010	55510	4480							70000
1997	14434													5152	28570	2306						36028
1998	14181														5062	28069	2265					35396
1999	36007															10010	55510	4480				70000
2000	38446																10010	55510	4480			70000
2001	35828																	10010	55510	4480		70000
2002	20962																		7482	41490	3348	52320
2003	22212																			7928	43964	55440
2004	37282																				10010	70000

WILD RETURN 36244 64591 47105 17917 13246 49872 67941 59276 26244 25784 65467 69902 65142 38112 40385 67785 70000 67472 53898 57322

" HARVEST 16310 29066 21197 8063 5961 22443 30573 26674 11810 11603 29460 31456 29314 17150 18173 30503 31500 30362 24254 25795

ESCAPEMENT 19934 35525 25908 9854 7285 27430 37368 32602 14434 14181 36007 38446 35828 20962 22212 37282 38500 37110 29644 31527

AGE : 4 SUB 2's = 0.143  
5 SUB 2's = 0.770  
5 SUB 3's = 0.023  
6 SUB 2's = 0.002  
6 SUB 3's = 0.062

SURVIVAL : EGG-to-FRY (wild) = 0.08  
(enhanced) = 0.80  
FRY-to-SMOLT = 0.20  
SMOLT-to-ADULT = 0.12  
(enhanced egg-to-adult) = 0.019

SEX RATIO = 0.50  
FECUNDITY = 2600  
HARVEST RATE = 0.45  
RETURN RATE (wild) = 2.50 : 1  
(enhanced) = 24.96 : 1

TAHLTAN NATURAL PRODUCTION LIMIT = 70000 ADULTS  
(ESTIMATED FROM OBSERVED RETURNS)

\* 1984 BROOD RETURN ESTIMATED FROM KNOWN SMOLT PRODUCTION (240,000).

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\* 1984 BROOD RETURN ESTIMATED FROM KNOWN SMOLT PRODUCTION (240,000)  
\*\* ENHANCED FRY BACKPLANTED TO TAHITAN LAKE IF BROOD ESCAPEMENT IS LESS THAN 15,000 PIECES

APPENDIX 7 : FORECAST OF ADULT SOCKEYE RETURNS TO TATSAMENIE LAKE SYSTEM, WITHOUT ENHANCEMENT.

BROOD YEAR	SPAWN ESCAPE	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	TOTAL
* 1983	2000	624																				4915
* 1984	7000	12145	2185																			17203
1985	13015	5010	21180	3810																		30000
1986	11368		4666	19724	3548																	27938
1987	2794			1147	4848	872																6867
1988	1992				818	3456	622															4896
1989	9779					4013	16967	3052														24032
1990	15417						5010	21180	3810													30000
1991	13575							5010	21180	3810												30000
1992	5067								2080	8792	1582											12454
1993	4587									1883	7959	1432										11274
1994	12430										5010	21180	3810									30000
1995	16083											5010	21180	3810								30000
1996	14889												5010	21180	3810							30000
1997	7967													3270	13822	2487						19579
1998	8003														3285	13885	2498					19668
1999	15192															5010	21180	3810				30000
2000	16500																5010	21180	3810			30000
2001	15543																	5010	21180	3810		30000
2002	15543																		5010	21180	3810	30000
2003	11760																			4827	20404	28902
2004	15778																				5010	30000
WILD RETURN		17779	28031	24681	9214	8341	22599	29242	27070	14485	14551	27622	30000	28260	20917	21382	28688	30000	30000	29817	29224	
" HARVEST		8001	12614	11106	4146	3753	10170	13159	12182	6518	6548	12430	13500	12717	9413	9622	12910	13500	13500	13418	13151	
ESCAPEMENT		9779	15417	13575	5067	4587	12430	16083	14889	7967	8003	15192	16500	15543	11504	11760	15778	16500	16500	16399	16073	

BIOSTANDARD ASSUMPTIONS :

AGE : 4 SUB 1's = 0.068  
 4 SUB 2's = 0.099  
 5 SUB 2's = 0.699  
 5 SUB 3's = 0.007  
 6 SUB 3's = 0.127

SURVIVAL : EGG-to-FRY (wild) = 0.08  
 (enhanced) = 0.80  
 FRY-to-SMOLT = 0.20  
 SMOLT-to-ADULT = 0.12  
 (enhanced egg-to-adult) = 0.019

SEX RATIO = 0.50  
 FECUNDITY = 2560  
 HARVEST RATE = 0.45  
 RETURN RATE (wild) = 2.46 : 1  
 (enhanced) = 24.58 : 1

TATSAMENIE NATURAL PRODUCTION LIMIT = 30000 ADULTS  
 (ESTIMATED FROM OBSERVED RETURNS)  
 (SPAWNING GROUND LIMITED ? )

\* ESTIMATED SPAWNING ESCAPEMENTS

APPENDIX B : FORECAST OF ADULT SOCKEYE RETURNS TO TATSAMENIE LAKE SYSTEM, WITH ENHANCEMENT.

BROOD YEAR	SPAWN ESCAPE	1989	1990	1991	ADULT RETURNS TO TATSAMENIE LAKE SYSTEM, FROM NATURAL SPAWNING (includes progeny of hatchery origin adults)															TOTAL
* 1983	2000	624																		4915
* 1984	7000	12145	2185																	17203
1985	13015	5010	21180	3810																30000
1986	11368		4666	19724	3548															27938
1987	2794			1147	4848	872														6867
1988	1992				818	3456	622													4896
1989	7825					3212	13578	2442												19232
1990	13464						5010	21180	3810											30000
1991	11622							4770	20165	3627										28562
1992	3115								1278	5404	972									7654
1993	4808									1973	8341	1501								11815
1994	31660										5010	21180	3810							30000
1995	40063											5010	21180	3810						30000
1996	38336												5010	21180	3810					30000
1997	30499													5010	21180	3810				30000
1998	32325														5010	21180	3810			30000
1999	39677															5010	21180	3810		30000
2000	40947																5010	21180	3810	30000
2001	40947																	5010	21180	30000
2002	40947																		5010	30000
2003	40947																			30000
2004	40947																			30000

WILD RETURN 17779 28031 24681 9214 7540 19210 28392 25253 11004 14323 27691 30000 30000 30000 30000 30000 30000 30000 30000 30000

EGGTAKE	ENHANCED RETURNS TO TATSAMENIE LAKE SYSTEM (from enhanced fry outplants)																		TOTAL
1989	2.5				4752	37152	6096												48000
1990	2.5					4752	37152	6096											48000
1991	2.5						4752	37152	6096										48000
1992	2.5							4752	37152	6096									48000
1993	2.5								4752	37152	6096								48000
1994	2.5									4752	37152	6096							48000
1995	2.5										4752	37152	6096						48000
1996	2.5											4752	37152	6096					48000
1997	2.5												4752	37152	6096				48000
1998	2.5													4752	37152	6096			48000
1999	2.5														4752	37152	6096		48000
2000	2.5															4752	37152	6096	48000
2001	2.5																4752	37152	48000
2002	2.5																	4752	48000
2003	2.5																		48000
2004	2.5																		48000

ENHANCED RETURN 4752 41904 48000 48000 48000 48000 48000 48000 48000 48000 48000 48000 48000 48000 48000 48000 48000 48000

TOTAL RETURN	17779	28031	24681	9214	12292	61114	76392	73253	59004	62323	75691	78000	78000	78000	78000	78000	78000	78000	78000
HARVEST	8001	12614	11106	4146	5531	27501	34376	32964	26552	28045	34061	35100	35100	35100	35100	35100	35100	35100	35100
BROODSTOCK	1953	1953	1953	1953	1953	18857	21600	21600	21600	21600	21600	21600	21600	21600	21600	21600	21600	21600	21600
ESCAPEMENT	7825	13464	11622	3115	4808	31660	40063	38336	30499	32325	39677	40947	40947	40947	40947	40947	40947	40947	40947

BIOSTANDARD ASSUMPTIONS :

AGE : 4 SUB 1's = 0.068 SURVIVAL : EGG-to-FRY (wild) = 0.08 SEX RATIO = 0.50 TATSAMENIE NATURAL PRODUCTION LIMIT = 30000 ADULTS  
 4 SUB 2's = 0.099 (enhanced) = 0.80 FECUNDITY = 2560 (ESTIMATED FROM OBSERVED RETURNS)  
 5 SUB 2's = 0.699 FRY-to-SMOLT = 0.20 HARVEST RATE = 0.45 (SPAWNING GROUND LIMITED ?)  
 5 SUB 3's = 0.007 SMOLT-to-ADULT = 0.12 RETURN RATE (wild) = 2.46 : 1  
 6 SUB 3's = 0.127 (enhanced egg-to-adult) = 0.019 (enhanced) = 24.58 : 1

\* ESTIMATED SPAWNING ESCAPEMENTS  
 NATURAL ADULT PRODUCTION MAY BE LIMITED BY SPAWNING AREA. REARING CAPACITY MAY BE CAPABLE OF PRODUCING 394,000 ADULTS.

## APPENDIX 9 : FORECAST OF ADULT SOCKEYE RETURNS TO LITTLE TRAPPER LAKE, WITHOUT ENHANCEMENT.

BROOD YEAR	SPAWN ESCAPE	ADULT RETURNS TO LITTLE TRAPPER LAKE (from wild spawners)																				TOTAL
		1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	
1983	7402	1692																				18191
1984	13084	18950	2325																			25000
1985	12397	3725	18950	2325																		25000
1986	13820		3725	18950	2325																	25000
1987	11009			3725	18950	2325																25000
1988	10629				3725	18950	2325															25000
1989	13402					3725	18950	2325														25000
1990	13750						3725	18950	2325													25000
1991	13750							3725	18950	2325												25000
1992	13750								3725	18950	2325											25000
1993	13750									3725	18950	2325										25000
1994	13750										3725	18950	2325									25000
1995	13750											3725	18950	2325								25000
1996	13750												3725	18950	2325							25000
1997	13750													3725	18950	2325						25000
1998	13750														3725	18950	2325					25000
1999	13750															3725	18950	2325				25000
2000	13750																3725	18950	2325			25000
2001	13750																	3725	18950	2325		25000
2002	13750																		3725	18950	2325	25000
2003	13750																			3725	18950	25000
2004	13750																				3725	25000
WILD RETURN		24367	25000	25000	25000	25000	25000	25000	25000	25000	25000	25000	25000	25000	25000	25000	25000	25000	25000	25000	25000	
" HARVEST		10965	11250	11250	11250	11250	11250	11250	11250	11250	11250	11250	11250	11250	11250	11250	11250	11250	11250	11250	11250	
ESCAPEMENT		13402	13750	13750	13750	13750	13750	13750	13750	13750	13750	13750	13750	13750	13750	13750	13750	13750	13750	13750	13750	

## BIOSTANDARD ASSUMPTIONS :

AGE : 4 SUB 1's = 0.000  
 4 SUB 2's = 0.149  
 5 SUB 2's = 0.737  
 5 SUB 3's = 0.021  
 6 SUB 3's = 0.093

SURVIVAL : EGG-to-FRY (wild) = 0.08  
 (enhanced) = 0.80  
 FRY-to-SMOLT = 0.20  
 SMOLT-to-ADULT = 0.12  
 (enhanced egg-to-adult) = 0.019

SEX RATIO = 0.50  
 FECUNDITY = 2560  
 HARVEST RATE = 0.45  
 RETURN RATE (wild) = 2.46 : 1  
 (enhanced) = 24.58 : 1

L. TRAPPER NATURAL PRODUCTION LIMIT = 25000 ADULTS  
 (ESTIMATED FROM OBSERVED RETURNS)  
 (REARING CAPACITY LIMITED ? )

APPENDIX 10 : FORECAST OF ADULT SOCKEYE RETURNS TO LITTLE TRAPPER LAKE, WITH ENHANCEMENT.

BROOD YEAR	SPAWN ESCAPE	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	TOTAL
1983	7402	1692																				18191
1984	13084	18950																				25000
1985	12397	3725	18950	2325																		25000
1986	13820		3725	18950	2325																	25000
1987	11009			3725	18950	2325																25000
1988	10629				3725	18950	2325															25000
1989	11449					3725	18950	2325														25000
1990	11797						3725	18950	2325													25000
1991	11797							3725	18950	2325												25000
1992	11797								3725	18950	2325											25000
1993	15730									3725	18950	2325										25000
1994	35742										3725	18950	2325									25000
1995	38197											3725	18950	2325								25000
1996	38197												3725	18950	2325							25000
1997	38197													3725	18950	2325						25000
1998	38197														3725	18950	2325					25000
1999	38197															3725	18950	2325				25000
2000	38197																3725	18950	2325			25000
2001	38197																	3725	18950	2325		25000
2002	38197																		3725	18950	2325	25000
2003	38197																			3725	18950	25000
2004	38197																				3725	25000

WILD RETURN 24367 25000

EGGTAKE	ADULT RETURNS TO LITTLE TRAPPER LAKE (from enhanced fry outplant to Trapper Lake) *	TOTAL
1989 2.5	7152 36384 4464	48000
1990 2.5	7152 36384 4464	48000
1991 2.5	7152 36384 4464	48000
1992 2.5	7152 36384 4464	48000
1993 2.5	7152 36384 4464	48000
1994 2.5	7152 36384 4464	48000
1995 2.5	7152 36384 4464	48000
1996 2.5	7152 36384 4464	48000
1997 2.5	7152 36384 4464	48000
1998 2.5	7152 36384 4464	48000
1999 2.5	7152 36384 4464	48000
2000 2.5	7152 36384 4464	48000
2001 2.5	7152 36384 4464	48000
2002 2.5	7152 36384 4464	48000
2003 2.5	7152 36384 4464	48000
2004 2.5	7152 36384 4464	48000

ENHANCED RETURN 7152 43536 48000 48000 48000 48000 48000 48000 48000 48000 48000 48000 48000 48000 48000 48000 48000 48000 48000 48000 48000

TOTAL RETURN	24367	25000	25000	25000	32152	68536	73000	73000	73000	73000	73000	73000	73000	73000	73000	73000	73000	73000	73000	73000	73000
HARVEST	10965	11250	11250	11250	14468	30841	32850	32850	32850	32850	32850	32850	32850	32850	32850	32850	32850	32850	32850	32850	32850
ENHANCED BROODSTOCK	1953	1953	1953	1953	3218	19591	21600	21600	21600	21600	21600	21600	21600	21600	21600	21600	21600	21600	21600	21600	21600
ESCAPEMENT	11449	11797	11797	11797	15730	35742	38197	38197	38197	38197	38197	38197	38197	38197	38197	38197	38197	38197	38197	38197	38197

BIOSTANDARD ASSUMPTIONS :

AGE : 4 SUB 1's = 0.000	SURVIVAL : EGG-to-FRY (wild) = 0.08	SEX RATIO = 0.50	L. TRAPPER NATURAL PRODUCTION LIMIT = 25000 ADULTS
4 SUB 2's = 0.149	(enhanced) = 0.80	FECUNDITY = 2560	(ESTIMATED FROM OBSERVED RETURNS)
5 SUB 2's = 0.737	FRY-to-SMOLT = 0.20	HARVEST RATE = 0.45	(REARING CAPACITY LIMITED ?)
5 SUB 3's = 0.021	SMOLT-to-ADULT = 0.12	RETURN RATE (wild) = 2.46 : 1	
6 SUB 3's = 0.093	(enhanced egg-to-adult) = 0.019	(enhanced) = 24.58 : 1	TRAPPER (UPPER) PRODUCTION LIMIT = 93000 ADULTS (EUPHOTIC VOLUME LIMIT)

\* ENHANCED FRY WILL BE OUTPLANTED TO TRAPPER LAKE WHICH IS UPSTREAM OF LITTLE TRAPPER LAKE, BUT IS INACCESSABLE TO RETURNING ADULTS. BOTH WILD AND ENHANCED RETURNS WILL SPAWN BELOW IN LITTLE TRAPPER AND THE INTERCONNECTING CREEK.

APPENDIX 11 : COST PROJECTIONS FOR ENHANCEMENT, JUVENILE EVALUATION, AND HARVEST MANAGEMENT OF THE TAHLTAN / TUYA, TATSAMENIE AND TRAPPER LAKE SYSTEMS. COST PROJECTIONS ARE IN 1988 \$US (THOUSANDS), AND ARE CONSTANT AFTER 1995 (TOTALS INCLUDE AVERAGES OF THE CANADIAN AND US ESTIMATES FOR LIMNOLOGY & HYDROACOUSTICS).

TRANSBOUNDARY ENHANCEMENT COSTS IN \$US (THOUSANDS)

TAHLTAN / TUYA LAKES		1989	1990	1991	1992	1993	1994	1995
-----		-----	-----	-----	-----	-----	-----	-----
ENHANCEMENT	egg-take	35.0	47.8	47.8	47.8	47.8	47.8	47.8
	egg transport	5.8	11.7	11.7	11.7	11.7	11.7	11.7
	incubation	38.3	26.9	26.9	26.9	26.9	26.9	26.9
	fry transport	15.4	30.1	30.1	30.1	30.1	30.1	30.1
	disease sampling	4.0	4.0	4.0	3.0	2.0	2.0	2.0
-----		-----	-----	-----	-----	-----	-----	-----
sub-total		98.5	120.5	120.5	119.5	118.5	118.5	118.5
JUVENILE EVALUATION								
limnology & hydroacoustics	(CAN)		27.4	16.5	16.5	16.5	16.5	16.5
	(US)		24.5	24.5	24.5	24.5	24.5	24.5
-----			-----	-----	-----	-----	-----	-----
(AVG)			26.0	20.5	20.5	20.5	20.5	20.5
	smolt sampling			14.8	14.8	14.8	14.8	14.8
HARVEST MANAGEMENT otolith program								
(CAN fishery)					3.3	3.3	3.3	3.3
	(US fishery)	2.0	10.3	113.4	54.6	75.0	148.3	130.7
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TAHLTAN / TUYA LAKES TOTAL		100.5	156.8	269.2	212.7	232.1	305.4	287.8
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TATSAMENIE LAKES

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ENHANCEMENT	egg-take	35.6	35.6	35.6	35.6	35.6	35.6	35.6
	egg transport	5.3	5.3	5.3	5.3	5.3	5.3	5.3
	incubation	19.1	13.5	13.5	13.5	13.5	13.5	13.5
	fry transport	15.4	15.0	15.0	15.0	15.0	15.0	15.0
	disease sampling	2.0	2.0	2.0	2.0	2.0	2.0	2.0
-----		-----	-----	-----	-----	-----	-----	-----
sub-total		77.4	71.4	71.4	71.4	71.4	71.4	71.4
JUVENILE EVALUATION								
limnology & hydroacoustics	(CAN)		35.1	24.2	24.2	24.2	24.2	24.2
	(US)	38.1	43.4	43.4	43.4	43.4	43.4	43.4
-----		-----	-----	-----	-----	-----	-----	-----
(AVG)		38.1	39.3	33.8	33.8	33.8	33.8	33.8
	smolt sampling			7.0	7.0	7.0	7.0	7.0
HARVEST MANAGEMENT otolith program								
(CAN fishery)					3.3	3.3	3.3	3.3
	(US fishery)	1.0	5.1	56.8	27.2	37.5	74.1	65.4
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TATSAMENIE LAKES TOTAL		116.5	115.8	169.0	142.7	153.0	189.6	180.9
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(...con't)

APPENDIX 11 : (con't)

TRAPPER LAKES		1989	1990	1991	1992	1993	1994	1995
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ENHANCEMENT	egg-take	33.6	33.6	33.6	33.6	33.6	33.6	33.6
	egg transport	9.6	9.6	9.6	9.6	9.6	9.6	9.6
	incubation	19.1	13.5	13.5	13.5	13.5	13.5	13.5
	fry transport	15.4	15.0	15.0	15.0	15.0	15.0	15.0
	disease sampling	2.0	2.0	2.0	2.0	2.0	2.0	2.0
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sub-total		79.7	73.7	73.7	73.7	73.7	73.7	73.7
JUVENILE EVALUATION								
limnology & hydroacoustics	(CAN)		34.5	23.6	23.6	23.6	23.6	23.6
	(US)		21.6	21.6	21.6	21.6	21.6	21.6
	(AVG)		28.1	22.6	22.6	22.6	22.6	22.6
smolt sampling				7.0	7.0	7.0	7.0	7.0
HARVEST MANAGEMENT	otolith program							
	(CAN fishery)				3.3	3.3	3.3	3.3
	(US fishery)	1.0	5.1	56.8	27.2	37.5	74.1	65.4
TRAPPER LAKES TOTAL		80.7	106.9	160.1	133.8	144.1	180.7	172.0
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ALL								
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ENHANCEMENT	egg-take	104.2	117.0	117.0	117.0	117.0	117.0	117.0
	egg transport	20.7	26.6	26.6	26.6	26.6	26.6	26.6
	incubation	76.5	53.9	53.9	53.9	53.9	53.9	53.9
	fry transport	46.2	60.1	60.1	60.1	60.1	60.1	60.1
	disease sampling	8.0	8.0	8.0	7.0	6.0	6.0	6.0
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sub-total		255.6	265.6	265.6	264.6	263.6	263.6	263.6
JUVENILE EVALUATION								
limnology & hydroacoustics	(CAN)		97.0	64.3	64.3	64.3	64.3	64.3
	(US)	38.1	89.5	89.5	89.5	89.5	89.5	89.5
	(AVG)	38.1	93.3	76.9	76.9	76.9	76.9	76.9
smolt sampling				14.8	28.8	28.8	28.8	28.8
HARVEST MANAGEMENT	otolith program							
	(CAN fishery)				9.9	9.9	9.9	9.9
	(US fishery)	4.0	20.5	227.0	109.0	150.0	296.5	261.5
GRAND TOTAL		297.7	379.4	598.3	489.2	529.2	675.7	640.7
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CONSTRUCTION COSTS = \$ 100.0 K 10 M EGG INTERIM FACILITY IN 1988  
\$ 1000.0 K 25 M EGG PERMANENT FACILITY IN 1990

VALUE OF FISH = \$ 14 / PIECE 1981 - 1985 AVG = \$7.10 / PIECE  
(ALASKA) 1989 AVG = \$17.00 / PIECE (RECORD PRICE)

NOTE : ENHANCEMENT PLANS FOR 1989 HAVE NOT BEEN FINALIZED. FOR PURPOSES OF THESE  
ESTIMATES IT IS ASSUMED THAT ENHANCEMENT ON ALL SYSTEMS WILL BEGIN IN 1989.