TRANSBOUNDARY RIVER SOCKEYE SALMON ENHANCEMENT ACTIVITIES FINAL REPORT FOR SUMMER, 1995 TO FALL, 1999.

TCTR (01)-2

Prepared By

The Transboundary River Technical Committee

For

The Pacific Salmon Commission

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EXECUTIVE SUMMARY

A joint Canada/U.S. transboundary sockeye enhancement program was initiated in 1989 with the first egg take at Tahltan Lake and has continued annually to the present. The intent of the program is to increase sockeye salmon production from the Stikine and Taku Rivers pursuant to specific terms within the Pacific Salmon Treaty. This report presents the methods and results of the transboundary sockeye enhancement program from summer 1995 to fall 1999. Enhancement activities that occurred prior to summer 1995 have been previously reported (PSC 1991; PSC 1994; PSC 1998). A brief summary of activities and results are presented below.

Hatchery Operations

All sockeye eggs collected for the enhancement program were incubated at the Snettisham Hatchery Incubation Facility in Southeast Alaska. In 1995 a cooperative agreement between Alaska Department of Fish and Game (ADF&G) and Douglas Island Pink and Chum (DIPAC), a private aquaculture organization in Juneau, provided for the continued operation of Snettisham Hatchery. This arrangement included the provision of egg incubation, otolith marking, and fry transport for the transboundary enhancement projects.

Otolith Marking and analysis

All developing sockeye fry originating from the transboundary enhancement program are marked with a distinct thermal otolith mark applied at Snettisham Hatchery. Laboratories in Juneau, Alaska and Whitehorse, Yukon examine otoliths collected by ADF&G and Fisheries and Oceans Canada (FOC) as part of the enhancement program evaluation and management. The Juneau Laboratory analyzes adult sockeye otoliths collected from U.S. and Canadian commercial and test fisheries and provides timely in season estimates of the enhanced proportion of the commercial catch for Canadian and U.S. fisheries managers. Juvenile and adult otoliths collected as a result of ongoing enhancement evaluation programs are processed at the Whitehorse Otolith Lab.

Tahltan Lake Outplant Project

Egg takes and fry outplants have occurred annually at Tahltan Lake. Egg take targets were not reached in 1997, 1998, and 1999 due to low escapements. Growth of enhanced fry has been consistently similar to that of wild fry. Enhanced fry to smolt survival has been variable, although average enhanced egg to smolt survival has been approximately triple that of wild egg to smolt survival. Limnological observations suggest the juvenile sockeye carrying capacity has not been reached at past and current stocking densities. Enhanced Tahltan Lake sockeye have accounted for approximately 40% of the total Stikine River enhanced sockeye harvest from 1993 through 1999. The overall enhanced contribution to the total Stikine River sockeye harvest over this period has averaged approximately 30%.

Tuya Lake Outplant Project

Tahltan Lake broodstock have continued to be the source of fry outplants to Tuya Lake. Growth and survival of outplanted fry has been exceptional. Limnological data indicate that minor changes to the zooplankton community have occurred as a result of the fry outplants, however the forage base biomass and carrying capacity appears to be stable and the system is likely capable of supporting higher fry densities. Ongoing evaluation surveys suggest that a non-anadromous sockeye (kokanee) population originating from progeny of outplanted fry has become established in Tuya Lake. This may have implications with respect to increased intra-specific competition and future fry stocking densities. Adult returns of Tuya Lake outplanted fry have accounted for approximately 60% of the total Stikine River enhanced sockeye catch during the years 1993 to 1999.

Tatsamenie Lake Outplant Project

Egg take goals at Tatsamenie Lake have been attained for all years except 1999 when low escapements precluded reaching the target. Growth of outplanted fry has been good and limnological observations indicate the system is readily capable of supporting prevailing population levels of enhanced and wild fry. However, enhanced fry to smolt survival continues to be much lower than expected despite varied and ongoing attempts to increase it. The continuation of the Tatsamenie Lake outplant project is in doubt if efforts to increase survival are not effective. The enhanced contribution to the total Taku River commercial sockeye catch has only averaged approximately 2% from 1994 to 1999 and is reflective of the poor enhanced production from both Tatsamenie and Trapper lakes.

Trapper Lake Outplant Project

The Trapper Lake outplant project was suspended in 1995 due to low survival of the outplanted fry and the small number of emigrating smolts captured. Adult returns have confirmed the low enhanced production from Trapper Lake and it is improbable the project will be re-instated unless correctable causes for the poor fry survival are identified.

1.0 INTRODUCTION

Enhancement of transboundary river sockeye stocks began in 1987 with the initiation of studies by Canada and the United States directed at increasing the returns of sockeye salmon to the Stikine and Taku rivers. The Transboundary enhancement programs involve collecting and fertilizing eggs from donor stocks spawning in the headwaters of the Taku and Stikine river systems and flying the fertilized eggs to the Snettisham Hatchery in Alaska. The eggs are incubated over winter and the resultant fry transplanted back to suitable Canadian nursery lakes. Canadian participation in the program includes collecting and transporting the fertilized eggs, monitoring outplanted fry, conducting limnological and acoustic surveys of nursery lakes, and reading adult and juvenile otoliths. U.S. responsibilities include hatchery operations, fry transport, and the marking of fry and the reading of adult otoliths. Egg takes began in 1989 at Tahltan Lake on the Stikine system, and in 1990 at Tatsamenie and Trapper Lakes on the Taku River system. The programs at Tahltan, Tuya, and Tatsamenie lakes have continued up to the present. The Trapper Lake program was suspended in 1995 due to low enhancement production. The results of the enhancement activities from 1989 through to spring of 1995 have been previously documented in two reports (PSC 1994; PSC 1998).

This report examines the transboundary enhancement activities from 1995 through to the fall of 1999, as well as tabulating the previous results from 1989 through 1995. The format of this report is different from that of the previous reports dealing with transboundary enhancement activities in that it contains limited analysis and interpretation of the results presented, and no recommendations regarding the course of future enhancement activities. It is anticipated that future recommendations and detailed analysis of transboundary enhancement results will be presented in memoranda released by the Transboundary Technical Committee (TTC) and Enhancement sub-committee co-chairpersons.

2.0 METHODS

2.1 Egg-takes

Egg-take methods at Tatsamenie and Tahltan lakes have been relatively consistent from 1995 through 1999. These methods have been previously reported (PSC 1998; PSC 1994). As well, egg targets, methodology, and results are detailed in annual reports submitted to FOC by the contractors conducting the egg-takes.

Minor infrastructure changes at Tatsamenie Lake involved the construction of additional net pens as well as the enlargement of the spawning shed to accommodate the increased egg take target (2.5 to 5.0 million) that was initiated in 1996. At Tahltan Lake, starting in 1998, sorted broodstock have been held in offshore floating vexar pens to reduce the risk of bear predation. During the period 1995 through 1999 ARC Environmental Ltd. and B. Mercer & Associates Ltd. have conducted the egg takes at Tahltan and Tatsamenie lakes respectively.

2.2 Hatchery Operations

Hatchery methods, for the most part, have not changed and have been previously described (PSC 1994; PSC 1998). A minor aspect of hatchery operations that has been modified is the method for fry ponding. Fry are now transferred from the main incubation building to another building for short-term holding prior to transport. The water temperature of the holding containers is slowly raised to about 5° C. prior to transport to more closely match the stocked lake.

2.3 Otolith Marking and Reading

2.3.1 Alaska

Each year ADF&G port samplers collected approximately 15,000 otolith pairs to estimate the contribution of the various groups of enhanced sockeye in the District 106, 108, and 111 Gillnet Fisheries. Laboratory personnel process a portion of the otolith samples the week of harvest for management purposes and later process more samples based on an optimizing algorithm that minimizes the overall uncertainty on the proportion of enhanced fish in the commercial fisheries. A subsample of the otoliths are independently read twice and in some cases three times. The between reader agreement data is used to derive estimates of reading accuracy. In 1998 and 1999 the Alaska Lab processed otoliths inseason from the Canadian commercial fisheries to provide managers an estimate of the enhanced component.[1] Samples were also obtained and processed from test fishing operations in both Canada and U.S. fishing districts. Additional otoliths are examined for a myriad of purposes including validation of marks on fry prior to transport from Snettisham Hatchery.

[1] In order to procure analysis results in a timely manner, as well as in some instances to verify thermal mark detection, some Canadian collected otoliths were processed at the ADF&G otolith lab in Juneau during the period 1995 through 1999

2.3.2 Canada

In 1994 Canada hired and trained a technician to begin processing otoliths under the direction of the FOC Aging Lab at the Pacific Biological Station (PBS) in Nanaimo, B.C. This position was created to allow processing of otoliths from the transboundary enhancement program, as well as other Canadian programs that employed thermal marks. Otoliths from fry and smolts obtained from the ongoing evaluation program as well as from broodstock and Canadian test and commercial fishery samples from the Taku and Stikine rivers were analyzed at this facility from 1996 through 1998. In 1998 FOC (Yukon and Northern B.C. Division, Whitehorse) began training a technician and equipped a small-scale thermal mark laboratory to examine otoliths collected from the transboundary enhancement program. In 1999 the Whitehorse laboratory analyzed both juvenile and adult sockeye otoliths collected during the 1998 and 1999 seasons. The PBS otolith technician position was terminated in 1999.

2.4 Outplanting

Tahltan Lake

From 1995 through 1997 outplant procedures at Tahltan Lake were similar to those reported for previous years. In 1998 two of four fry shipments were held in net pens for approximately 32 hours to assess short-term transport and holding mortality. Two floating fine mesh net pens measuring 3.5m x 3.5m x 3.5m were used to hold the fry. Two of the 1998 fry shipments were released directly into the lake near shore as strong winds prevented the aircraft off-loading into the net pens. In 1999 three of four fry shipments were held in near-shore net pens for approximately 24 hours prior to release into the lake. Brood year 1998 (BY 98) Tahltan fry were stocked at an earlier date by accelerating development at the hatchery.

Tatsamenie Lake

At Tatsamenie Lake changes in outplanting procedures began in 1997 (BY 96). Prior to 1997 outplanted sockeye fry were released in the middle of the lake. These outplant procedures are documented in previous reports (PSC 1994; PSC 1998). From 1997 through 1999, fry were released near shore in the littoral zone. As well, beginning in 1997 all except two fry shipments have been held in net pens positioned near the shore for short periods of time (24 -72 hours), to determine short term holding/transport mortality. Two floating fine mesh net pens measuring 3.5m x 3.5m x 3.5m were used to hold the fry.

In 1998 and 1999, 394,000 and 1,017,989 fry were held and fed, in the same floating net pens described above, for periods ranging from 15-30 days. In 1998, the fry were fed standard “Ewos” brand starter mash, and in 1999 the fry were fed Moore-Clarke brand starter and #1mesh food. The feeding was initiated to determine if it would confer a survival advantage over the unfed fry and therefore lower the high mortality rate experienced by the outplanted fry to date.

In addition to the near shore releases and short term holding and feeding, attempts were made in 1999 (BY 98) to outplant the fry earlier in the season. Development of the fry was accelerated at the hatchery by raising the incubation water temperature allowing an earlier stocking window. This was done in an attempt to improve enhanced fry survival by better emulating the emergence timing of the wild fry. Prior to 1998 and beginning in 1993, the timing of fry outplants had shifted to later in the season as a result of volitional emergence and other techniques adopted by the Snettisham Hatchery.

Tuya Lake

Outplant procedures and stocking dates at Tuya Lake have remained relatively consistent since initiation of the outplants in 1992 (BY 91), and have been documented in previous reports (PSC 1994; PSC 1998). Outplanting occurs from mid to late June and is largely determined by ice out timing which at Tuya Lake typically occurs in mid June.

2.5 Monitoring of Outplants

2.5.1 Hydroacoustic/Limnological Surveys

From 1995 through 1999 hydroacoustic and limnological surveys were performed at Tahltan, Tuya, Tatsamenie, and Trapper lakes by Triton Environmental consultants, Pacific Biological Station (PBS) staff, and B. Mercer & Associates. Survey methodology was similar to procedures used from 1988 through 1994 and reported in previous reports (PSC 1994; PSC 1998), and described in more detail by Hyatt et al. (1984).

The number of hydroacoustic surveys at each outplant lake was decreased after 1996 to one per year. Exceptions were the years 1997 and 1998 at Tatsamenie Lake when several surveys were performed during these two years as part of an increased evaluation effort directed at determining the reasons for the low outplanted fry survival at this lake. Acoustic and trawl surveys for all lakes included limetic zone trawling to determine the ratios of wild and enhanced sockeye fry and acoustic transect soundings to determine the abundance of juvenile sockeye and other species targeted by the echo-sounder.

Limnological surveys at all subject lakes included beach seining in the littoral zone at established index sites, water clarity measurements, vertical zooplankton tows, chlorophyll *a* sampling, total phosphorus, and water temperature profiles. At Tuya Lake, in addition to the usual limnological sampling regime, horizontal stratified zooplankton tows were conducted from 1995 to 1997. These were discontinued in 1998. All limnological and hydroacoustic surveys at Trapper Lake were discontinued in 1996. Fry sampling at Tahltan Lake has been sporadic with no beach seine sampling in 1995 and 1998, and trawling only in 1999.

2.5.2 Smolt sampling

Tahltan Lake

At Tahltan Lake, the smolt emigrant population was enumerated and sampled using an inclined plane wolf trap and volumetric displacement technique. This program been operated by FOC, Whitehorse continuously from 1984 through 1999 and has been described in previous reports (PSC 1994; PSC 1998).

Tatsamenie Lake

Smolt sampling was conducted in the spring at the outlet of Tatsamenie Lake from 1995 through 1999. Representative samples were collected using a 2m x 2m fyke net set at intervals over the period of smolt migration. Sampling methods were similar to those reported in previous reports (PSC 1994; PSC 1998). In the years 1996, 1998, and 1999 smolt mark-recapture projects were also conducted in order to obtain outmigrating smolt population estimates. These projects involved tagging emigrating smolts captured by the fyke net in the outlet stream, returning the tagged fish to the lake then sampling a proportion of the emigrating population to determine marked-unmarked ratios. Details of these projects are contained in unpublished and in-preparation reports prepared for FOC stock assessment division in Whitehorse (Mercer 1998). B. Mercer and Associates conducted the sampling and mark-recapture programs.

Tuya Lake

Smolt sampling at Tuya Lake was initiated in 1993 and has been conducted annually up to 1999. On-site sampling methods have remained unchanged since 1993 (PSC 1998). From 1996 through 1999 the sampling has been conducted jointly by B. Mercer & Associates and the Tahltan Tribal Council. Since Tuya Lake is ice covered during most of the smolt emigration period access to the outlet of Tuya Lake during the height of the smolt out-migration is either via helicopter or by float plane to a small lake approximately 1 km downstream from the lake outlet. Timing of the sampling period is usually dependent on when sufficient open water is available to permit float plane access.

2.6 Ancillary Enhancement Activities

In addition to short term fry holding and feeding studies at Tatsamenie Lake during the period 1998 to 1999, the following sockeye enhancement related studies were also conducted:

- In 1998 at Tatsamenie Lake 150 wild and 150 enhanced fry were held separately in a net pen from June 15 to August 10 to determine long term holding mortality rates.

- In 1998 and 1999 small scale passive flow incubators were installed in Tatsamenie Lake near the outlet. In 1998 approximately 30,000 fertilized eggs were placed in mesh covered trays on September 18 to determine the feasibility of incubating sockeye eggs in-lake. The eggs were shocked and picked at the eyed stage on October 20. The incubator was opened, examined, and resultant fry released the following spring on May 25. In the fall of 1999 40,000 fertilized eggs were placed in two separate incubators. The trays of these incubators employed a variety of mesh types and egg loading densities. These eggs were not picked and will be examined in spring 2000.

- In 1998 a study was initiated to determine the migration pattern of returning adult Tuya Lake sockeye after entry into the Tuya River. A total of 28 “Lotek” brand radio tags (MHz 149.32 - 149.44) were applied to adult sockeye captured near the mouth of the Tuya River using dip nets. The tagged fish were released at the point of capture immediately after tagging. The radio tagged sockeye were tracked via foot, boat, and helicopter. The purpose of the study was to determine the migratory behavior of the Tuya origin sockeye after they encountered the barrier as well as the potential for straying to other areas.

- In 1999 another radio tagging study was conducted to determine if Tuya River sockeye released above the Tuya River velocity barriers are able to migrate to and spawn in Tuya Lake. Tuya Lake origin sockeye were captured using dip and gill nets near the mouth of the Tuya River. “Lotek” radio tags (MHz 149.34 - 149.44) were applied to 53 fish and the tagged sockeye were placed in a fish tote and transferred in the tote via helicopter to a holding pen located 2 km upstream of the velocity
- barriers. The radio tagged fish were able to move volitionally out of the pen and were tracked using both fixed and rotary wing aircraft.

3.0 RESULTS

3.1 Hatchery Operations

Operation of the Snettisham Hatchery has been without significant incident relative to the transboundary river program.

3.2 Otolith Marking and Processing

A summary description of otolith marks applied to enhanced transboundary sockeye fry from 1989 to 1999 is presented in Table 22. Since 1995 the otolith marks have been generally of good quality based on analysis of voucher samples collected from each incubator and processed at the ADF&G lab in Juneau. Processing of adult otoliths has proceeded according to plan and is the basis for all estimates of US commercial harvest of enhanced fish in this report.

3.3 Disease Testing

Disease histories of broodstock collected at Tatsamenie, Tahltan, and Little Trapper lakes from 1988 through 1999 are detailed in Table 23. The incidence and levels of Infectious Hematopoietic Necrosis Virus (IHNV) in the broodstock collected at Tatsamenie and Tahltan lakes was quite variable between brood-years. Although the average number of IHNV positive fish was lower at Tatsamenie (24%) than at Tahltan Lake (54%), the inter-annual variations in the number of IHNV positive fish were more extreme at Tatsamenie compared to Tahltan Lake. The incidence of bacterial kidney disease (BKD) varied much less and was relatively low at all three lakes.

Excepting a probable outbreak of white spot disease in Little Trapper BY90 stock, IHNV is the only known pathogen to have produced losses in transboundary sockeye stocks at Snettisham Hatchery. Hatchery losses due to IHNV in Tahltan Lake origin fish have occurred in brood years 1991, 1992, 1995, and 1996. Losses occurred with Tatsamenie Lake origin eggs in BY's 1992, 1993, and 1997. With gained experience and refined egg collection protocol the number and severity of IHNV outbreaks have diminished during the period 1989 to 1999.

3.4 Outplant Dates

Fry stocking dates for Tuya, Tahltan, and Tatsamenie lakes for brood years 1995 through 1998 are presented in Table 22. During the period 1996 through 1998 (BY95 through BY97) the stocking dates for Tatsamenie and Tahltan Lake were largely determined by the emergence timing of the incubating fry. Emergence timing of the fry is largely dependent on the timing of egg collection and the thermal regime of the incubation water. Consequently Tahltan fry outplants usually occur earlier in the season than Tatsamenie fry because the eggs arrive at the hatchery, on average, earlier during the preceding fall. Outplants to Tuya Lake are later than at Tahltan Lake (even though they share a common broodstock source) because the incubation water is chilled to slow egg development in order to be certain Tuya Lake is ice free at the time of scheduled outplanting. Characteristically, ice out time at Tuya Lake (mid-June) is approximately one month later than Tahltan Lake (mid- May).

In 1999 (BY 98) the scheduled fry stocking dates for Tatsamenie and Tahltan lakes were advanced so that fry release timing was closer to the emergence timing of the wild fry. In some years to accelerate development, incubation water used for these stocks was heated using waste heat generated by the hatchery water chillers.

3.5 Egg-takes, Incubation, and Outplanting

Tahltan Lake

Results of the egg takes, incubation, thermal marking, and egg to outplanted fry survival at Tahltan Lake from broodyears 1989 through 1999 are presented in Table 1. Annual reports detailing egg take results and activities have been prepared and submitted to the FOC contracting authority (DFO-SEP; Vancouver, B.C.) by the contractor (ARC Environmental Ltd.).

Tahltan Lake egg take targets have remained at 6.0 million since 1993, and were attained in two of the seven years. Low escapements are the reason the targets have not been reached in all years. Fertilization rates have ranged from 90% to 97% with a five year average of 93%. Green egg to outplanted fry survival has ranged from 70% to 84% with a 1995 to 1998 average of 75%. This green egg to fry survival is below the original biostandard of 80% anticipated at the inception of the transboundary enhancement program (PSC 1988).

Thermal marks applied to Tahltan Lake destined fry from BY95 through BY99 (excepting BY97) have been marked at pre-hatch locations with different ring patterns between brood years. BY97 fry were marked at a post hatch location (Table 22).

Tuya Lake

No egg takes occur at Tuya Lake, the source of broodstock for these outplants is Tahltan Lake. The number of eggs taken for Tuya Lake, egg to fry survival, fry outplants, and thermal marking results are presented in Tables 2 and 22. Since they have a common brood stock source, egg to fry survivals are similar for Tahltan and Tuya lakes. However, they are not identical due to different fertilization rates between egg-takes/shipments as well as hatchery losses due to disease. The green egg to outplanted fry survivals at Tuya Lake for BY's 1995 through 1998 have averaged 72% (range 64% to 77%), slightly lower than the same year average for Tahltan Lake. As for fry destined for other outplant locations, thermal marks applied to Tuya Lake destined fry are unique to the stock and vary with brood year.

Tatsamenie Lake

Results of the Tatsamenie Lake egg takes, incubation, thermal marking, and survivals are presented in Tables 3 and 22. Unpublished annual reports detailing egg take results and activities have been prepared by the contractor and submitted to the FOC contracting authority. These reports are available from DFO - SEP Enhancement Operations, Vancouver and DFO – Stock Assessment, Whitehorse. Egg take targets at Tatsamenie Lake have been variable ranging from 2.5 to 5.0 million. Egg take targets set by the TTC were increased in BY96 to compensate for the termination of the Trapper Lake enhancement program. Lower egg targets for BY's 1998 and 1999 were set by the TTC until the causes of the low survival of outplanted Tatsamenie Lake fry could be determined. The 1999 egg collection target was not achieved due to the low escapement.

The Tatsamenie BY 1995 to 1998 green egg to planted fry survival ranged from 69% to 76%, and averaged 73%. As with Tuya and Tahltan lakes, this green egg to fry survival is below the original anticipated biostandard of 80%.

Two separate and distinct thermal marks were applied each year to two separate groups of Tatsamenie Lake fry for BY's 1996 through 1999 (Table 22). The rationale for the different marks was to allow evaluation of different outplant/feeding strategies.

3.6 Hydroacoustic Estimates and Fry and Smolt Growth and Survival

Tahltan Lake:

The results of Tahltan Lake beach seine and trawl surveys conducted from 1992 through 1999 are presented in Table 4. Tahltan Lake sockeye fry grow rapidly and beach seine index catches indicate that relatively few fry remain onshore by the end of July. Over the years sampled, the mean size of Tahltan Lake fry was greater than those produced at Tatsamenie Lake, but smaller than fry captured at Tuya Lake. Trawl catch per unit effort at

Tahltan Lake was quite low, likely a result of high net avoidance due to water clarity and the large size of the fry.

As evidenced by acoustic surveys (Table 26), the number of juvenile sockeye in the Tahltan Lake limnetic zone has been decreasing in recent years. The 1999 densities are well below average corresponding with a below average escapement from BY98.

The proportions of enhanced fry obtained in Tahltan trawl catches for the years 1993, 1996, and 1997 are relatively high (Table 4). Wild and enhanced fry ratios are a function not only of relative survival and in-lake production rates, but also escapement, number of eggs collected, and hatchery survival. Proportions of enhanced and wild sockeye fry in the beach seine catches are variable which may be due to low sampling effort and small sample sizes.

Egg to smolt survivals at Tahltan Lake for the period 1981 through 1998 are presented in Table 16. For broodyears 1981 through 1998 the mean egg to smolt production rates for wild age 1+ and age 2+ fish were 3.38% (range 0.52% - 13.5%) and 0.38% (range 0.02% - 2.55%) respectively. Enhanced egg to smolt production from 1991 to 1998 averaged 11.4% (range 4.6% - 24.4%) for age 1+ and 0.41% (range 0.00% - 1.05%) for age 2+. The egg to smolt production for age 1+ enhanced fish is approximately triple that of wild age 1+ sockeye over the same period. For age 2+ smolts the egg to smolt production of wild fish was slightly lower than for enhanced fish. It should be noted that the enhanced egg to smolt survival in Table 16(b) is based on the number of green eggs delivered to the hatchery; included in these survival rates are losses due to poor fertilization rates and hatchery losses due to IHNV.

Tahltan Lake smolt weight, length, and age class data, as well as emigration estimates from 1984 to 1999, are contained in Tables 9, 10, and 16. The proportion of enhanced smolts has ranged from 6.7% to 51.7%. The proportion of emigrating enhanced smolts in sample years 1995 and 1996 was quite low, but increased to above average levels through 1997 to 1999. Smolt size varies within each age class for a given year. There appears to be no significant relationship (Figure 1) between either wild (R^2= 0.018; p = 0.05; d.f.= 15) or enhanced (R^2= 0.042; p = 0.05; d.f. = 8) smolt population estimates and smolt size. Although similar, the average size of wild Tahltan smolts (age 1+ = 4.90; age 2+ = 10.10) is larger than the enhanced smolts (age 1+ = 4.30; age 2+ = 9.57). This size differential is likely due to outplant timing rather than differential growth rates. On average Tahltan smolts were smaller than Tuya smolts but larger than Tatsamenie or Trapper smolts (Figure 3).

Smolt outmigration estimates from Tahltan Lake have been variable, ranging from 218,702 in 1984 to 3,255,045 in 1993. The 16 year average from 1984 through 1999 is 978,777.

Tuya Lake:

Tuya Lake fry beach seine and trawl results for the 1992-1999 period are detailed in Table 5. Due to the relatively rich zooplankton forage base the growth of Tuya Lake fry was markedly more rapid than in other outplant lakes. Relatively low numbers of sockeye fry have been captured in both beach seine and trawl surveys at Tuya Lake from 1993 through 1999. Low beach seine catches were likely due to the relatively short onshore residency period. Low trawl catches were likely a result of trawl net avoidance by the large fish (Hyatt and Rankin 2000). The relatively low fry densities in Tuya Lake also contributed to the small sample sizes.

Otolith samples from the August 1999 beach seine catches indicated approximately 40% of the fry captured were unmarked and probably of wild origin (Table 5). This was the first year unmarked sockeye fry were captured in beach seine sets at Tuya Lake. It is probable these fry were the progeny of residual adults (kokanee). If the residual sexual maturation process mimics that of the anadromous sockeye with 5 year old spawners predominate, the 1999 unmarked fry would be the brood of kokanee originating from the relatively large (4,690,000) 1993 fry outplanting. It should be noted that the ratio of marked to unmarked fry captured in the August beach seines is probably not representative of the true in lake ratios since most of the marked fish likely would have moved from the littoral to the limnetic zone before the beach seine survey was conducted.

The mean trawl length and weights presented in Table 5 are likely not representative of the in-lake population and are biased low due to a direct relationship between fry size and trawl net avoidance. Adjusted trawl sample mean lengths and weights that have been corrected for net avoidance are found in appendix 2.

Tuya Lake smolt weight, length, and age class data are presented in Table 11. As with the fry at Tuya Lake the smolts are much larger than smolts at other outplant lakes (Figure 3). Until the 1999 sample year no unmarked smolts were found leaving Tuya Lake. The 1999 Tuya smolt thermal mark analysis indicated that 8.2% of the age 1+ smolts leaving Tuya Lake were unmarked. No unmarked age 2+ smolts were observed. Unmarked smolts are likely progeny from residual spawners originating from the 1992, 1993, or 1994 fry outplants. Smolt enumeration has not occurred at Tuya Lake.

Tatsamenie Lake:

Tatsamenie Lake fry beach seine and trawl data obtained from 1992 through 1999 are presented in Table 6. Tatsamenie Lake sockeye fry are on average smaller than those at Tahltan and Tuya lakes. As occurs at other transboundary sockeye lakes, both wild and enhanced fry exhibit a tendency to migrate offshore over the season. However, Tatsamenie fry appear to remain onshore longer than at either Tuya or Tahltan lakes.

Growth rate and subsequent size of wild and enhanced sockeye fry captured in fall trawling are similar, with enhanced fry being slightly larger in 1997 and 1998, but smaller in the years from 1992 through 1996. The fed enhanced fry released in 1998 and 1999 were consistently larger than unfed enhanced fry over the course of the season. The relative proportions of wild to enhanced fry in beach seine samples increased over the season during the years 1997 through 1999. Prior to 1997 the proportion of enhanced fry in beach seined samples was relatively low throughout the season.

The mean trawl caught fry length and weight presented in Table 6 is likely not representative of the in-lake juvenile sockeye population and is biased low due to a positive relationship between trawl net avoidance and fry size. Adjusted trawl sample mean lengths and weights that have been corrected for net avoidance are found in Appendix 2c.

Tatsamenie Lake smolt sampling results are presented in Tables 12, 15, and 17. Tatsamenie smolts at age 1+ are, on average, smaller than those leaving the other outplant lakes (Figure 3). The proportion of enhanced smolts leaving Tatsamenie lake is variable ranging from 2.5% to 23.2%, but for most years the portion of enhanced fish is relatively low, averaging 8.5% from 1992 through 1999. Egg to smolt survival for age 1+ is variable and ranges from 1.2% to 6.5% (average 3.12%) for enhanced fish, and 6.0 % to 10.9% (average 9.0%) for wild fish. Tatsamenie Lake emigrating smolt population estimates obtained in 1996, 1998, and 1999, and were 505,187, 2,443,575, and 776,641 respectively (Table 17). There appears to be no significant relationship between either wild (R^2= 0.006; p = 0.05; d.f.= 6) or enhanced (R^2= 0.262; p = 0.05; d.f. = 6) smolt population estimates and smolt size (Figure 2).

The low number of emigrating enhanced smolts appears to be a result of a relatively higher mortality rate among the outplanted fry in the first three months of lake residence. This is evidenced by the decline in proportion of enhanced to wild fry in beach seine and trawl catches over this period (Table 6). As well, the wild/enhanced ratios of trawl caught fall fry correspond relatively well with the wild /enhanced age 1+ smolts the following spring (Table 12), suggesting that differential mortality of the enhanced fish occurs between the time of outplanting and fall trawling. Data from the years 1997, 1998, and 1999 support this hypothesis better than the data from years 1992 through 1996. It should be noted, that after 1996 the limnological and smolt sampling regimes at Tatsamenie Lake were substantially increased., resulting it is assumed, in improved more representative data.

Trapper Lake:

Results of beach seine and trawl surveys conducted at Trapper Lake in 1995 are presented in Table 8. This was the last year of juvenile beach seine and trawl surveys conducted at Trapper Lake. As in previous years at Trapper Lake, substantial numbers of outplanted fry remained in littoral regions later in the season than was observed in other transboundary outplant lakes. The average weight of the enhanced age 1 fry (1.81 g) captured in July beach seine sets was considerably higher than the enhanced age 1 fry (0.46 g) beach seined at approximately the same time of year in previous Trapper Lake surveys. It is possible that pen reared fry were included in these beach seine samples which would account for the larger average size.

Trapper Lake smolts were sampled in1996 and 1997; these along with data from previous years are presented Table 13. A total of 101 smolts were captured in 1996, but none were captured in 1997. The sampling program did not continue after 1997. Trapper Lake smolts were slighter larger than those from Tatsamenie Lake (Figure 3). All smolts emigrating from Trapper Lake were enhanced fish. In 1996 age 1+ was the dominant age class, but in 1994 and 1995 the proportion of age 2+ was slightly higher.[2] The Trapper Lake smolt age structure is notable in that it had the largest proportion of age 3+ in the emigrating population (3.4% average) of the outplant lakes.

Smolt enumeration studies have not been conducted at Trapper Lake. However, intensive sampling efforts with low capture rates and the low enhanced adult returns suggest the outmigrating smolt populations in 1996 and 1997, as well as in previous years, were quite low.

The fry feeding experiment at Trapper Lake, outlined in a previous report (PSC 1998), involved marking fed fry with a strontium otolith mark to determine if differential survival occurred between fed and unfed fry. None of the 91 smolts captured in 1996 have yet been analyzed for the strontium mark.

Little Trapper Lake:

Results of 1995 beach seine and trawl surveys at Little Trapper Lake are outlined in Table 7. This was the last year of juvenile surveys at this site. The rationale for conducting limnological surveys at Little Trapper Lake was to determine the extent of emigration into the lake of fry outplanted to Trapper Lake and the potential impacts of this premature emigration on the Little Trapper wild sockeye fry. The implications of this pre-smolt emigration have been considered in previous reports (PSC 1994; PSC 1998). The 1995 beach seine and trawl surveys indicated that very few enhanced fry were present in Little Trapper Lake.

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[2] The sample size at Trapper Lake in 1993 was limited to one smolt.

Little Trapper smolt sampling was performed from 1992 through 1997 and the results are presented in Table 14. Smolt sampling was conducted to examine the impact of enhanced fry migrating prematurely from Trapper to Little Trapper Lake. As well, the enhanced/wild smolt ratios leaving Little Trapper Lake provided a rough indicator of the size of the Trapper Lake emigrating smolt population since Trapper Lake origin smolts must pass through Little Trapper Lake during their migration. From 1992 through 1997 the ratio of wild to enhanced smolts leaving Little Trapper Lake has been relatively low, with the proportion of enhanced smolts ranging from 0% to 7.1% with a five year average of 4.2%. It is impossible to determine with certainty if a marked Little Trapper Lake smolt reared in Little Trapper or in Trapper Lake. However the relatively small average size (2.5g) of enhanced age 1+ Little Trapper smolts compared to the average size of the Trapper Lake age 1+ smolt (5.9g) suggests that most of the marked fish sampled probably reared in Little Trapper Lake. Little Trapper Lake has higher wild sockeye fry densities and a lower zooplankton forage base than does Trapper Lake resulting in the production of much larger smolts from the latter system.

Smolt enumeration studies have not been conducted at Little Trapper Lake. The relative ease of smolt capture at this location during all sample years indicates that the outmigrating smolt populations have been relatively large.

3.7 Limnological Observations

In this publication the reporting of limnological observations will be confined to presenting the zooplankton sampling results. It is anticipated that future report(s) will document the results of water chemistry, phytoplankton, chlorophyll a, temperature and dissolved oxygen sampling as well as examining outplant lake productivity models and carrying capacity estimates.

3.7.1 Zooplankton

A zooplankton data summary and analysis report for Tatsamenie, Tahltan, and Tuya lakes is in preparation (PSC, 1999; in prep.). The methods used in preparation and analysis of zooplankton samples are detailed in the above-mentioned report. This report summarizes the average biomasses of zooplankton taxa in each lake (Figures 7,8, 9), and presents mean annual biomass and density data for each zooplankton taxa in each lake (Tables 18,19, 20). Mean annual biomass is also reported for aquatic organisms termed “large beasts”, which consist primarily of chironomid larva, fish larva, and acarina (mite).

<u>Tahltan Lake</u>: Zooplankton sampling results for Tahltan Lake from 1988 through 1998 are found in Table 18 and Figure 7. Tahltan Lake has the highest mean annual zooplankton biomass and densities of all the outplant lakes, averaging 949 mg/m^3 and 42,840/ m^3

respectively. The largest components of the mean annual Tahltan Lake zooplankton biomass are *Daphnia sp.* followed by *Cyclops sp*.

Fry outplants into Tahltan Lake do not appear to have produced noticeable qualitative or quantitative changes in the zooplankton community. Tahltan Lake appears capable of readily supporting past and present numbers of wild and enhanced sockeye fry.

Tuya Lake: The zooplankton data for Tuya Lake collected from 1988 through 1998 are presented in Table 19 and Figure 8. Tuya Lake zooplankton species are large and abundant resulting in a relatively high mean annual biomass of 483 mg/m^3. Mean annual zooplankter densities averaged 23,441/m^3. *Cyclops sp.* followed by *Skistodiaptomous sp.* formed the largest biomass component as well as being the most numerically abundant taxa (aside from nauplii and rotifers). Stratified plankton tows indicated that most of the zooplankton biomass was found in the upper 7 meters of the water column with the greatest concentration found within the first meter (PSC, 1999; in prep.).

From the initial observations of the plankton community structure in Tuya Lake it was assumed there was a relatively low rate of predation on the plankton community prior to the first fry outplants (PSC 1998). Following the outplanting of fry there has been a shift in both zooplankton size and species composition. The average size of Daphnia decreased from 1.3 mm to 0.8 mm. The calanoid copepod taxa *Epischura sp*. and *Heterocope sp*. were both significantly reduced in number one year after the first stocking. In summary it appears the largest zooplankters in Tuya Lake (*Daphnia sp*. and calanoid copepods) have been heavily cropped following the first years of outplanting, however the average total biomass and densities have not significantly changed during the 12 years of data collection. The shift in species composition and size is an expected response to the introduction of sockeye fry. The current fry stocking densities appear to have had a minimal impact on productivity and the fry carrying capacity at Tuya lake. Based on these observations it is presumed the lake is presently capable of supporting higher sockeye fry densities.

Tatsamenie Lake: Tatsamenie Lake zooplankton data results collected from 1988 through 1998 are presented in Table 20 and Figure 9. The mean annual zooplankton biomass and density for this period is 309 mg/m^3 and 18,051/m^3, respectively. The largest component of the zooplankton taxa, in terms of both mass and numerical abundance, was *Cyclops sp*., followed by *Bosmina sp*. and *Daphnia sp*. Fry outplants in Tatsamenie Lake do not appear to have had a measurable effect on the zooplankton community. At current levels of wild production, the data suggest that the Tatsamenie Lake limnetic zooplankton forage base is capable of supporting larger numbers of fry outplants than have been made to date.

3.8 Ancillary Enhancement Activities

1998 short term holding at Tatsamenie Lake:

Two groups of fry (150 wild and 150 enhanced) were held in a net pen for 62 days at Tatsamenie Lake from mid-June to mid-August, 1998. Of the 150 enhanced fry held, two dead fish were observed during the holding period. Only 106 fry were released after the holding period and it was assumed that 42 fry had escaped during a storm in late July. Since the pen was left unattended for extended periods, feeding of the held fry was intermittent and when the fish were released it was apparent through visual observation that they were in an emaciated condition. The holding study was further confounded by the presence of six coho fry in the wild fry compartment of the pen. These fry were captured with the wild sockeye fry and were not correctly identified prior to placement in the pen. The coho fry were observed to prey on the smaller sockeye fry. Only 27 wild sockeye fry remained in the pen at the end of the time of release. The only conclusion that could be reached from this experiment was that during the two month period the held enhanced fry did not appear to suffer from a sudden mortality event.

Passive flow incubators at Tatsamenie Lake:

On May 25 1999, an experimental passive flow incubator was retrieved from where it was anchored and moved to shallow water near shore. This incubator had contained approximately 30,000 fertilized eggs and had been placed in the lake the previous fall. The cover was removed from the incubation box and each of five individual trays was removed and examined. The mesh from each tray was removed, the contents examined, and the fry to un-hatched egg ratio was estimated and recorded. The fertilized egg to fry survival varied for each tray and ranged from 5% to 40% with an average of 20%. No dead fry were observed. A minor amount of fungus on the undeveloped eggs was present in three of the trays. All resultant fry were examined and released into the lake. It was apparent that for approximately 95% of the dead eggs examined, development had been arrested at or near the eyed stage. This likely was a result of shocking the eggs the previous fall before they were all fully eyed. The timing of the egg shocking was necessitated by accessibility to the site and the lateness of the season. Consequently, the egg to fry survival results from this incubator may not be indicative of the results that could be obtained using a different incubation strategy.

In September of 1999 two incubation boxes containing approximately 40,000 eggs were placed in Tatsamenie Lake near the outlet. These eggs were not shocked and picked. The incubators will be examined in May 2000.

1998 Tuya River radio tagging:

Of the 28 radio tagged adult sockeye released near the mouth of the Tuya River, only tag (5%) remained in the river, and this was attributed to a signal from a regurgitated tag. A total of 23 (82%) tags were tracked to sites within the Stikine River basin, and 5 tags (18%) were not accounted for. Three tags (13%), were tracked into the Tahltan River although none as far as Tahltan Lake. The majority of fish were tracked to the Stikine River at points between the mouth of the Chutine River and the Canada/U.S. border.

This study demonstrated that 100% of the radio tagged fish moved out of the Tuya River after tagging, however anecdotal reports indicate that some sockeye[3] were observed in the Tuya River in September and October. It is not known if these fish successfully spawned at this site. As a result of this downstream migration of the Tuya Lake origin sockeye it is possible that intermixing of Tuya and mainstem sockeye stocks could occur. Although the sample size was small, no tagged sockeye were tracked to a known mainstem spawning site.

1999 Tuya River radio tagging:

The results of the 1999 Tuya River radio tagging study are illustrated in Figure 4. Of the 53 radio tagged sockeye released upstream of the Tuya River barrier, 41 tags (77%) were tracked to various sites in the Tuya and Stikine river drainages. Only two fish (4%) were traced to Tuya Lake, one of which was a weak signal and not conclusive. Four (8%) tagged fish were tracked to a small lake located 2 km downstream from the Tuya Lake outlet. A majority of the tags (n=29; 54%) were tracked to sites located between the release site and 50 km upstream. Three tags (7%) were tracked to an area above the river mouth but downstream of the Tuya River barrier. One tag was found in the Stikine River, and it is assumed the remaining 12 tags, which were not found, either migrated or were swept downstream. No spawning was observed by any fish tracked, and no pre-spawn mortalities were observed.

This study showed that it is possible for sockeye to negotiate the Tuya River from the barrier to Tuya Lake, a distance of approximately 150 km. It is not known why the four sockeye stopped at Little Tuya Lake instead of continuing a further 2 km to Tuya Lake, since the intervening section of river is not considered a serious impediment to upstream migration. Nevertheless, only 4% of the tagged fish reached Tuya Lake, the other 96% either migrated downstream or were located within 50 km upstream of the release site. Of the tags located upstream, the signals were emitted from within deep pools below rapids and riffle sections of the river, indicating the fish were either dead or holding in the pools. Survey conditions were good and the lack of observed fish would indicate the

[3] These sockeye are considered to be enhanced returns, however their origin is not confirmed.

signals came from dead fish. It is not known if the tagged fish failed to reach Tuya Lake because of difficulty negotiating swift water sections of the river, tag induced mortality/lower fitness, tagging fish from the latter part of the run, in-river temperature regimes, or a combination of these and other factors.

3.9 Adult Returns

Stikine River

The adult returns, catches by country, and escapements of enhanced sockeye salmon in the Stikine River from 1993 through 1999 are presented in Table 24 and Figure 5. Adult returns of enhanced Stikine River sockeye are intercepted by the U.S. marine fisheries (Districts 106 and 108 commercial drift gillnet), commercial and subsistence fisheries in Canada, and test fisheries in both countries. As well, Excess Salmon to Spawning Requirements (ESSR) licenses have been issued to conduct Canadian commercial harvests at Tahltan Lake and the Tuya River barrier.

The total enhanced sockeye production for the Stikine River from 1994 to 1999 has ranged from 28,242 to 86,827 with an average of 55,574. Average Canadian and U.S. catches of enhanced sockeye for this period have been 16,935 and 27,766 respectively. Total enhanced sockeye escapements into both Tahltan Lake and the Tuya River system from 1994 to 1999 is estimated to have ranged from 4,034 to 17,101 with an average of 10,872. Exploitation rates on the enhanced component of the Stikine sockeye run range from 65% to 93%, with an average of 80%. Exploitation rates on wild Stikine River stocks are somewhat lower for the same period and ranged from 61% to 82% with an average of 70%. The higher harvest rate for the enhanced component of the run is due to the Tuya River ESSR fishery which specifically targets enhanced fish.

Taku River

Estimates of catches by country of wild and enhanced sockeye, as well as total enhanced and wild production of Taku River sockeye are presented in Table 25. The principal U.S. commercial fishery targeting Taku River origin sockeye is the District 111 gillnet fishery located at the mouth of the Taku River. Lesser numbers of Taku River sockeye are caught in adjacent gillnet fisheries as well as in a small in-river subsistence fishery. Canadian interception of Taku origin sockeye is largely confined to an in-river commercial fishery situated immediately upstream of the Canada/U.S. border. A small Canadian aboriginal fishery also exists on the lower Taku River.

Total annual Canadian and U.S. catches of enhanced Taku River sockeye from 1995 to 1999 have ranged from 1,409 to 5,511 with an average of 3,295. Annual Canadian catches of enhanced sockeye during this period have averaged 720 (range 290 to 1334), and U.S. catches have averaged 2,575 (range 820 - 4,779). For the same period total annual enhanced Taku sockeye production is estimated to have averaged 5,711 (range 2,884 to 10,283), with wild production averaging 207,982. The enhanced proportion has averaged 2.7% (range 1.7% to 4.3%) of the total run from 1995 through 1999 (Figure 6).

4.0 DISCUSSION

4.1 Hatchery Operations

The hatchery operations have gone as planned for the most part. Survivals from green egg to planted fry have been slightly below the original target of 80% but that is at least partly due to the more rigorous procedures used for sockeye salmon. It is expected that the hatchery operations will continue to be fine-tuned in the effort to provide the best environment for the sockeye program.

4.2 Otolith Marking and Processing

Alaska

Otolith marking has gone well for this project. With one exception, a difficult to recover post-hatch accessory mark on the Tuya 95 brood year, the release groups have been easy to identify and the marks distinctive. Processing of otoliths at the lab has also gone well and the information has been available for inseason management, usually within 24 hours after a fishery closes. Estimates of reader accuracy typically have ranged from 95% to 99% on distinguishing between hatchery and wild stocks. Since a majority of the otoliths are read at least twice and disagreements resolved by a third reading, actual accuracy rates are likely higher. Overall estimates of enhanced contribution to the fisheries typically have 95% confidence range of 2% to 5% by the time postseason samples are completed.

Canada

It is anticipated that all sockeye juvenile, smolt, and adult otoliths obtained from the transboundary enhancement evaluation conducted in year 2000 will be processed at the FOC otolith Lab in Whitehorse, Yukon. At present, funding is in place to enable processing of all otoliths obtained through the 2000 evaluation program to be processed by March 2001. Cooperation between the Whitehorse and Juneau otolith labs has been very good, with the Juneau Lab offering ongoing technical assistance and secondary reading of otoliths when requested.

4.3 Disease History

For both Tatsamenie and Tahltan Lake stocks IHNV outbreaks at the Snettisham Hatchery have declined over the course of the transboundary enhancement program, with no losses recorded in 1998 and 1999. This is likely attributable, in part, to the continued refinement of egg collection techniques and it is anticipated that IHNV outbreaks will continue at these relatively low levels.

4.4 Egg Takes, Incubation, and Outplanting

Tahltan Lake

In accordance with the enhancement appendix to Annex IV of the Pacific Salmon Treaty (Appendix 1), the Tahltan Lake egg take target has been set at 6.0 million, with a minimum target of 600,000 eggs, broodstock availability permitting. At Tahltan Lake the egg take targets of 6.0 million have not been achieved for the years 1997, 1998, and 1999 due to low sockeye returns to Tahltan Lake. Stikine River sockeye management strategies are under review by the TTC to ensure future Tahltan Lake sockeye escapements meet the minimum escapement goal of 24,000.

Concerns have been expressed regarding loss of genetic diversity and/or genetic drift as a result of the use of the enhanced component of the Tahltan lake sockeye run for broodstock. It is possible that the enhanced component of the Tahltan sockeye run will increase over successive generations due to differential survival of the enhanced fish. Low escapements may exacerbate this possibility as the proportion of enhanced fish within the run is expected to be higher from brood years with low escapements. The Enhancement Sub-Committee of the TTC has discussed this issue, but no consensus has been reached regarding the significance and validity of the concerns raised. It has been agreed by the TTC that the situation warrants continued monitoring.

Outplant strategies to Tahltan Lake will continue to involve outplanting fry as early as possible after ice out, and short term holding of fry in net pens attached to the shore. Although the release strategies require further evaluation, the evidence suggests earlier outplant timing may convey some survival advantage.

Since 1991 enhanced fry originating from Tahltan Lake have been outplanted in both Tahltan and Tuya lakes. The number of outplants destined for each lake is decided by the TTC on an annual basis depending on a number of factors including but not limited to:

i) An agreement within the enhancement appendix to Annex IV of the Pacific Salmon Treaty that stipulates when Tahltan Lake sockeye escapements are below 15,000, all enhanced fry are to be planted back to Tahltan Lake. When the escapement is greater than 15,000 or based on an agreed alternative threshold, the fry will be distributed between Tuya and Tahltan Lakes in a way that maximizes harvestable production and provides an outplant level to Tuya Lake that is sufficient for assessment purposes.

ii) Configuration of incubators and modules at Snettisham Hatchery.

iii) Additional data which may include fry survival rates, zooplankton analysis, smolt size and age composition, ESSR fishing strategies, and recent escapement levels.

Tuya Lake

Eggs and resultant fry outplants destined for Tuya Lake will continue to be obtained from Tahltan Lake broodstock. The number of fry planted into Tuya Lake will continue to be assessed annually by the TTC based on the criteria outlined above. The relatively high fry to adult survival of the Tuya Lake outplanted fry suggests that past outplant techniques are appropriate for this system and should be continued.

Tatsamenie Lake

Egg take goals at Tatsamenie Lake have ranged from 2.5 to 5.0 million from 1995 through 1999. Since 1995, with the exception of 1999, the egg take goals at Tatsamenie Lake have been met or exceeded. The egg take goal of 2.5 million was not met in 1999 due to the exceptionally low escapement into Tatsamenie Lake. The Pacific Salmon Treaty, Annex IV, specifies a Tatsamenie Lake egg take goal of 5.0 million, with a minimum target of 600,000 eggs, dependent on broodstock availability.

4.5 Hydroacoustic Estimates and Fry to Smolt Growth and Survival

Tahltan Lake

Fall limnetic fry hydroacoustic estimates for Tahltan Lake are contained in Table 26. With the exception of the 1996 estimate, the fall fry acoustic estimates from 1990 through 1999 do not correlate well with the emigrating smolt populations enumerated the following spring. There is not a significant relationship (R^2=0.093, d.f.=5, p<.10) between fall fry and spring smolt estimates (Figure 10).

Fry outplanted to Tahltan Lake continue to grow well. The average size of enhanced smolts has been slightly smaller than their wild counterpart (Table 10), a phenomenon likely attributable to outplant timing.

The egg to age 1+ smolt survival for enhanced fish at Tahltan Lake (Table 16) has been variable, with relatively low survivals from BY 1993 to BY 1997 (average 6.9%), and a subsequent increase in the BY 1998 survival. Nevertheless, the average enhanced egg to smolt survival has been approximately three times (11.4% compared to 3.5%) that of the wild counterpart.

A number of potential causes have been examined by the Enhancement Sub-Committee that may account for the lower enhanced egg to smolt survivals from 1993 to 1997. These include later release timing, volitional emergence, and shorter acclimation periods; however no definitive factors have been identified.

The outplanted fry held in net pens in 1997 and 1998 exhibited no significant short term mortalities. It is expected that short term holding of outplanted fry in net pens coupled with onshore releases will continue at Tahltan Lake. The Enhancement Sub-Committee has adopted an earlier stocking window (May 15 -30) in order to emulate the wild sockeye emergence timing.

Tuya Lake

Acoustic sockeye fry population estimates for Tuya Lake are presented in Table 26. These fry estimates are considered preliminary and have yet to be corrected for the presence of limnetic sculpins in the lake.

Outplanted fry growth and survival at Tuya Lake continues to be exceptionally high. The size of age 1+ Tuya origin smolts is approximately double that of Tahltan Lake smolts (Table 11). Unmarked and presumably wild origin smolts and fry from BY98 and BY99 exhibit growth rates similar to those of enhanced fish with the unmarked smolts slightly larger on average than the marked smolts.

The presence of unmarked sockeye fry and smolts in Tuya Lake and the possible establishment of a perpetuating kokanee population may have considerable implications with respect to competition for the zooplankton forage base and future stocking densities. The Enhancement Sub-Committee has recommended increased monitoring of the system beginning in year 2000 to monitor and evaluate potential impacts arising from the establishment of a Tuya Lake kokanee population as a result of residual outplanted fry.

Tatsamenie Lake

Tatsamenie Lake acoustic fry population estimates are presented in Table 26. The fall fry acoustic estimates have tracked relatively well with the following spring smolt populations derived from the mark-recapture estimates (Tables 15 and 17). Although the data set is small, there has been a significant relationship (Figure 11) between fall fry and spring smolt estimates ($R^2 = 0.912$, d.f.=3, $p>0.05$).

The growth rates of fry planted into Tatsamenie Lake have been relatively high and consistent over the course of the enhancement program. Growth rates of enhanced and wild fry are very similar, with enhanced smolts being, on average, slightly smaller than wild smolts.

The fry to smolt survival of fry outplanted to Tatsamenie Lake has been consistently lower than the 20% fry to smolt biostandard used in the initial formulation of the enhancement program, and lower than wild egg to smolt survival estimates obtained for BY's 1994, 1996, and 1997 (Table 17). Evaluation studies to date indicate that most of the differential mortality of enhanced versus wild fry occurs between the time of outplanting in June and mid-October when almost all the fry have moved offshore. Although many potential causes of the high fry mortality have been postulated and ongoing evaluation studies have been enacted to define the problem, no definitive causal agents have yet been identified.

Several different fry outplant strategies, previously described above, have been conducted at Tatsamenie Lake in an attempt to address the low enhanced fry to smolt survival. The results of the near shore fry releases are mixed. Compared to enhanced egg to age 1+ smolt survivals observed for BY 94 (1.2%) there was an improvement in survivals of near shore released fry from BY 96 (7.3%; Table 17). However, no substantive increase was observed in the following year for near shore released fry. With only two years of data it is not possible to determine if near shore releases confer a substantive or sustained survival advantage to the enhanced fry. Fry feeding studies conducted in 1998 and 1999 were designed to determine if the release of larger fry would result in an increase in survival. The results from the 1998 fry feeding program indicate an increase in the egg to smolt survival of fed enhanced fry (5.5%) compared to the unfed fry (1.6%). However, the egg to smolt survival of wild fry was estimated to be 6.0%, thus no net production advantage was realized from the release of enhanced fed fry.

The Enhancement Sub-Committee of the TTC has been directed by the Transboundary Panel to continue efforts aimed at increasing Tatsamenie Lake enhanced fry to smolt survival. Additional fry feeding and release strategies are planned for year 2000, along with the evaluation of the earlier 1999 fed fry releases.

4.6 Zooplankton

With the exception of Tuya Lake, zooplankton results indicate that fry outplants into Tahltan, Trapper, and Tatsamenie lakes did not produce noticeable changes in the biomass, density, or species composition of the zooplankton communities. As expected, fry outplants into Tuya Lake, previously barren of sockeye, produced changes in size and densities of large bodied zooplankters although the average total biomass did not change.

The absence of a significant relationship between smolt population and smolt size at Tahltan and Tatsamenie lakes (Figures 1 and 2), as well as consistent size of the Tuya Lake smolts suggests that past fry stocking densities have not taxed the zooplankton forage base. At present stocking densities, no significant changes in the zooplankton communities of outplant lakes are expected.

4.7 Ancillary Activities

Experimentation directed at the viability of using passive flow incubators at Tatsamenie Lake is expected to continue. The results of the BY 99 incubators will determine the further course of this experiment. If the BY 99 results are positive a production scale incubator with approximately 300,000 fertilized eggs will be placed in Tatsamenie Lake in the fall of 2000. The results of a production scale incubator may also help explain why low enhanced egg to smolt survivals are experienced in this system by determining if incubation/fry transport protocol or dissimilar water chemistry regimes are possibly effecting fry survival.

The TTC has expressed an inclination to continue the Tuya River radio tagging studies to determine definitively if adult sockeye can navigate the Tuya River upstream of the barrier and successfully spawn in Tuya Lake. This information will be necessary to properly evaluate the feasibility of the barrier removal, and determine the long-term viability of the Tuya Lake enhancement program and the ESSR fishery.

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Figures

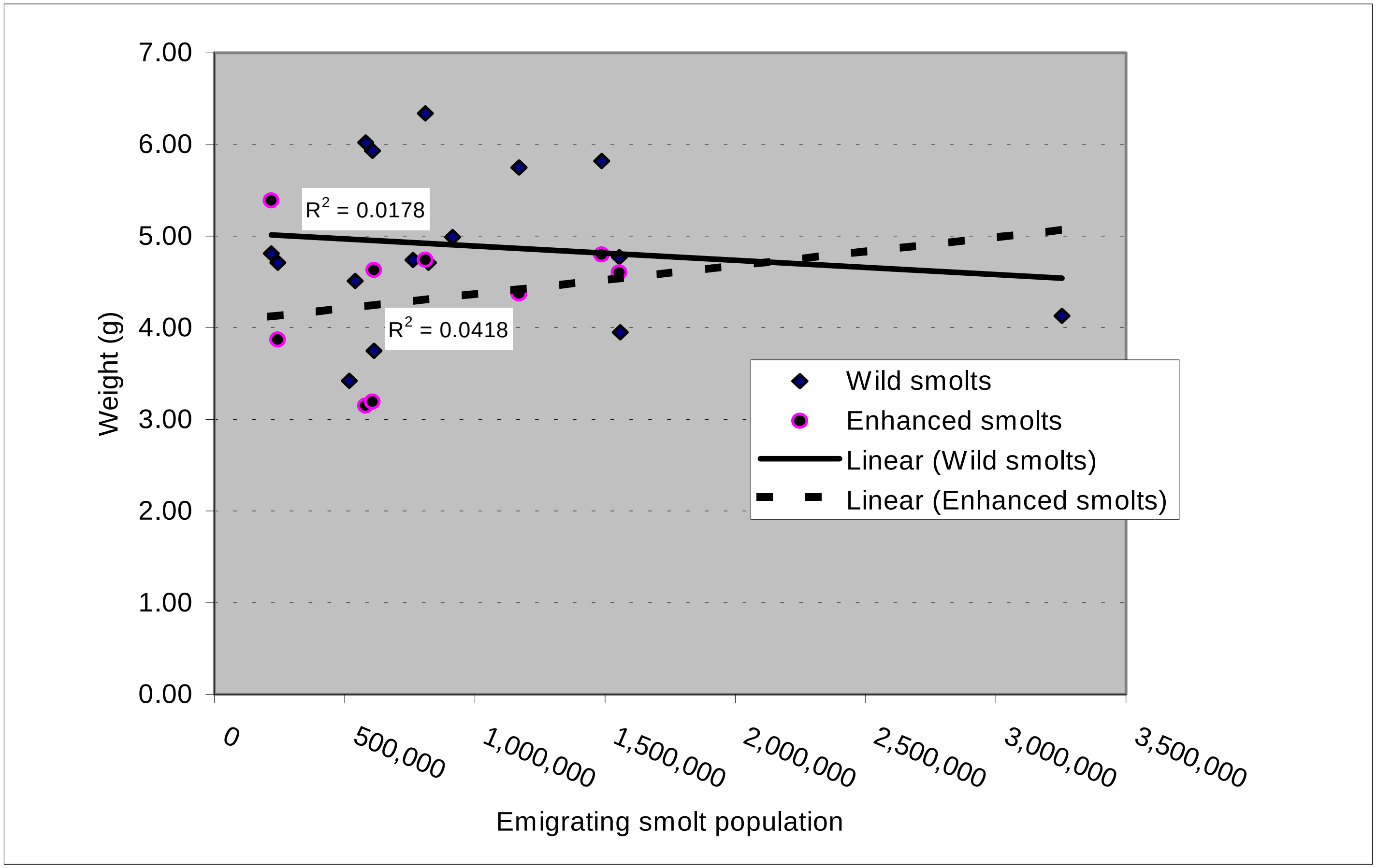

Figure 1. Average mean weight and population size of age 1+ Tahltan Lake smolts, 1984 – 1999.

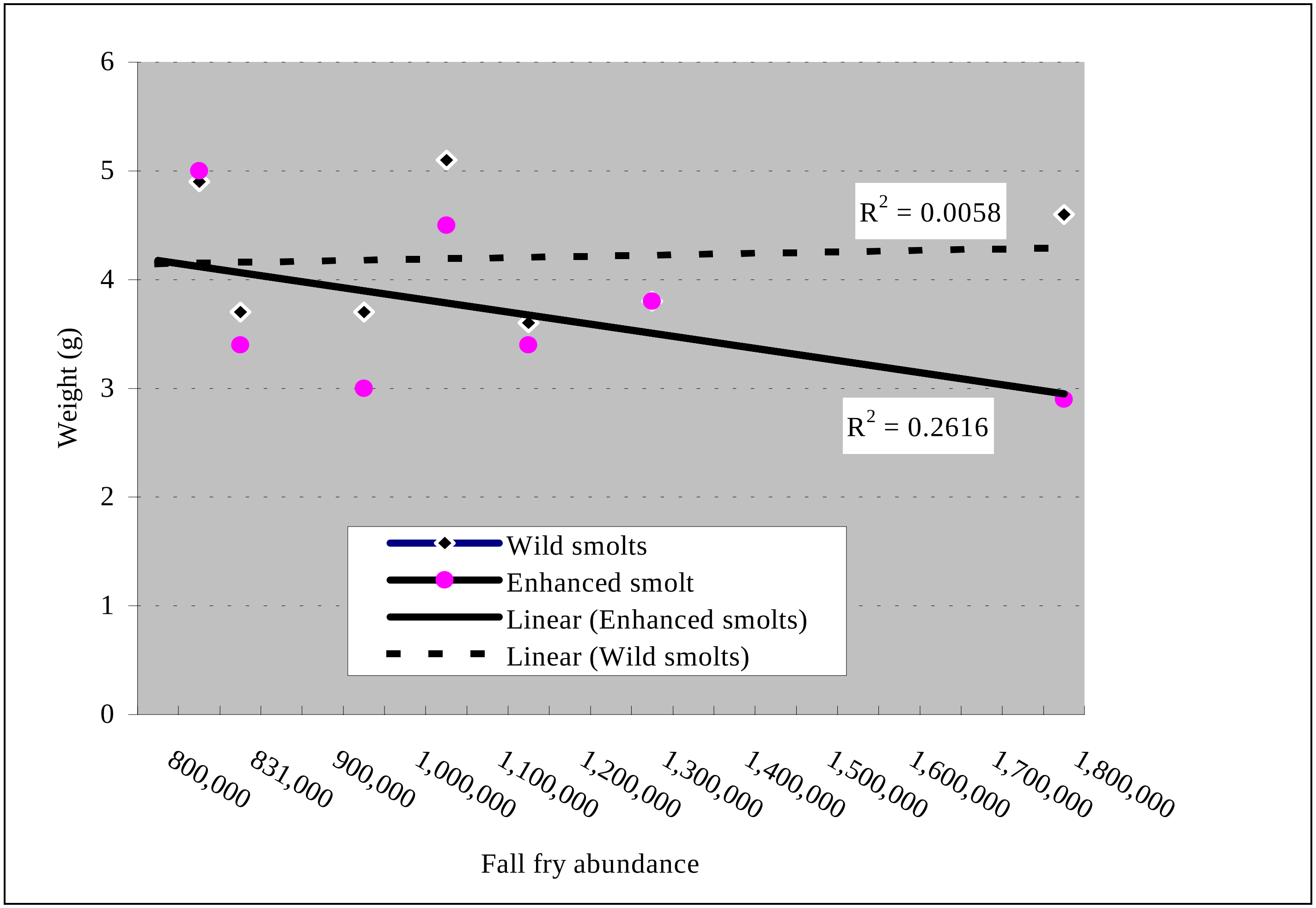

Figure 2. Average age 1+ smolt weight and fall fry abundance at Tatsamenie Lake, 1992 - 1999.

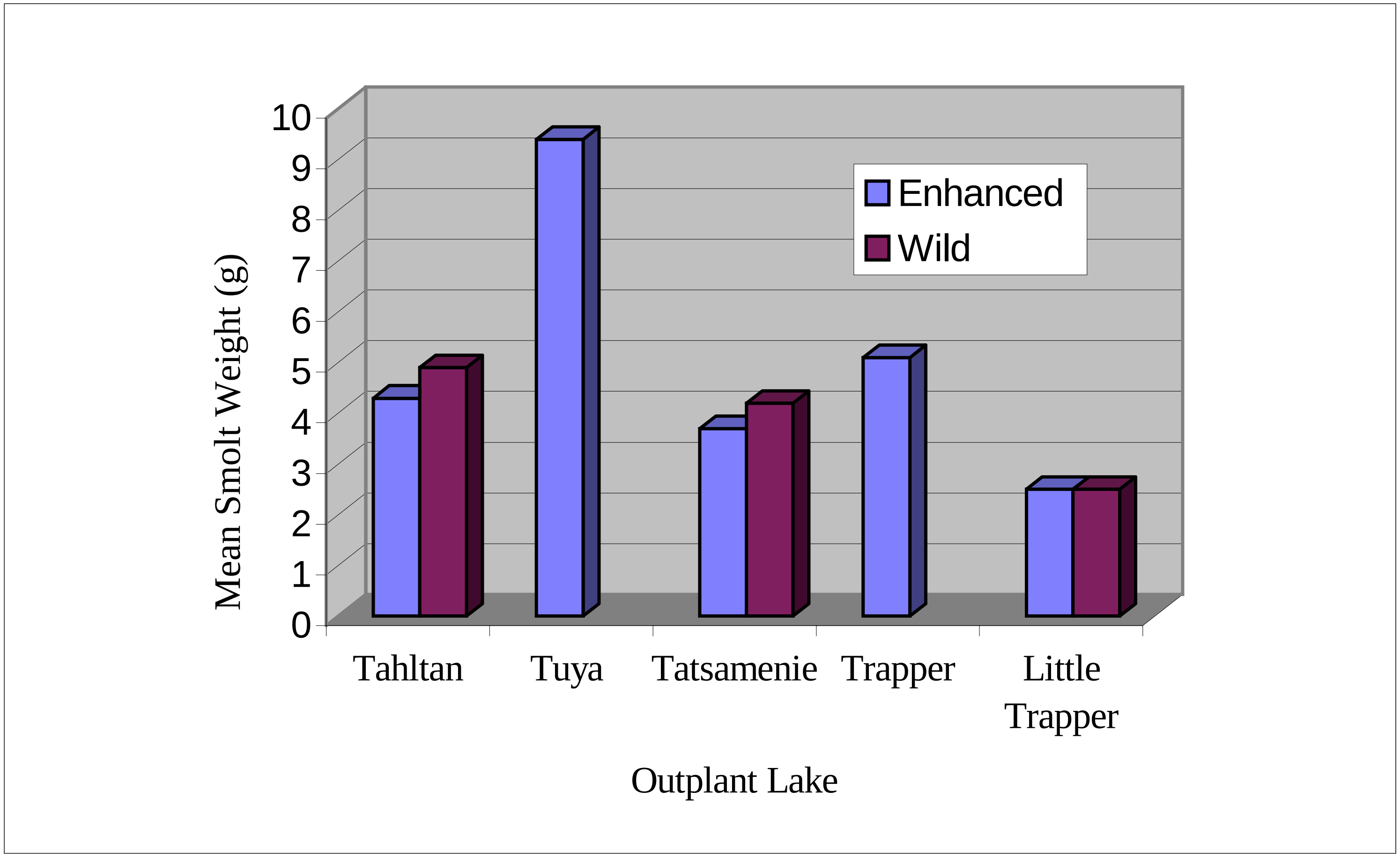

Figure 3. Combined average weight of age 1+ sockeye smolts sampled from transboundary outplant lakes, 1990 - 1999.

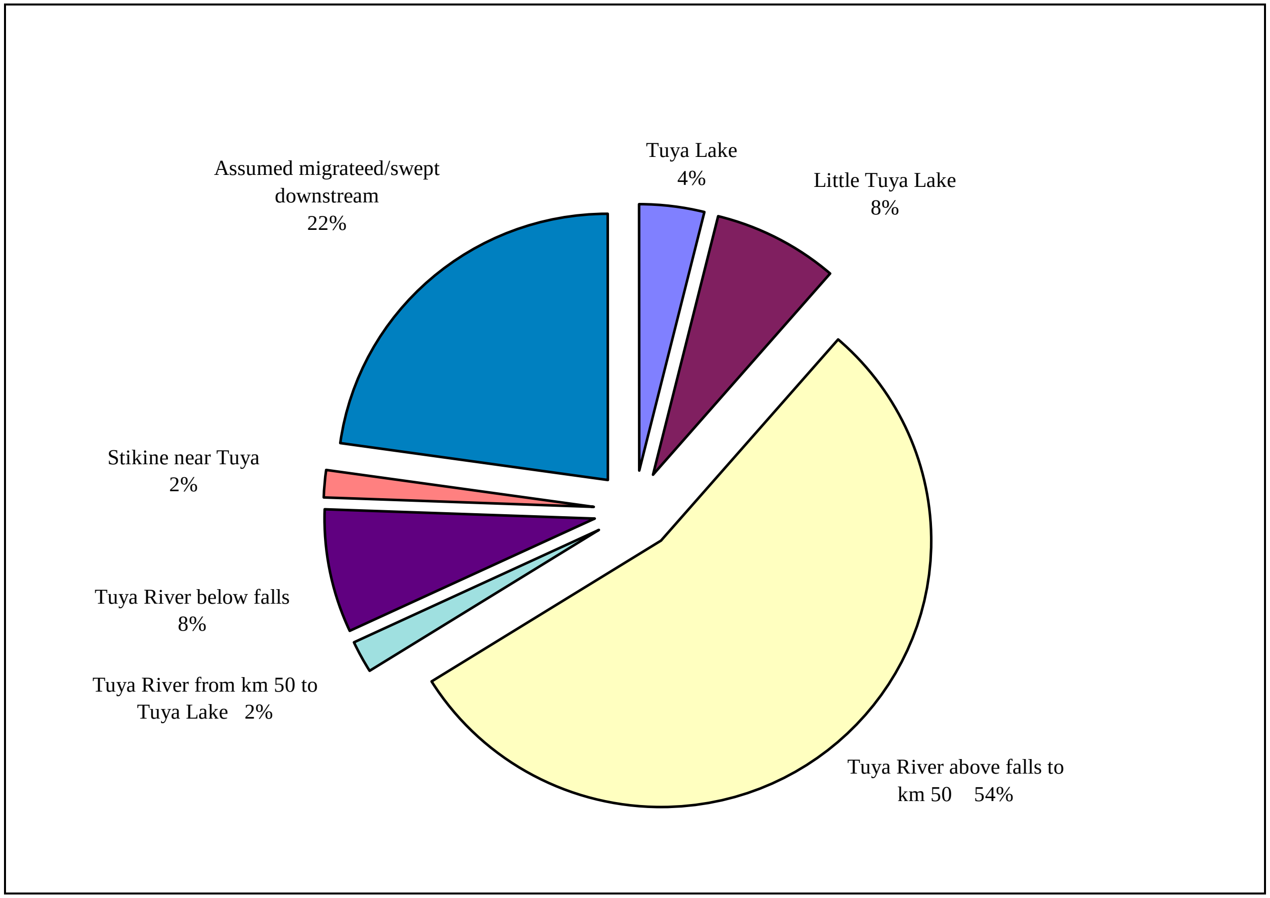

Figure 4. Proportional distribution of Tuya River radio tagged sockeye released above the Tuya River Barrier.

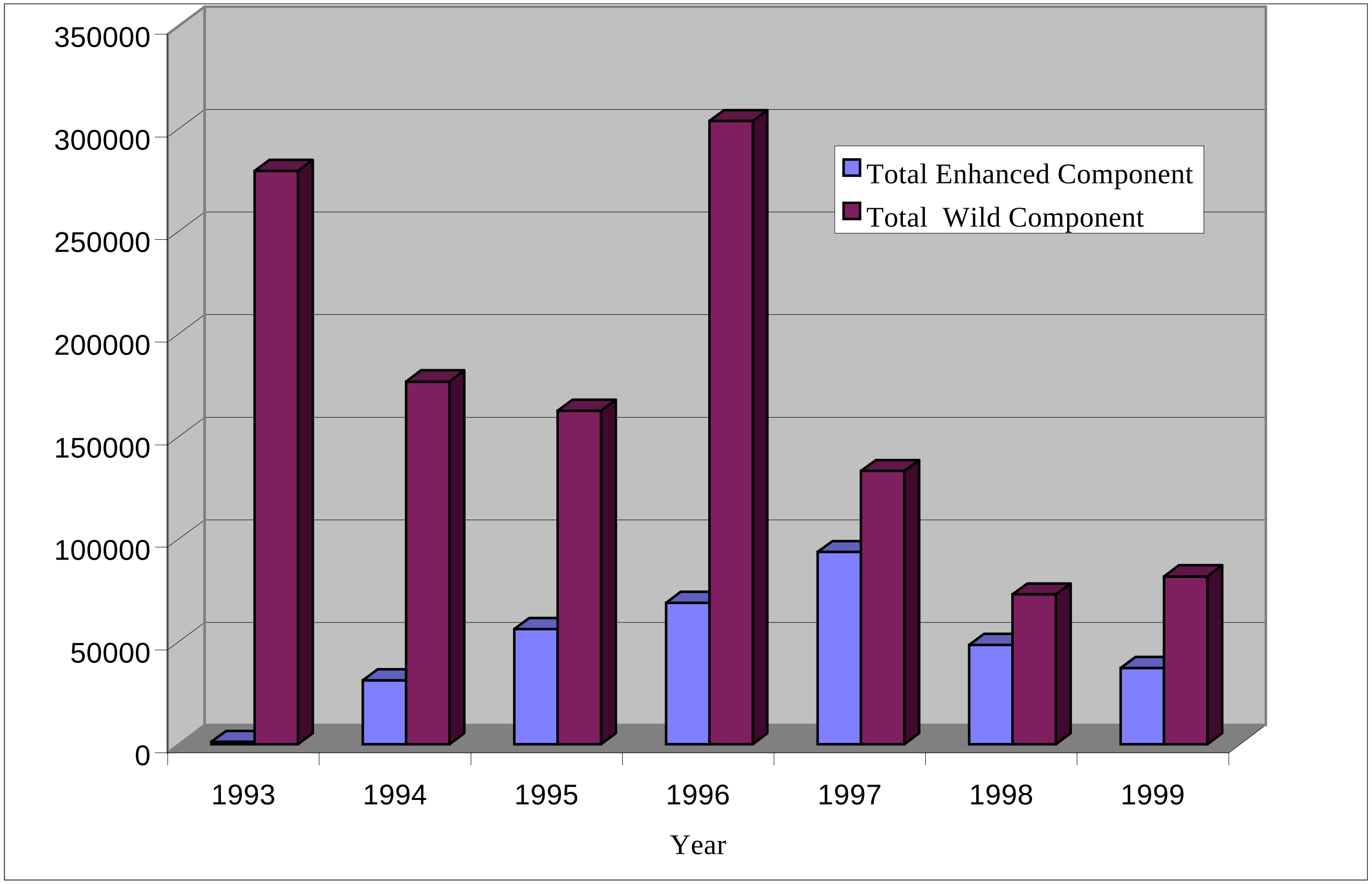

Figure 5. Wild and enhanced adult sockeye production from the Stikine River, 1993 – 1999.

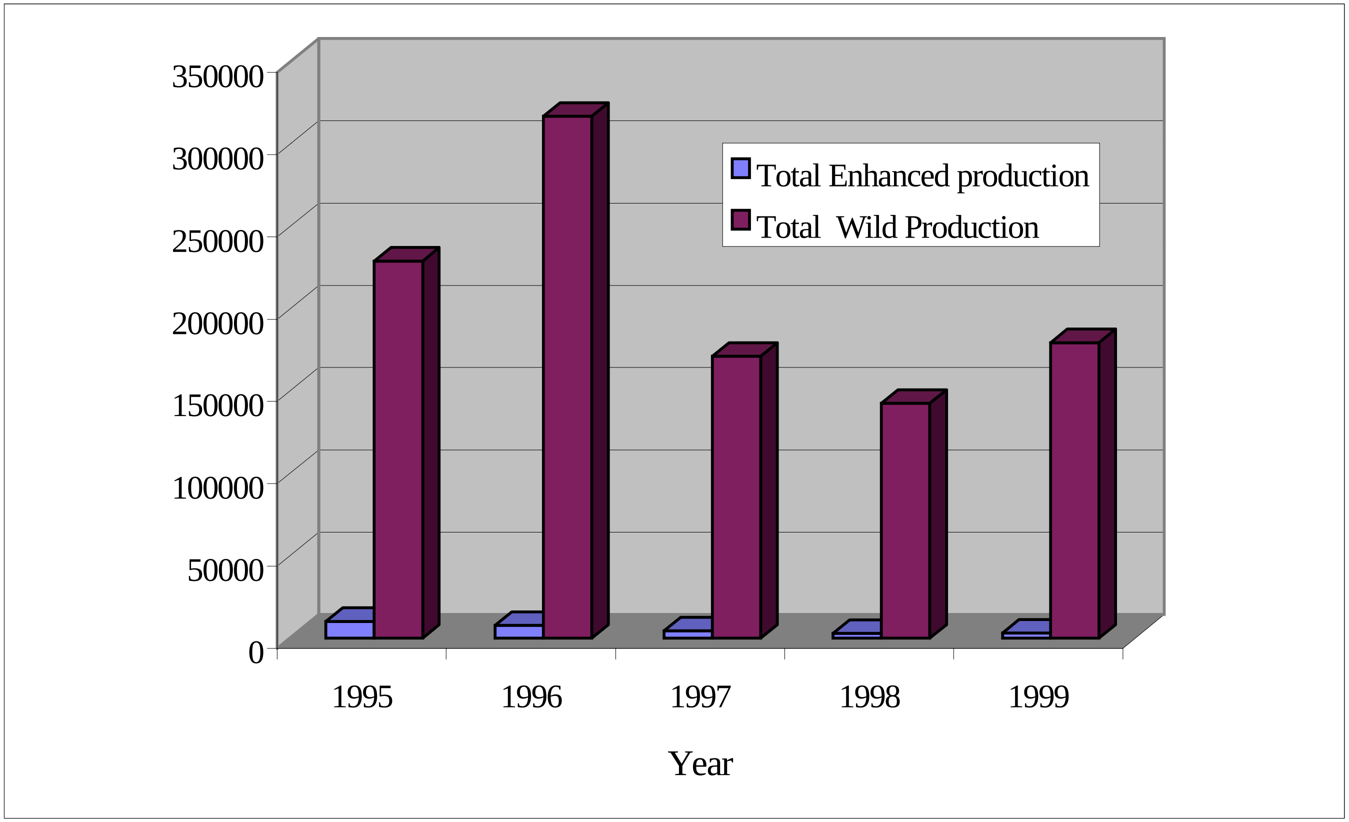

Figure 6. Enhanced and wild adult sockeye production from the Taku River, 1995 –1999.

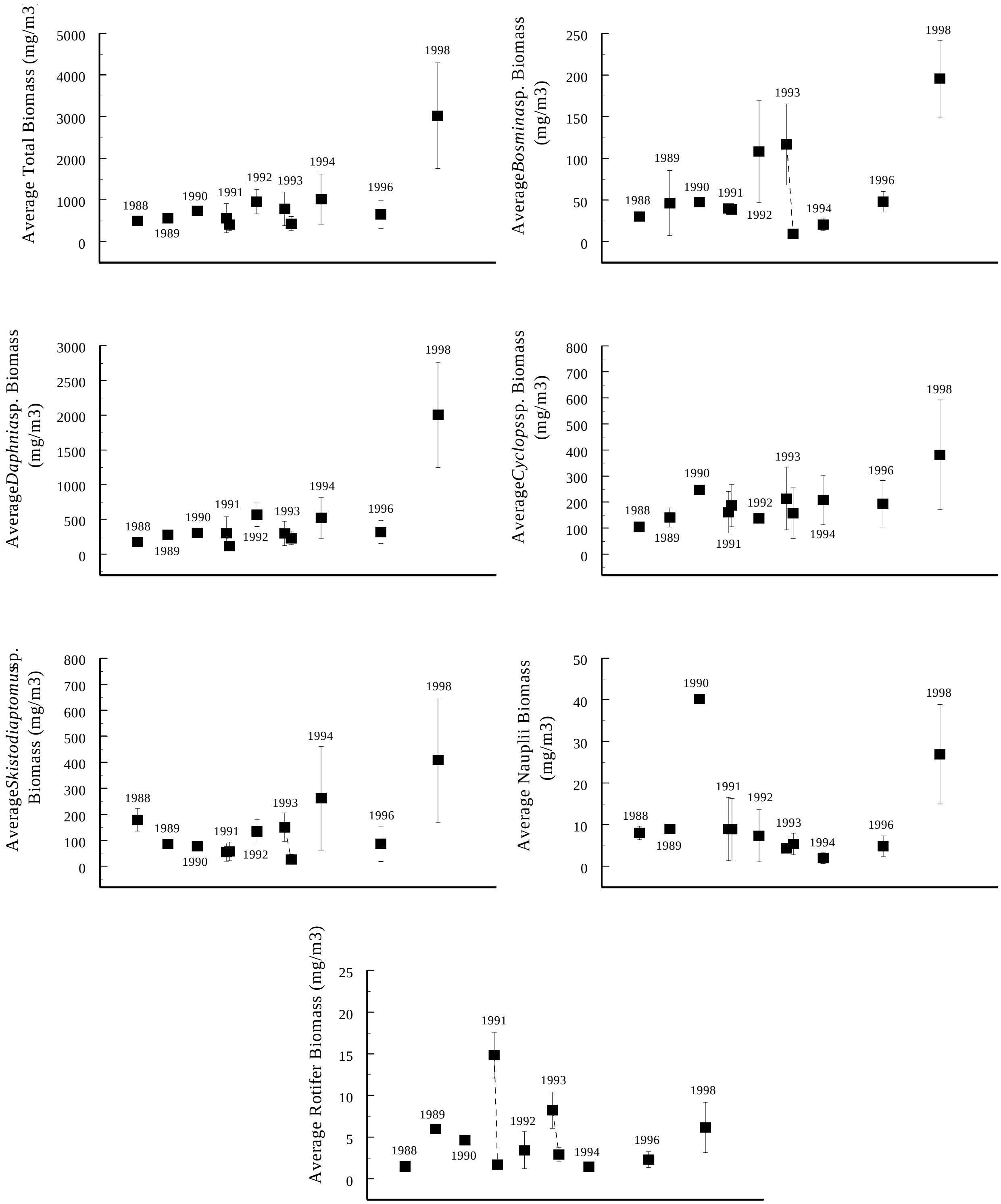

Figure 7. Tahltan Lake. Index of average biomass (mg/m^3) of zooplankton groups in August and September samples taken from 1988 to 1998.

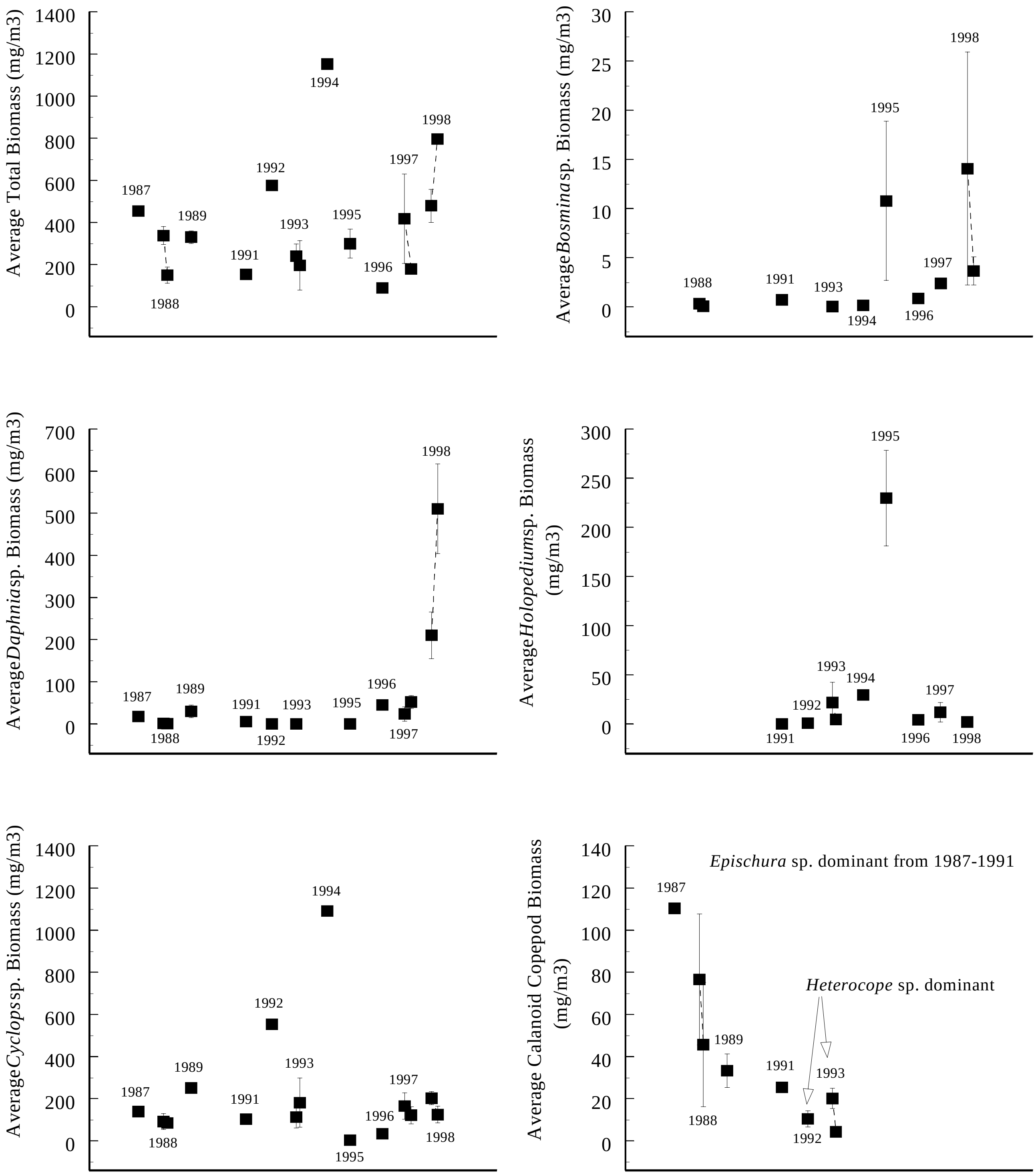

Figure 8. Tuya Lake. Index of average biomass (mg/m^3) of zooplankton groups in August and September samples taken from 1987 to 1998.

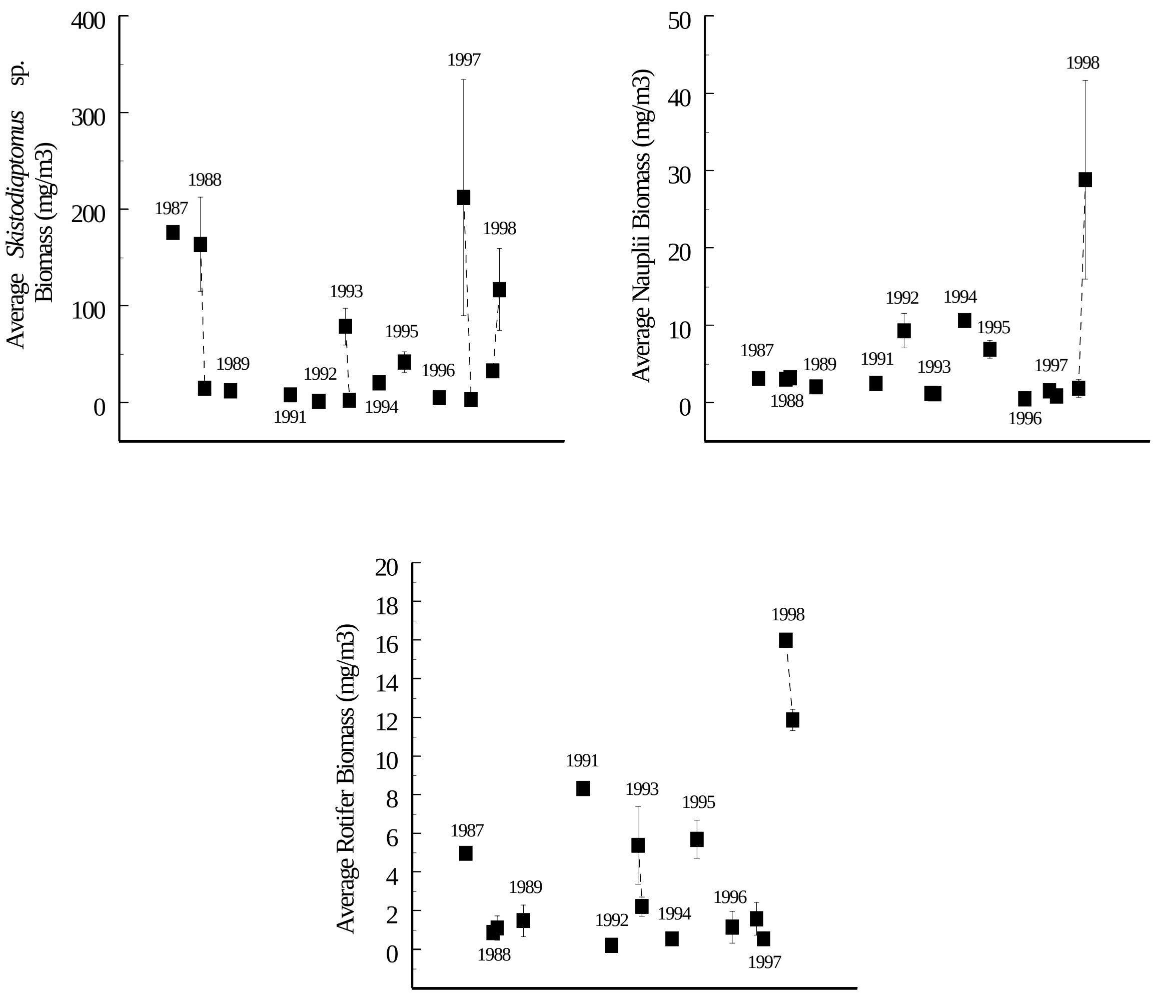

Figure 8. Continued. Tuya Lake. Index of average biomass (mg/m^3) of zooplankton groups in August and September samples taken from 1987 to 1998.

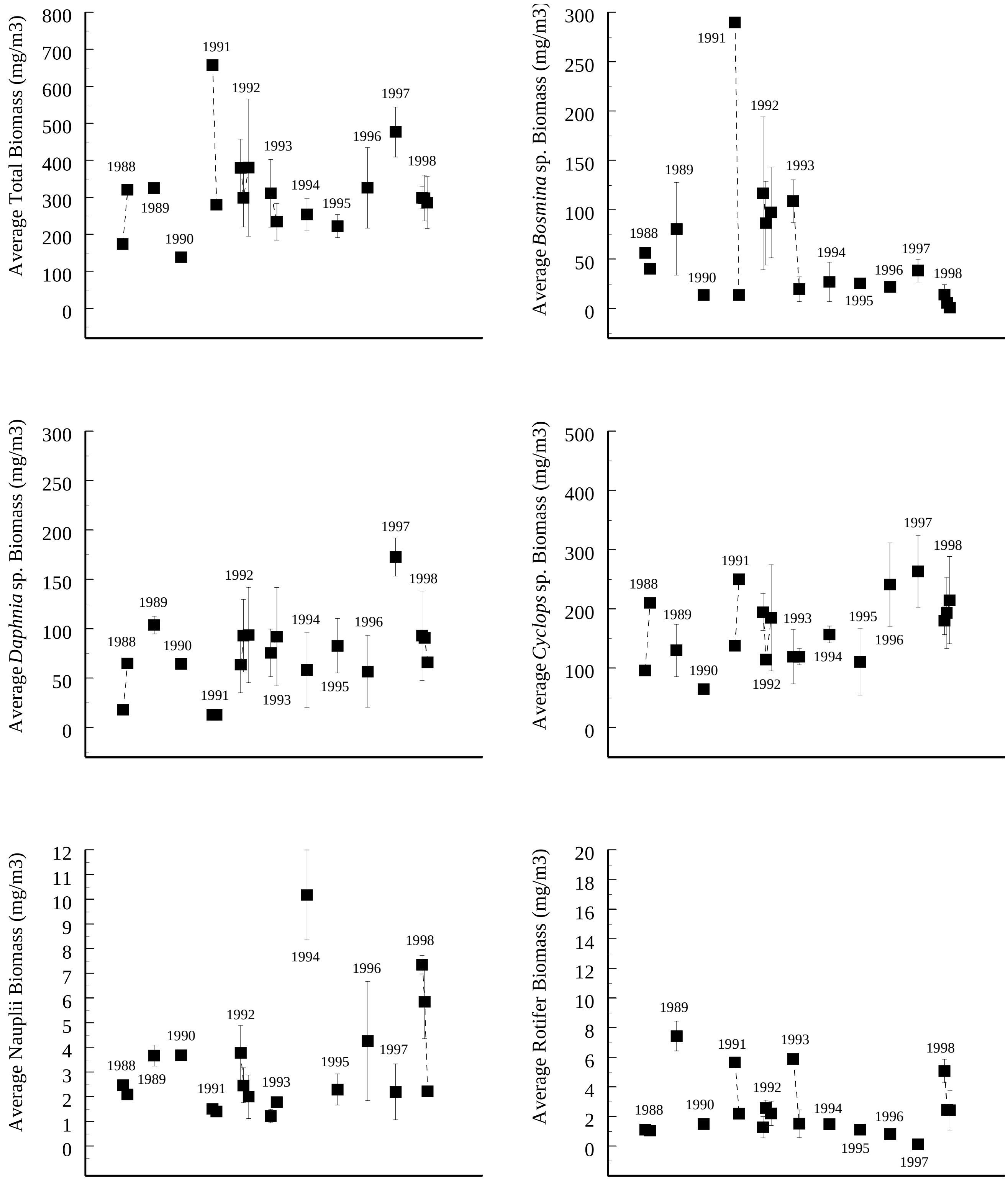

Figure 9. Tatsamenie Lake. Index of average biomass (mg/m^3) of zooplankton groups in August and September samples taken from 1988 to 1998.

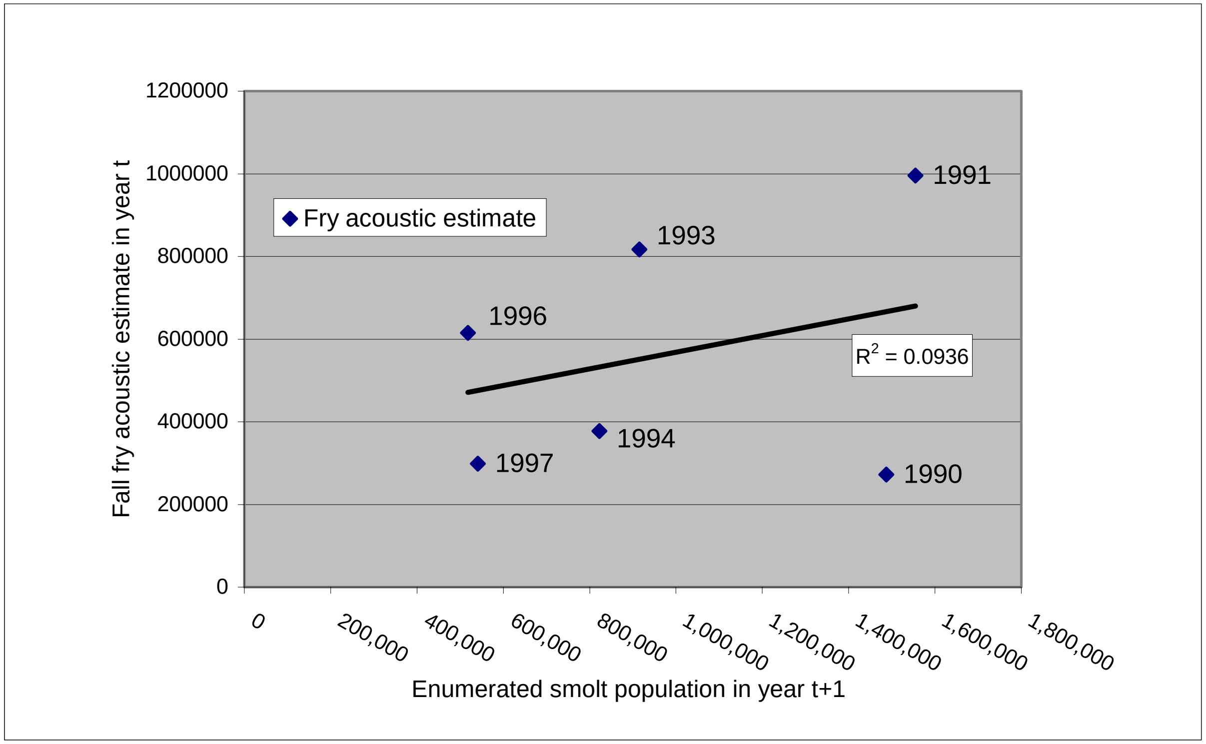

Figure 10. Tahltan Lake fall fry acoustic estimate in year t and enumerated smolt population in year t+1.

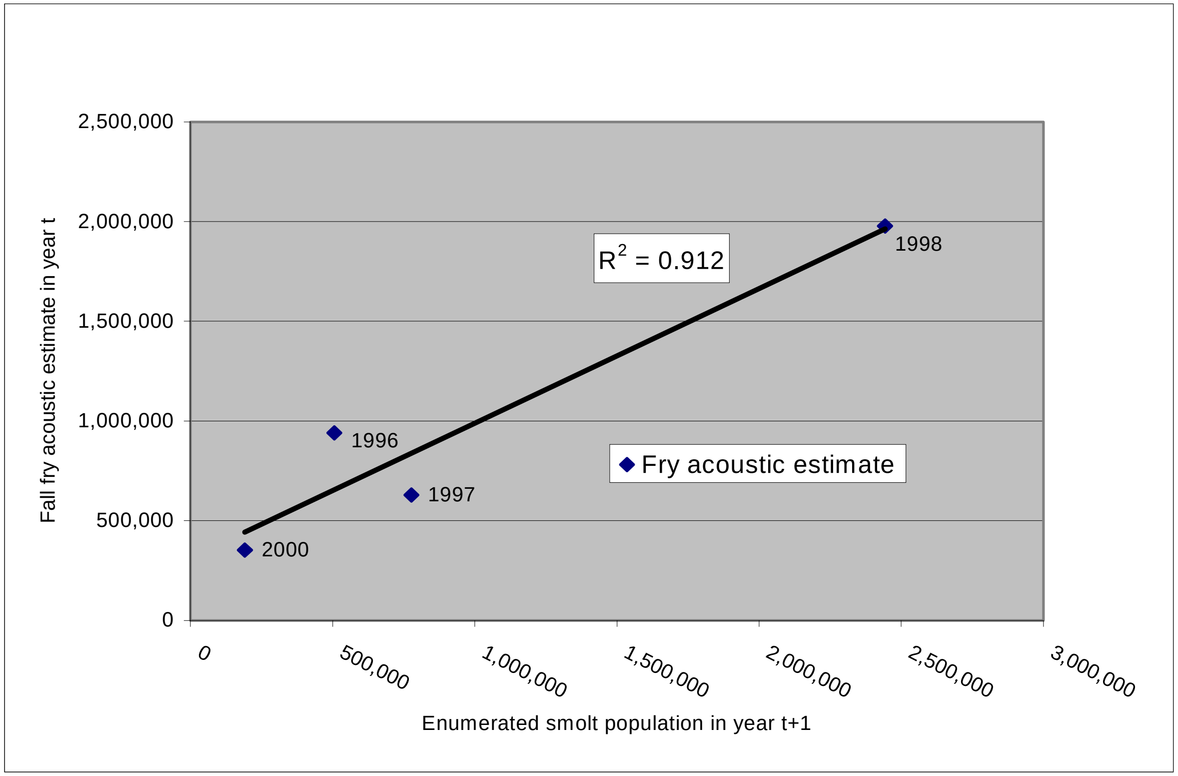

Figure 11. Tatsamenie Lake fall fry acoustic estimate in year t and smolt population estimate in year t+1.
Note: Year 2000 smolt estimate is preliminary.

Tables

Table 1. Summary of results of Tahltan Lake outplant projects, egg-take to outplanted fry stages, 1989 to 1999.

Brood Year	Total no. eggs taken ($x10^6$)	Eggs taken ($x10^6$) for Tahltan Lake	Egg Take Target($x10^6$)	No. fry planted ($x10^6$)	Percent Fertilized	Fertilized egg to planted fry	Green egg to planted fry
1989[a]	2.955	2.955	3.0	1.042	70%	50%	35%
1990	4.511	4.511	5.0	3.585	82%	96%	79%
1991	4.246	1.514	5.0	1.415	95%	98%	94%
1992	4.901	2.154	5.4	1.947	92%	98%	90%
1993	6.140	0.969	6.0	0.904	n/a	n/a	93%
1994	4.182	1.326	6.0	1.143	n/a	n/a	86%
1995	6.891	3.008	6.0	2.300	95%	80%	76%
1996	6.200	3.100	6.0	2.200	94%	75%	71%
1997	3.200	2.725	6.0	1.900	90%	77%	70%
1998	4.300	1.998	6.0	1.671	97%	86%	84%
1999	3.826	2.497	6.0		90%		
Avg. 1989-99	4.753	2.426	5.440	1.811	89%	83%	78%

[a] The values given here for BY 1989 differ slightly from those reported previously (PSC 1991) as a result of minor corrections to the data.

Table 2. Summary of results of Tuya Lake outplant projects, egg-take to outplanted fry stage, 1991 to 1999.

Brood year	No. eggs taken for Tuya ($x10^6$)	Total no. eggs taken[a] ($x10^6$)	Egg Take target ($x10^6$)	No. fry planted ($x10^6$)	Survival		
					Percent fertilized	Fertilized egg to planted fry	Green egg to planted fry
1991	2.732	4.246	5.0 - 6.0	1.632	95%	63%	60%
1992	2.747	4.901	5.4	1.990	92%	78%	72%
1993	5.171	6.140	6.0	4.691	n/a	n/a	91%
1994	2.765	4.182	6.0	2.267	87%	94%	81%
1995	3.883	6.891	6.0	2.500	95%	73%	64%
1996	3.200	6.200	6.0	2.611	94%	86%	77%
1997	0.475	3.200	6.0	0.433	90%	81%	72%
1998	2.100	4.360	6.0	1.603	96%	80%	76%
1999	1.008	3.826	6.0		90%		
Average	2.676	4.883		2.216	92%	79%	74%

[a] The values given here are for eggs taken from Tahltan Lake broodstock for outplants to both Tuya and Tahltan lakes.

Table 3. Summary of results of Tatsamenie Lake outplant projects, egg-take to outplanted fry stages, 1990 to 1999.

Brood-year	No. eggs taken ($x10^6$)	Egg Take Target ($x10^6$)	No. fry planted ($x10^6$)	Survival		
				Percent Fertilized	Fertilized egg to planted fry	Green egg to planted fry
1990	0.985	2.5	0.673	78%	88%	68%
1991	1.360	1.5	1.232	93%	98%	91%
1992	1.486	1.75	0.909	86%	71%	61%
1993	1.144	2.5	0.521	n/a	n/a	45%
1994	1.229	2.5	0.898	n/a	n/a	73%
1995	2.408	2.5	1.700	84%	84%	72%
1996	5.142	5.0	3.900	92%	82%	76%
1997	4.979	5.0	3.596	94%	77%	74%
1998	2.560	2.5	1.769	92%	75%	69%

Table 4. Tahltan Lake. Numbers captured, mean lengths and weights, and percentages of enhanced and wild sockeye salmon juveniles from surveys from 1992 to 1999.

		Wild fry						***Enhanced fry***					
Sampling date	**Capture method**	**Mean length (mm)**	**95%CI**	**Mean weight (g)**	**95%CI**	**n**	**%**	**Mean length (mm)**	**95%CI**	**Mean weight (g)**	**95%CI**	**n**	**%**
09-Jun-92	stocking	.	.	.	.	.	.	.	.	0.13	0.00	.	
23-Jun-92	beach seine	31.7	1.2	0.26	0.05	72	90	29.6	1.8	0.17	0.04	8	10
29-Jul-92	beach seine	30.7	1.3	0.22	0.06	71	95	33.3	5.9	0.31	0.25	4	5
29-Jul-92	trawl	51.3	3.8	1.45	0.35	21	88	53.0	28.7	1.51	2.47	3	13
20-Aug-92	beach seine	27.6	0.6	0.11	0.01	12	100	.	.	.	.	0	0
03-Oct-92	trawl	60.7	4.0	2.37	0.48	32	86	62.4	17.2	2.72	1.65	5	14
17-Jun-93	stocking	.	.	.	.	.		.	.	0.13	0.00	.	
03-Aug-93	beach seine	29.2	0.3	0.15	0.01	95	99	28.0	.	0.14	.	1	1
19-Sep-93	trawl	61.0	2.2	2.57	0.27	93	58	61.6	1.6	2.50	0.21	68	42
26-Jun-94	stocking	.	.	.	.	.		.	.	0.13	0.00	.	
19-Sep-94	beach seine	54.6	15.7	2.10	1.42	8	100	.	.	.	.	0	0
19-Sep-94	trawl	53.3	6.2	1.69	0.65	16	94	63.0	.	2.63	.	1	6
29-Jun-95	stocking	.	.	.	.	.		.	.	0.13	0.00	.	
1995	no fry sampling conducted in 1995												
20-Jun-96	stocking	.	.	.	.	.		.	.	0.12	0.00	.	
19-Sep-96	beach seine	43.4	3.6	0.95	0.23	59	86	58.5	2.3	1.79	0.33	10	14
19-Sep-96	trawl	57.0	2.3	1.99	0.26	56	64	58.6	1.6	1.95	0.16	31	36
21-Jun-97	stocking	.	.	.	.	.		.	.	0.14	0.00	.	
29-Sep-97	trawl	66.8	1.7	3.70	0.32	58	37	67.6	0.7	3.60	0.13	100	63
10-Jun-98	stocking	.	.	.	.	.			.	0.12	0.00	.	
1998	no fry sampling conducted in 1998												
31-May-99	stocking	.	.	.	.	.		.	.	0.13	0.00	.	
in-lake 1999	no beach seines were conducted; no fry were caught in trawls												

[a] Weights have been adjusted upwards for shrinkage in preservative of 94% denatured ethanol.
Fresh weight = preserved weight/0.841.

Table 5. Tuya Lake. Numbers captured, mean lengths and weights[a] (and 95% confidence intervals) and percentages of enhanced and unmarked sockeye salmon juveniles surveys from 1992 to 1999.

		Enhanced fry				
Date	**Capture method**	**Mean length (mm)**	**95 % CI**	**Mean weight (g)**	**95 % CI**	**n**
19-Jun-92	stocking	.	.	0.13	0.00	.
24-Jun-92	beach seine	27.7	0.2	0.14	0.00	150
25-Jul-92	beach seine	32.3	0.6	0.27	0.02	150
24-Aug-92	beach seine	63.2	4.8	2.57	0.66	5
18-Sep-92	beach seine	no fry caught in beach seines				
18-Sep-92	trawl	70.1	4.3	3.60	0.81	10
27-Jun-93	stocking	.	.	0.13	0.00	.
02-Sep-93	beach seine	no fry caught in beach seines				
02-Sep-93	trawl	57.8	10.5	2.15	1.32	5
03-Jul-94	stocking	.	.	0.13	0.00	.
05-Sep-94	beach seine	no fry caught in beach seines				
05-Sep-94	trawl	60.5	1.3	2.40	0.17	75
27-Jun-95	stocking	.	.	0.13	0.00	.
01-Aug-95	beach seine	no fry caught in beach seines				
12-Sep-95	beach seine	no fry caught in beach seines				
12-Sep-95	trawl	67.6	2.2	3.38	0.37	20
27-Jun-96	stocking	.	.	0.11	0.00	.
26-Jul-96	beach seine	only 7 fry caught in beach seines (not processed)				
12-Sep-96	beach seine	no fry caught in beach seines				
12-Sep-96	trawl	57.4	1.6	1.91	0.16	51
27-Jun-97	stocking	.	.	0.14	0.00	.
03-Aug-97	beach seine	42.2	0.7	0.75	0.04	129
25-Sep-97	beach seine	no fry caught in beach seines				
25-Sep-97	trawl	72.0	2.5	4.04	0.32	6
26-Jun-98	stocking	.	.	0.12	0.00	.
02-Aug-98	beach seine	no fry caught in beach seines				0
19-Sep-98	beach seine	no fry caught in beach seines				0
19-Sep-98	trawl	only one fry caught in 8 trawls			.	0
26-Jun-99	stocking	.	.	0.12	0.00	.
1-Aug-99	beach seine	38.4	1.4	0.55	0.07	71
14-Sep-99	trawl	no fry caught in 5 trawls			.	0

	Unmarked fry					
Sampling date	**Capture method**	**Mean length (mm)**	**95% CI**	**Mean weight (g)[a]**	**95% CI**	**n**
1-Aug-99	beach seine	38.4	1.4	0.55	0.07	44
14-Sep-99	trawl	no fry caught in 5 trawls			.	0

[a] Weights have been adjusted upwards for shrinkage in preservative of 94% denatured ethanol (fresh weight = preserved weight/0.841.

Table 6. Tatsamenie Lake. Mean lengths, weights, and 95% confidence intervals (CI) of wild and enhanced sockeye fry captured by beach seine and trawl net from 1992 through 1999.

		Wild fry						*Enhanced fry*					
Sampling date	**Capture method**	**Mean length (mm)**	**95% CI**	**Mean weight (g)[a]**	**95% CI**	**n**	**%**	**Mean length (mm)**	**95% CI**	**Mean weight (g)[a]**	**95% CI**	**n**	**%**
21-Jun-92	beach seine	33.4	0.4	0.28	0.02	100	100	.	.	.	.	0	0
24-Jun-92	stocking	.	.	.	.	.		.	.	0.15	.	.	
01-Aug-92	beach seine	36.0	0.7	0.29	0.02	116	93	33.4	1.9	0.20	0.04	9	7
01-Aug-92	trawl age 0+	36.0	32.3	0.54	1.78	3	100	.	.	.	.	0	0
21-Aug-92	beach seine	50.2	2.0	1.33	0.19	89	98	48.5	57.2	1.14	5.14	2	2
28-Sep-92	beach seine	35.3	2.7	0.36	0.11	32	97	30.0	.	0.19	.	1	3
28-Sep-92	trawl age 0+	50.9	.	1.03	.	49	92	48.3	.	0.77	.	4	8
10-Jul-93	stocking	.	.	.	.	.		.	.	0.13	.	.	
01-Aug-93	beach seine	37.4	1.2	0.47	0.05	95	96	34.3	11.1	0.36	0.39	4	4
14-Sep-93	beach seine	33.5	2.8	0.28	0.09	10	91	41.0	.	0.49	.	1	9
14-Sep-93	trawl age 0+	47.9	1.2	1.10	0.08	102	86	43.8	4.1	0.89	0.45	16	14
14-Jul-94	stocking	.	.	.	.	.		.	.	0.15	.	.	
26-Jul-94	beach seine	44.3	1.5	0.89	0.09	119	98	31.5	6.4	0.21	0.30	2	2
15-Sep-94	beach seine	38.4	4.8	0.55	0.22	16	94	55.0	.	1.46	.	1	6
15-Sep-94	trawl age 0+	60.0	2.6	2.43	0.32	50	98	55.0	.	1.93	.	1	2
20-Jul-95	stocking	.	.	.	.	.		.	.	0.15	.	.	
28-Jul-95	beach seine	36.7	1.4	0.46	0.06	37	48	29.1	0.7	0.17	0.01	40	52
19-Sep-95	trawl age 0+	48.4	2.5	1.16	0.19	39	91	46.5	10.3	1.00	0.67	4	9
20-Jun-96	stocking	.	.	.	.	.		.	.	0.11	.	.	
23-Jul-96	beach seine	31.4	0.5	0.21	0.02	186	93	31.4	1.4	0.23	0.05	13	7
19-Sep-96	beach seine	38.9	1.8	0.54	0.14	52	93	47.5	16.8	0.98	1.08	4	7
19-Sep-96	trawl age 0+	45.2	1.4	0.86	0.11	51	94	50.3	16.9	1.21	0.99	3	6

[a] Weights have been adjusted upwards for shrinkage in preservative of 94% denatured ethanol (fresh weight = preserved weight/0.841).

Table 6. (Continued) Tatsamenie Lake sockeye fry mean lengths, weights, and 95% confidence intervals (CI) for wild and enhanced fry captured by beachseine and trawl net from 1992 through 1999.

		Wild fry						***Enhanced fry***					
Sampling date	**Capture method**	**Mean length (mm)**	**95% CI**	**Mean weight (g)[a]**	**95% CI**	**n**	%	**Mean length (mm)**	**95% CI**	**Mean weight (g)[a]**	**95% CI**	**n**	**%**
22-Jun-97	stocking	.	.	.	.	.		.	.	0.17	.	.	
26-Jun-97	beach seine	33.1	0.6	0.27	0.02	126	62	29.8	0.3	0.16	0.01	78	38
25-Jul-97	beach seine	36.0	0.6	0.41	0.03	228	65	35.8	0.5	0.39	0.02	125	35
04-Sep-97	beach seine	45.5	1.4	0.96	0.13	124	93	48.6	7.6	1.23	0.83	9	7
04-Sep-97	trawl	44.9	1.8	1.00	0.17	85	89	49.5	6.0	1.32	0.59	10	11
01-Oct-97	beach seine	38.0	2.3	0.55	0.20	42	100	.	.	.	.	0	0
01-Oct-97[b]	trawl	68.9	2.2	4.20	0.42	88	90	76.2	4.1	5.64	1.00	10	10
22-Jun-98	stocking	.	.	.	.	.		.	.	0.14	.	.	
30-Jun-98	beach seine	33.9	1.4	0.29	0.05	93	52	30.2	0.6	0.17	0.02	87	48
19-Jul-98	beach seine	36.7	1.4	0.45	0.08	82	65	36.2	0.9	0.39	0.04	45	35
05-Aug-98	beach seine	38.8	4.4	0.58	0.28	23	61	46.1	3.5	0.88	0.17	15	39
23-Aug-98	beach seine	31.3	1.0	0.22	0.03	52	95	45.0	7.5	0.74	0.58	3	5
13-Sep-98	beach seine	48.3	1.8	0.98	0.12	47	85	51.4	2.9	1.20	0.20	8	15
23-Sep-98	trawl	43.8	1.0	0.80	0.07	134	92	44.2	4.5	0.81	0.23	11	8
03-Oct-98	beach seine	45.0	4.7	1.23	0.44	48	84	54.2	8.8	1.51	0.66	9	16
15-Oct-98	trawl age 0+	54.1	2.2	1.54	0.27	79	89	59.2	5.2	2.20	0.77	10	11
04-Jun-99	stocking	.	.	.	.	.		.	.	0.15	.	.	
14-Jun-99	beach seine	31.6	0.4	0.17	0.01	57	70	29.9	0.5	0.13	0.01	24	30
02-Jul-99	beach seine	34.2	0.8	0.27	0.03	74	62	35.3	0.8	0.27	0.04	45	38
22-Jul-99	beach seine	34.7	1.1	0.35	0.05	65	79	42.2	1.1	0.66	0.06	17	21
10-Aug-99	beach seine	37.9	1.6	0.43	0.07	91	91	44.0	1.7	0.66	0.10	9	9
31-Aug-99	beach seine	42.6	5.4	0.77	0.35	16	100	.	.	.	.	0	0
17-Sep-99	beach seine	37.8	1.5	0.41	0.06	72	99	50.0	.	0.88	.	1	1
05-Oct-99	beach seine	37.7	2.2	0.42	0.08	27	100	.	.	.	.	0	0
15-17-Oct-99	trawl age 0+	48.0	1.8	0.82	0.11	25	100	.	.	.	.	0	0

[a] Weights have been adjusted upwards for shrinkage in preservative of 94% denatured ethanol (fresh weight = preserved weight/0.841.)

[b] 1-Oct-97 trawl figures are for age 0+ and 1+ combined.

Table 7. Little Trapper Lake. Numbers captured, mean lengths and weights[a], and percentages of enhanced and wild fry in samples of sockeye salmon juveniles from surveys in 1995.

	Date	Gear	Age	Length (mm)	Weight (g)	n	%
Wild	24-Jul	Beachseine	1	43	0.63	74	100
Enhanced	24-Jul	Beachseine	-	-	-	-	-
Wild	Sept. 14-15	Trawl	1	52	1.21	99	99
Enhanced	Sept. 14-15	Trawl	1	48	0.89	1	1

[a] Weights not corrected for preservative shrinkage.

Table 8. Trapper Lake. Numbers captured, mean lengths and weights[a], and percentages of enhanced and wild fry in samples of sockeye salmon from surveys in 1995.

	Date	Gear	Age	Length (mm)	Weight (g)	n	%
Wild	26-Jul	Beachseine	1	58	0.46	98	98
Enhanced	26-Jul	Beachseine	1	58	1.81	2	2
Wild	Sept. 16	Beachseine	1	43	0.59	4	8
Enhanced	Sept. 16	Beachseine	1	54	1.33	49	92
Wild	Sept. 16	Trawl	1	39	0.43	6	46
Wild	Sept. 16	Trawl	2	68	2.89	4	31
Enhanced	Sept. 16	Trawl	1	54	1.24	2	15
Enhanced	Sept. 16	Trawl	2	n/a	n/a	0	0
Unknown	Sept. 16	Trawl	3	109	13.99	1	8

[a] Weights not corrected for shrinkage

Table 9. Tahltan Lake smolt population estimates[a] and percent by age class, 1991-1999.

Sample Year	Smolt Sample Size	Wild						Enhanced					
		%			Population Estimate			%			Population estimate		
		1+	2+	3+	1+	2+	3+	1+	2+	3+	1+	2+	3+
1991	1210	75.37	6.51	0.18	1,120,941	96,820	2,636	17.94	0.00	0.00	266,868	0	0
1992	1143	42.28	5.76	0.18	656,666	89,405	2,732	49.76	2.03	0.00	772,782	31,542	0
1993[b]	1289	86.01	1.72	0.00	2,799,607	55,955	0	11.36	0.91	0.00	369,892	29,591	0
1994	736	60.00	7.84	0.00	549,077	71,731	0	32.16	0.00	0.00	294,310	0	0
1995	783	90.44	2.84	0.00	743,668	23,372	0	5.43	1.29	0.00	44,620	10,624	0
1996	735	85.95	4.36	0.00	1,340,504	67,975	0	9.29	0.40	0.00	144,843	6,240	0
1997	555	61.34	5.78	0.00	317,850	29,931	0	31.29	1.59	0.00	162,162	8,259	0
1998	682	53.20	7.15	0.00	287,747	38,674	0	38.90	0.75	0.00	210,393	4,052	0
1999	504	59.29	2.19	0.00	451,796	16,694	0	38.34	0.18	0.00	292,167	1,377	0
Average 1991-99		68.21	4.90	0.04	918,651	54,506	596	26.05	0.80	0.00	284,226	10,187	0

[a] Smolt population estimate derived from Tahltan Lake smolt weir program.

[b] Does not include a count of 1899 age 4+ smolts.

Table 10. Tahltan Lake smolts. Length and weight characteristics by age class for the wild and enhanced sockeye smolts sampled at the Tahltan Lake counting fence, 1984-99.

	Total	Smolt	Wild				Enhanced				
	Smolt	Sample	Weight (g)		Length (mm)		Weight (g)		Length (mm)		Lake
Year	Estimate	Size	1+	2+	1+	2+	1+	2+	1+	2+	Enrichment
1984	218,702	1254	4.81	11.57	86.2	112.1					no
1985	613,531	1187	3.75	9.31	78.8	111.5					yes
1986	244,330	1979	4.71	8.45	86.3	103.8					yes
1987	810,432	2039	6.34	10.77	85.4	111.1					no
1988	1,170,136	2637	5.75	12.11	92.1	115.7					no
1989	580,574	2243	6.02	15.85	90.5	118.3					no
1990	607,645	1444	5.93	8.97	89.0	111.0					no
1991	1,487,265	1210	5.82	11.47	90.6	112.0	5.39		88.6		no
1992	1,555,026	1143	4.77	10.17	84.8	110.1	4.63	12.00	84.3	115.0	no
1993	3,255,045	1289	4.13	10.03	80.7	105.3	3.87	12.90	79.7	117.0	no
1994	915,119	736	4.99	8.63	84.3	102.5	4.74		83.4		no
1995	822,284	783	4.71	13.50	83.4	116.7	4.37	11.98	81.7	113.0	no
1996	1,559,236	735	3.95	7.22	80.0	103.8	3.15	8.67	74.4	105.5	no
1997	518,202	555	3.42	6.21	77.4	95.2	3.19	5.70	76.3	93.3	no
1998	540,866	682	4.51	8.37	83.4	103.2	4.80	9.26	85.8	103.3	no
1999	762,033	822	4.74	8.94	83.8	107.8	4.60	6.50	83.4	95.0	no
Avg. 1984-99	978,777	1,296	4.9	10.10	84.8	108.8	4.30	9.57	81.96	106.0	

Table 11. Tuya Lake sockeye smolts. Length and weight characteristics[a] by age class, 1993-1999.

Sample Year	Origin	Brood-year	Age	Sample size	Percent	Length (mm)	Weight (g)
1993	Enhanced	1991	1	370	100	99.7	8.76
	Enhanced	1990	2	0			
1994	Enhanced	1992	1	432	96.0	99.0	8.99
	Enhanced	1991	2	20	4.0	135.3	22.34
1995	Enhanced	1993	1	208	97.1	95.6	9.64
	Enhanced	1992	2	4	2.9	137.0	27.35
1996	Enhanced	1994	1	235	95.9	99.5	9.70
	Enhanced	1993	2	10	4.1	133.1	24.50
1997[c]	Enhanced	1995	1	178	55.7	93.8	8.40
	Enhanced	1994	2	139	43.9	136.1	26.40
1998	Enhanced	1996	1	228	94.2	103.4	10.10
	Enhanced	1995	2	14	5.8	140.7	25.20
1999	Enhanced	1997	1	89	74.8	104.1	11.20
	Enhanced	1996	2	19	16.0	158.2	35.1
	Enhanced	1995	3	3	2.5	205.3	67.9
	Unmarked[b]	1997	1	8	6.7	96.4	9.6
Average	Enhanced		1	n/a	85.6	98.3	9.37
	Enhanced		2	n/a	12.8	140.1	26.82
	Enhanced		3	n/a	2.5	205.3	67.9
	Unmarkeed		1	n/a	6.7	96.4	9.6

[a] Population estimates have not been determined for Tuya Lake smolts; measurements are from fresh (unpreserved fish).
[b] 1999 (BY97) was the first year unmarked smolts were observed at Tuya Lake. It is assumed these fish are progeny from residual outplanted sockeye.

Table 12. Tatsamenie Lake smolts. Length and weight characteristics[a] by age class , 1992 - 1999.

Sample year	Origin	Age	Sample size	Brood year	Percent	Estimated[b] population	Length (mm)	Weight (g)
1992	Wild	1	n/a	1990	61.5	no estimate	81.0	4.9
		2	n/a	1989	32.6	no estimate	117.5	14.1
	Enhanced	1	n/a	1990	5.9	no estimate	81.6	5.0
		2	n/a	1989	n/a			
1993	Wild	1	n/a	1991	84.2	no estimate	76.3	4.6
		2	n/a	1990	9.5	no estimate	102.8	9.5
	Enhanced	1	n/a	1991	6.3	no estimate	65.2	2.9
		2	n/a	1990	0.0	-	-	-
1994	Wild	1	n/a	1992	84.1	no estimate	75.9	3.6
		2	n/a	1991	11.0	no estimate	114.7	13.3
	Enhanced	1	n/a	1992	3.1	no estimate	73.0	3.4
		2	n/a	1991	1.8	no estimate	111.4	11.5
1995	Wild	1	n/a	1993	84.8	no estimate	81.9	5.1
		2	n/a	1992	12.7	no estimate	119.3	16.1
	Enhanced	1	n/a	1993	2.0	no estimate	79.8	4.5
		2	n/a	1992	0.5	no estimate	117.0	15.2
1996	Wild	1	n/a	1994	81.0	406,714	75.0	3.7
		2	n/a	1993	15.5	77,326	124.3	16.3
	Enhanced	1	n/a	1994	2.3	14,442	69.9	3.0
		2	n/a	1993	1.3	6,705	126.8	16.9
1997	Wild	1	331	1995	67.5	no estimate	75.3	3.7
		2	45	1994	9.2	no estimate	106.3	9.6
	Enhanced	1	109	1995	22.2	no estimate	73.0	3.4
		2	5	1994	1.0	no estimate	107.0	9.5
1998	Wild	1	390	1996	82.3	2,042,661	78.2	4.1
		2	13	1995	2.8	69,495	108.2	10.2
	Enhanced	1	72	1996	14.9	331,419	82.2	4.3
		2	0	1995	0.0	0	-	-
1999	Wild	1	314	1997	63.1	455,240	75.2	3.9
		2	124	1996	24.9	236,401	114.3	12.8
	Enhanced	1	58	1997	11.6	81,544	75.0	3.6
		2	2	1996	0.4	3,455	129.0	16.2
Average	Wild	1			76.05	968,205	77.4	4.2
		2			14.78	127,741	113.4	13.2
	Enhanced	1			8.54	142,468	75.0	3.7
		2			0.84	3,387	118.2	13.3

[a]Measurement were from unpreserved fish.

[b]Population estmates were derived from smolt mark-recapture programs and age class ratios were derived from weighted samples.

Table 13. Trapper Lake smolts. Length and weight characteristics[a] by age class, 1992 - 1997.

Sample year	Age	Sample size	Broodb year	Percent	Length (mm)	Weight (g)
1992	Sampling occurred, but no smolts were captured in 1992					
1993	1	1	1991	100[c]	67.0	3.4
	2	0	1990	0	-	-
	3	0	1989	n/a		
1994	1	10	1992	26.3	71.3	3.6
	2	27	1991	71.1	107.0	12.4
	3	1	1990	2.6	142.0	26.9
1995	1	10	1993	6.1	84.7	6.0
	2	147	1992	89.1	111.0	13.7
	3	7	1991	4.2	134.6	23.9
	4	1	1990	0.6	167.0	44.7
1996	1	89	1994	87.9	93.8	7.6
	2	12	1993	12.1	121.7	17.2
1997	Sampling occurred, but no smolts were captured in 1997					
1998	Trapper Lake was not sampled in 1998 or 1999					
Average	1			40.1	79.2	5.1
	2			43.1	113.2	14.4
	3			3.4	138.3	25.4
	4			1	167.0	44.7

[a]Measurements are from fresh (unpreserved) fish.

[b] Emigrating smolt population estimates were not determined. All smolts captured were of enhanced origin.

[c] Only 1 fish captured.

Table 14. Length and weight characteristics by age class of smolt sampled at Little Trapper Lake, 1992 - 1997.

Sample year	Origin	Sample Size[c]	Age	Brood year	Percent	Length (mm)	Weight (g)
1992	Wild		1	1990	70.8	69.8	2.9
		n/a	2	1989	22.1	95.3	7.8
	Enhanced[b]		1	1990	7.1	69.9	2.9
			2	1989	No outplants until BY 1990		
1993	Wild	283	1	1991	71.0	59.0	2.1
		100	2	1990	25.0	82.3	5.0
	Enhanced	4	1	1991	1.0	54.0	1.3
		12	2	1990	3.0	86.0	5.4
1994	Wild	266	1	1992	88.8	59.9	1.7
		25	2	1991	8.4	81.3	4.0
	Enhanced	6	1	1992	2.1	54.7	1.4
		2	2	1991	0.7	70.0	2.5
1995	Wild	238	1	1993	64.1	66.5	2.8
		123	2	1992	33.1	80.9	4.8
	Enhanced	2	1	1993	0.4	69.0	3.2
		9	2	1992	2.5	110.7	13.4
1996	Wild	249	1	1994	90.4	61.6	2.0
		14	2	1993	5.2	86.0	5.2
	Enhanced	5	1	1994	1.7	69.7	3.5
		6	2	1993	2.3	124.5	19.6
1997	Wild	192	1	1995	96.0	73.9	3.4
		8	2	1994	4.0	92.1	6.7
1998	Sampling at Little Trapper Lake was discontinued in 1998.						
Average	Wild		1			65.1	2.5
			2			86.3	5.6
	Enhanced		1			63.5	2.5
			2			97.8	10.2

[a] Emigrating smolt population estimates were not determined. Measurements are from fresh (unpreserved) fish.

[b] All enhanced smolts are from outplants to Trapper Lake.

[c] Sample sizes for 1992 were not available.

Table 15. Tatsamenie Lake fall fry abundance and mean smolt length and weight by age class, 1990 - 1998.

Brood-year BY=t	Brood-year spawning escapement[a]	Fall limnetic sockeye fry abundance in t+1	Mean weight (g) of wild smolts in t+2 (age 1+)	Mean weight (g) of wild smolts in t+3 (age 2+)	Mean weight (g) of enhanced smolts in t+2 (age 1+)	Mean weight (g) of enhanced smolts in t+3 (age 2+)
1990	3,725	821,668	4.9	9.5	5.0	
1991	6,383	1,795,965	4.6	13.3	2.9	11.5
1992	4,541	1,146,054	3.6	16.1	3.4	15.2
1993	2,700	1,053,185	5.1	16.3	4.5	16.9
1994	1,740	940,100	3.7	9.6	3.0	9.5
1995	4,380	800,000	3.7	10.7	3.4	n/a
1996	6,447	1,300,000	3.8	12.8	3.8	16.2
1997	5,338	500,000	3.9	n/a	3.6	n/a
1998	4,070	352,000				
1999	1,890					
Average	4,121	316,567	4.2	12.6	3.7	13.9

[a] Tatsamenie Lake escapement estimates are derived from the Tatsamenie Lake (1994 to 1997) wier counts, minus sockeye used for broodstock, and the little Tatsamenie (1991 to 1993) wier counts less broodstock and the estimated connecting stream stock.

[b] Fall limnetic sckeye fry abundance based on fall hydroacoustic estimates.

Table 16. Tahltan Lake sockeye smolts, egg to smolt survival, 1981-1999.

Table 16 (a). Wild egg to smolt survival.

						Wild Smolt Production																Total	Egg/smolt	Egg/smolt	Egg/smolt
BROOD YEAR	WEIR # COUNT	# FEMALE EGG TK	# FEMALE OTHER	NO. FEMALES	NO. EGGS DEPOSITEDa	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Smolts	% surv 1+	% surv 2+	% surv comb
1981	50790			24744	68738832	13189	6035															19224		0.02	
1982	28257			13853	38483634	205513	106338															311851	0.53	0.28	0.81
1983	21256			8374	23262972		501158	23545														524703	2.15	0.10	2.26
1984	32777			15342	42620076			220785	126804	237												347826	0.52	0.30	0.82
1985	67326			29714	82545492				683628	113711	237											797576	0.83	0.14	0.97
1986	20280			10847	30132966					1056188	55883	3695										1115766	3.51	0.19	3.70
1987	6958			3618	10050804						524454	92969	2636	1899								621958	5.22	0.92	6.19
1988	2536			1369	3803082							513743	96820	2732								613295	13.51	2.55	16.13
1989	8316	1110		3381	9980712								1120941	89405								1210346	11.23	0.90	12.13
1990	14927	1615		7261	21492560									656666	55955							712621	3.06	0.26	3.32
1991	50135	1766		23302	65245600										2799607	71731						2871338	4.29	0.11	4.40
1992	59907	1847		33517	88920601											549077	23372					572449	0.62	0.03	0.64
1993	53362	2253	876	27153	73313100												743668	67975				811643	1.01	0.09	1.11
1994	46363	1689	4317	22764	57296988													1340504	29931			1370435	2.34	0.05	2.39
1995	42317	2425	5370	13364	33408750														317850	38674		356524	0.95	0.12	1.07
1996	52800	2226	6691	11201	32482900															287747	16694	304441	0.89	0.05	0.94
1997	12483	1140	189	4912	14244800																451796				
1998	12658	1574	209	4159	12061100																				
					TOTAL	218702	613531	244330	810432	1170136	580574	610407	1220397	750702	2855562	620808	767040	1408479	347781	326421	468490	**Avg.**	**3.38**	**0.38**	**3.79**

Table 16 (b). Enhanced egg to smolt survival.

Brood	Release	# Eggs	Smolt production										% egg to	% egg to	% egg to
year	year	to hatchery	1991	1992	1993	1994	1995	1996	1997	1998	1999	Total	smolt age 1+	smolt age 2+	smolt comb.
1989	1990	2995440	266868	31542								298410	8.91%	1.05%	9.96%
1990	1991	4510605		772782	29591							802373	17.13%	0.66%	17.79%
1991	1992	1,514,000			369892	0						369892	24.43%	0.00%	24.43%
1992	1993	2,154,000				294310	10624					304934	13.66%	0.49%	14.16%
1993	1994	969,000					44620	6346				50966	4.60%	0.65%	5.26%
1994	1995	1,326,000						144877	8259			153136	10.93%	0.62%	11.55%
1995	1996	3,008,000							162162	4052		166214	5.39%	0.13%	5.53%
1996	1997	3,100,000								210393	1377	211770	6.79%	0.04%	6.83%
1997	1998	2,725,000									292167	292167	10.72%	0.00%	
1998	1999	1,997,918													
TOTAL HATCHERY		2,496,689	266868	804324	399483	294310	55244	151223	170421	214446	293544				
TOTAL WILD			1220397	750702	2855562	620809	767040	1408340	347781	326420	468490				
COMBINED TOTAL			1487265	1555026	3255045	915119	822284	1559563	518202	540866	762034				
PROPORTION HATCHERY			0.179	0.517	0.123	0.322	0.067	0.097	0.329	0.396	0.385				
									Average			294429	11.40%	0.41%	11.94%

[a] Average fecundity of 2778 was used for years of no brood stock collection. Fecundity was determined from hatchery egg receipts for 1989-98.

[b] Smolt population estimates obtained from Tahltan Lake smolt enumeration program.

Table 17. Tatsamenie Lake sockeye egg to smolt survivals for brood years 1994,1996, and 1997.

Table 17 (a) Wild egg to smolt survival

Brood Year	Weir Count	# Female Egg take	# Female Morts	# Female Released	# Spawning Females	Fecundity	# Eggs Deposited	Wild Smolt Production 1996	1997	1998	1999	Total Smolts	Egg/smolt % surv comb	Egg/smolt % surv 1+	Egg/smolt % surv 2+
1993	4040	286	53	92	1100(est.)	3671	4038100	77326							1.91
1994	3559	381	29	108	1331	3056	4067536	406714						10.00	
1995	5780	726	32	177	3802	3796	14432392			69495					0.48
1996	9381	1244	30	160	4586	4068	18655848			2042661	236401	2279062	12.35	10.95	1.27
1997	8097	1212	142	212	1857	4113	7637841				455240			5.96	
1998	5997	648	25	189	1913	4124	7888729								
1999	2104	116	0	279	833	4241	3532753								
							Total Wild	484,040		2,112,156	691,641				
				Hatchery Contribution age 1+				14,442		331,419	81,544				
				Hatchery Contribution age 2+				6,705		0	3,456				
				Total Hatchery Contribution				21,147		331,419	85,000				
				Total Smolts[a]				505,187		2,443,575	776,641				

Table 17 (b). Enhanced egg to smolt survivals.

BY	# Eggs taken	#1+ Smolts	#2+ Smolts	% 1+	% 2+
1993	1,211,593		6,705		0.55
1994	1,228,541	14,442	0	1.18	0.00
1995	2,613,600				
1996	5,060,592	331,419	3,456	6.55	0.07
1997[b]	4,984,956	81,544		1.64	
1998	2,557,594				
1999	496,370				

[a]1998 and 1999 smolt estimates are preliminary

[b]BY1997 survivals for fed and unfed fry combined

Table 18. Tahltan Lake mean annual zooplankton biomass and density, 1988 through 1998.

Table 18 (a). Mean Annual Zooplankton Density (no./m3) - Tahltan Lake

Year	Total (minus LGB)	*Bosmina* sp.	*Daphnia* sp.	*Cyclops* sp.	*Skistodiaptomus* sp.	nauplii	rotifers	*Other groups	N
1988	24097.34	928.00	4608.00	5472.00	3968.00	7296.00	1824.00	0.00	1
1989	47828.84	1114.21	5501.30	9132.36	3793.52	20526.54	7760.57	0.00	4
1990	53488.16	1158.61	4692.27	10549.25	2101.34	21855.66	13130.54	0.00	4
1991	39774.85	1211.56	2561.42	5321.24	1383.49	16532.19	9223.20	0.32	4
1992	24782.71	3062.48	6326.56	5125.94	2461.16	11715.11	3250.25	0.00	4
1993	32204.22	2071.70	4970.67	8391.02	2055.54	8718.19	5996.98	0.00	3
1994	39545.52	2237.51	7635.27	7323.45	4697.58	9365.52	8300.42	0.00	3
1995	67519.89	5674.67	20579.23	7537.78	2070.09	22072.76	9585.78	0.00	1
1996	31696.81	1226.51	8488.09	7016.29	1467.94	6968.61	6464.36	0.00	2
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
1998	67461.08	2628.98	11349.27	9228.36	3751.82	34867.57	5636.44	0.00	4
Mean:	**42839.94**	**2131.42**	**7671.21**	**7509.77**	**2775.05**	**15991.82**	**7117.25**	**0.03**	

* Other groups include only *Diaphanosoma* sp.

Note: 1995 data were outliers (not included in the analysis); 1997 samples did not meet minimum criteria (not included in the analysis); see Methods)

Table 18 (b). Mean Annual Zooplankton Density (no./m3) - Tahltan Lake.

Year	Total (minus LGB)	*Bosmina* sp.	*Daphnia* sp.	*Cyclops* sp.	*Skistodiaptomus* sp.	nauplii	rotifers	Other groups*	N
1988	500.18	30.60	178.06	105.31	179.63	8.09	1.50	0.00	1
1989	699.55	33.97	221.57	225.99	170.52	7.51	6.36	0.00	4
1990	549.23	31.08	141.52	253.66	101.28	20.99	5.11	0.00	4
1991	475.60	35.00	126.88	205.62	95.43	9.23	7.56	0.00	4
1992	666.30	85.03	265.15	133.12	175.94	4.41	2.67	0.00	4
1993	578.15	51.58	204.43	207.20	105.71	4.32	4.92	0.00	3
1994	1532.40	81.69	591.42	332.36	514.67	5.46	6.81	0.00	3
1995	1720.80	196.76	1020.42	296.12	167.23	27.90	7.86	0.00	1
1996	980.76	36.83	523.26	251.89	158.64	4.80	5.33	0.00	2
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
1998	1791.22	113.18	981.58	386.68	293.25	25.15	4.62	0.00	4
Mean:	**949.42**	**69.57**	**425.43**	**239.79**	**196.23**	**11.78**	**5.27**	**0.00**	

* Other groups include only *Diaphanosoma* sp.

Note: 1995 data were outliers (not included in the analysis); 1997 samples did not meet minimum criteria (not included in the analysis; see Methods)

Table 18 (c). Mean Annual Large Beast (LGB) Biomass (mg/m3) - Tahltan Lake.

Year	Chironomid larva	Araneida (spider)	Acarina (mite)
1988	4.86	0.00	0.00
1989	0.00	13.92	0.00
1990	0.00	0.00	3.36
1991	0.00	3.71	0.00
1992	0.00	0.00	0.00
1993	33.00	0.00	0.00
1994	189.43	0.00	0.00
1995	0.00	0.00	0.00
1996	0.00	0.00	0.00
1997	0.00	0.00	0.00
1998	0.00	26.47	0.00
Mean:	**20.66**	**4.01**	**0.31**

Table 19. Tuya Lake mean annual zooplankton biomass and density, 1987 through 1998.

Table 19 (a). Mean Annual Zooplankton Biomass (mg/m3) - Tuya Lake.

Year	Total (minus LGB)	*Bosmina* sp.	*Daphnia* sp.	*Holopedium* sp.	*Cyclops* sp.	Calanoid Copepods	*kistodiaptomus* sp.	nauplii	rotifers	Other groups*	N
1987	1087.93	0.00	18.17	0.00	202.97	506.83	349.54	4.79	5.64	0.00	1
1988	270.76	0.14	28.34	0.01	95.59	51.42	121.65	2.28	0.98	0.00	3
1989	300.36	0.00	26.97	0.00	192.54	22.32	52.27	3.53	2.72	0.00	5
1990	192.48	0.11	0.03	0.02	98.24	43.95	44.69	3.08	2.42	0.00	3
1991	230.48	0.20	3.79	0.08	127.46	25.17	65.01	4.31	4.44	0.00	4
1992	481.48	0.93	1.09	0.71	437.33	4.52	29.17	7.59	0.62	0.00	4
1993	247.55	0.02	0.10	8.99	196.43	8.19	27.36	2.65	3.83	0.00	3
1994	1447.17	4.84	7.09	26.79	1393.40	0.00	19.85	6.62	3.35	0.00	3
1995	521.84	21.06	78.49	115.02	31.39	0.00	266.10	6.65	3.18	0.00	2
1996	72.52	0.77	23.98	3.24	39.72	0.00	4.05	0.27	1.30	0.00	2
1997	299.35	1.20	38.24	6.08	144.29	0.00	107.86	1.22	1.08	0.01	2
1998	639.40	8.88	360.74	1.17	164.63	0.00	75.25	15.38	13.94	0.00	2
Mean:	**482.61**	**3.18**	**48.92**	**13.51**	**260.33**	**55.20**	**96.90**	**4.86**	**3.63**	**0.00**	

* Other groups include only *Diaphanosoma* sp., Chydoridae and Harpacticoid copepods.

Table 19 (b). Mean Annual Zooplankton Density (no./m3) - Tuya Lake.

Year	Total (minus LGB)	*Bosmina* sp.	*Daphnia* sp.	*Holopedium* sp.	*Cyclops* sp.	Calanoid Copepods	*kistodiaptomus* sp.	nauplii	rotifers	*Other groups	N
1987	30225.28	0.00	64.75	0.00	4164.80	384.00	8086.06	10665.95	6880.00	0.00	1
1988	10342.16	2.22	11.12	0.24	2864.89	57.06	3634.67	2545.13	1201.19	0.00	3
1989	17914.09	0.00	120.63	0.00	8583.55	34.06	1385.08	4475.12	3315.35	0.00	5
1990	11718.44	3.56	0.57	0.27	3377.02	58.07	965.01	4359.62	2955.43	0.00	3
1991	22495.30	10.79	27.54	1.55	3114.67	25.68	2280.08	11615.90	5418.63	0.00	4
1992	26819.42	53.97	16.05	16.59	14802.98	6.03	830.88	10411.89	753.56	0.00	4
1993	18066.78	0.34	1.28	461.54	6109.58	6.74	1125.88	4686.52	4673.18	0.00	3
1994	55781.65	111.11	96.03	200.78	41798.51	0.00	123.21	9471.93	4081.77	0.00	3
1995	25995.54	907.11	4634.86	2549.34	731.73	0.00	8718.98	4580.89	3872.45	0.00	2
1996	4234.74	29.23	1041.92	76.54	903.47	0.00	134.10	481.60	1585.07	0.00	2
1997	10616.33	53.34	1258.31	140.78	3169.34	0.00	2017.40	2721.34	1316.00	0.80	2
1998	47077.92	280.32	5344.87	17.07	1873.78	0.00	1790.58	17781.06	16998.95	0.00	2
Mean:	**23440.64**	**121.00**	**1051.49**	**288.73**	**7624.53**	**47.64**	**2590.99**	**6983.08**	**4420.96**	**0.07**	

* Other groups include only *Diaphanosoma* sp., Chydoridae and Harpacticoid copepods.

Table 20 (c). Mean Annual Large Beast (LGB) Biomass (mg/m3) - **Tuya Lake.**

Year	Chironomid larva	Fish larva
1987	0.00	0.00
1988	797.93	0.00
1989	0.00	51.92
1990	0.00	94.98
1991	0.00	0.00
1992	41.28	0.00
1993	106.70	0.00
1994	0.00	0.00
1995	0.00	0.00
1996	187.44	0.00
1997	0.00	0.00
1998	0.00	0.00
Mean:	**94.45**	**12.24**

Table 20. Tatsamenie Lake mean annual zooplankton biomass and density, 1988 through 1998.

Table 20(a). Mean Annual Zooplankton Biomass (mg/m3) - Tatsamenie Lake.

Year	Total (minus LGB)	*Bosmina* sp.	*Daphnia* sp.	*Cyclops* sp.	nauplii	rotifers	Other groups*	N
1988	285.99	65.36	36.93	179.62	2.20	1.88	1.23	3
1989	314.34	57.59	70.97	176.73	2.81	6.17	0.07	4
1990	175.13	36.96	52.22	79.75	2.24	3.94	0.00	4
1991	449.88	139.84	15.67	238.16	1.23	3.07	51.90	4
1992	309.62	86.63	72.54	145.91	2.85	1.70	0.00	4
1993	286.69	73.34	56.70	148.35	2.34	5.97	0.00	3
1994	329.24	114.99	25.91	177.04	4.85	6.88	0.00	3
1995	278.05	54.77	59.60	139.40	1.98	3.31	0.00	2
1996	324.81	37.41	30.10	251.88	2.79	2.00	0.64	2
1997	346.65	30.00	122.03	193.09	2.15	0.49	0.00	3
1998	297.81	20.85	76.79	193.54	3.38	3.60	0.00	7
Mean:	**308.93**	**65.25**	**56.32**	**174.86**	**2.62**	**3.55**	**4.89**	

* Other groups include calanoid copepods, *Skistodiaptomus* sp. and *Holopedium* sp.

Table 20 (b). Mean Annual Zooplankton Density (no./m3) - Tatsamenie Lake.

Year	Total (minus LGB)	*Bosmina* sp.	*Daphnia* sp.	*Cyclops* sp.	nauplii	rotifers	*Other groups	N
1988	13689.47	1875.56	1088.00	6712.88	1699.45	2291.56	10.77	3
1989	23253.98	1721.33	1686.99	6484.78	7349.30	7528.47	0.16	4
1990	16916.79	1241.60	1397.85	3542.40	5933.56	4801.02	0.00	4
1991	22665.42	4693.35	455.04	7390.48	5569.53	3745.52	804.57	4
1992	17937.97	2847.54	2035.85	4730.82	6255.00	2067.89	0.00	4
1993	24667.36	2993.78	1915.73	6904.87	5572.27	7280.26	0.00	3
1994	23690.13	3121.78	585.89	4163.98	6858.59	7861.28	0.00	3
1995	14464.13	1360.00	1520.00	3520.00	4032.00	4031.95	0.00	2
1996	12117.10	985.60	394.40	6117.27	2204.80	2434.14	4.64	2
1997	12160.71	824.89	2350.22	5045.33	3313.78	597.33	0.00	3
1998	17001.64	493.43	1540.50	4531.81	6049.48	4391.83	0.00	7
Mean:	**18051.34**	**2014.44**	**1360.95**	**5376.78**	**4985.25**	**4275.57**	**74.56**	

* Other groups include calanoid copepods, *Skistodiaptomus* sp. and *Holopedium* sp.

Table 20(c). Mean Annual Large Beast (LGB) Biomass (mg/m3) - Tatsamenie Lake.

Year	Chironomid larva	Acarina
1988	84.88	0.00
1989	50.88	0.00
1990	1.34	0.00
1991	23.90	0.00
1992	272.89	0.00
1993	69.32	0.00
1994	3.98	0.00
1995	572.30	0.00
1996	539.68	0.00
1997	546.32	0.00
1998	129.23	0.09
Mean:	**208.61**	**0.01**

Table 21. Summary of Transboundary lakes egg receipt and incubation at Snettisham Hatchery by lake and brood year.

Tahltan Lake

Brood Year	Green Eggs	Eyed Eggs	Disease Loss[a]	Emergent Fry	Disease Loss	Fry Transport
1989	2,995,440	2,080,900		1,094,553		1,041,744
1990	4,510,605	3,718,585		3,626,347		3,584,658
1991	4,245,657	4,015,026		3,950,299	885,000	3,047,542
1992	4,901,140	4,530,777	521,400	3,938,777		3,937,577
1993	3,136,524	5,628,141		5,592,725		5,594,741
1994	4,182,543	3,721,215				3,410,299
1995	6,890,608	5,811,281	522,221	4,942,237		4,769,894
1996	6,401,763	5,937,218	681,946	4,926,916		4,858,568
1997	3,221,167	2,665,870		2,620,020		2,333,068
1998	4,022,202	3,676,229		3,656,429		3,274,056
1999	2,772,973	2,496,689				
Average	4,298,238	4,025,630	575,189	3,816,478	885,000	3,585,215

Tatsamenie Lake

Brood Year	Green Eggs	Eyed Eggs	Disease Loss	Emergent Fry	Disease Loss	Fry Transport
1993	136,897*					
1994	1,228,541	984,165				897,500
1995	2,406,707	2,028,504		1,724,228		1,724,228
1996	4,933,509	4,188,259		3,944,758		3,940,933
1997	4,650,516	4,232,964		4,214,614	178,577	3,596,593
1998	2,414,494	2,166,262		2,160,462		1,769,032
1999	461,436	435,104				
Average	2,682,534	2,339,210		3,011,016	178,577	2,385,657

* These eggs included in 1993 Little Tatsamenie total.

Little Tatsamenie Lake

Brood Year	Green Eggs	Eyed Eggs	Disease Loss	Emergent Fry	Disease Loss	Fry Transport
1990	984,681	762,965		680,596		673,236
1991	1,359,751	1,260,494		1,247,444		1,231,894
1992	1,486,091	1,275,238	246,000	915,502		909,452
1993	1,143,857	708,574	168,877	520,802		520,947
Average	1,243,595	1,001,818	207,439	841,086		833,882

Little Trapper Lake

Brood Year	Green Eggs	Eyed Eggs	Disease Loss	Emergent Fry	Disease Loss	Fry Transport
1990	2,313,686	2,020,843	1,001,250	944,913		933,791
1991	2,952,934	1,862,662		1,820,398		1,810,998
1992	2,520,953	2,054,881	917,303	1,113,578		1,113,128
1993	1,173,660	950,853		916,622		916,083
1994	1,117,249	837,316				773,375
Average	2,015,696	1,545,311	959,277	1,198,878		1,109,475

[a]All Disease loss was due to IHNV, with the exception of the Little Trapper 1990 brood year which was attributed to White Spot disease.

Table 22. Summary of transboundary fry transport and thermal mark by lake and broodyear.

Tahltan Lake

Brood Year	Green Eggs	Fry Transport	First Date	Last Date	Thermal Mark[a]
1989	2,995,440	1,041,744	6/6/90	6/25/90	1:1.4
1990	4,510,605	3,584,658	6/4/91	6/21/91	1:1.3
1991	1,513,520	1,415,459	6/9/92	6/10/92	1:1.4
1992	2,153,996	1,947,207	6/14/93	6/20/93	1:1.5+2.3
1993	968,752	903,908	6/24/94	6/28/94	1:1.6+2.5n
1994	1,418,013	1,142,856	6/26/95	7/3/95	1:1.6
1995	3,007,955	2,296,152	6/15/96	6/25/96	1:1.7
1996	3,168,947	2,247,730	6/16/97	6/27/97	1:1.6
1997	2,700,358	1,900,417	6/7/98	6/13/98	2:1.6
1998	1,997,918	1,670,615	5/29/99	6/2/99	1:1.7
1999	2,772,973				2:1.6

Tuya Lake (Tahltan Stock)

Brood Year	Green Eggs	Fry Transport	First Date	Last Date	Thermal Mark
1991	2,732,137	1,632,083	6/17/92	6/21/92	1:1.6
1992	2,747,144	1,990,370	6/16/93	7/6/93	1:1.7
1993	5,170,772	4,690,833	6/24/94	7/13/94	1:1.4+2.5n
1994	2,764,530	2,267,443	6/26/95	7/3/95	1:1.4
1995	3,882,653	2,473,742	6/21/96	7/3/96	1:1.4+2.4
1996	3,232,816	2,610,838	6/24/97	7/1/97	1:1.4
1997	520,809	432,651	6/26/98	6/26/98	2:1.4
1998	2,024,284	1,603,441	6/21/99	7/2/99	1:1.4
1999	2,772,973				2:1.4

Tatsamenie Lake (Tatsamenie Stocks)

Brood Year	Green Eggs	Fry Transport	First Date	Last Date	Thermal Mark
1990	984,681	673,236	6/22/91	6/22/91	1:1.3
1991	1,359,751	1,231,894	6/22/92	6/26/92	3:1.4
1992	1,486,091	909,452	7/9/93	7/14/93	3:1.5
1993	1,143,857	520,947	7/14/94	7/14/94	2:1.5
1994	1,228,541	897,500	7/18/95	7/21/95	1:1.5
1995	2,406,707	1,724,228	6/16/96	6/25/96	1:1.5
1996	4,933,509	3,940,933	6/16/97	6/27/97	1:1.5 & 1:1.5+2.3
1997	4,650,516	3,596,593	6/15/98	6/29/98	2:1.5 & 2:1.5+2.3
1998	2,414,494	1,769,032	6/1/99	6/9/99	1:1.4+2.3 & 1:1.4+2.5
1999	461,436				

Trapper Lake

Brood Year	Green Eggs	Fry Transport	First Date	Last Date	Thermal Mark
1990	2,313,686	933,791	6/8/91	6/22/91	1:1.5
1991	2,952,934	1,810,998	6/5/92	6/11/92	3:1.6
1992	2,520,953	1,113,128	6/13/93	6/22/93	1:1.7+2.3
1993	1,173,660	916,083	6/16/94	6/24/94	1:1.5+2.5n
1994	1,117,249	773,375	6/21/95	7/3/95	1:1.7

[a] For explanation of thermal mark notation refer to appendix 3.

Table 23. Transboundary Lakes sockeye brood stock disease histories for brood years 1988 to 1999.

Tahltan Lake

Brood Year	BKD Sample Size	BKD Percent Positive	IHNV # Positive and Sample Size	IHNV Percent Positive	IHNV Positives greater than or equal to 10^4 pfu.[a] Number	Percent
1988	19/60	31.70%	54/60	90.00%	28/54	51.90%
1989	7/151	4.60%	3/159	1.90%	1/3	33.30%
1990	9/150	6.00%	5/150	3.30%	0/5	0.00%
1991	11/148	7.40%	144/152	94.70%	65/144	45.10%
1992	9/154	5.80%	141/154	91.60%	82/141	58.20%
1993	11/150	7.30%	107/149	71.80%	45/107	42.10%
1994	4/150	2.70%	75/150	50.00%	21/75	28.00%
1995	7/150	4.70%	93/150	62.00%	45/93	48.40%
1996	12/151	7.95%	87/151	57.62%	29/87	33.33%
1997	14/253	5.53%	159/252	63.10%	63/159	39.62%
1998	1/163	0.61%	70/163	42.94%	19/70	27.14%
1999	2/152	1.32%	26/152	17.11%	6/26	23.08%
Average		7.13%		53.84%		35.85%

Tatsamenie Lake

Brood Year	BKD Sample Size	BKD Percent Positive	IHNV # Positive and Sample Size	IHNV Percent Positive	IHNV Positives greater than or equal to 10^4 pfu Number	Percent
1988	3/67	4.50%	25/65	38.50%	4/25	16.00%
1989	no egg take					
1990	12/150	8.00%	96/150	64.00%	50/96	52.10%
1991	9/150	6.00%	5/150	3.30%	0/5	0.00%
1992	5/151	3.30%	95/150	63.30%	49/95	51.60%
1993	24/111	21.60%	94/149	63.10%	57/94	60.60%
1994	10/150	6.70%	1/103	1.00%	0/1	0.00%
1995	15/150	10.00%	1/149	0.70%	1/1	100.00%
1996	5/150	3.33%	39/150	26.00%	24/39	61.54%
1997	17/150	11.33%	14/150	9.33%	10/14	71.43%
1998	5/149	3.36%	0/143	0.00%	0/0	0.00%
1999	2/120	1.67%	0/92	0.00%	0/0	0.00%
Average		7.25%		24.48%		37.57%

Little Trapper Lake

Brood Year	BKD Sample Size	BKD Percent Positive	IHNV # Positive and Sample Size	IHNV Percent Positive	IHNV Positives greater than or equal to 10^4 pfu Number	Percent
1988	2/60	3.30%	52/60	86.70%	23/52	44.20%
1989	no egg take					
1990	20/150	13.30%	146/152	96.10%	113/146l	77.40%
1991	9/150	6.00%	20/150	13.30%	5/20	25.00%
1992	1/153	0.70%	146/150	97.30%	126/146	86.30%
1993	10/150	6.70%	90/150	60.00%	47/90	52.20%
1994	10/150	6.70%	50/148	33.80%	16/50	32.00%
1995	no egg take					
Average		6.12%		64.53%		52.85%

[a]For IHNV, a titer greater than or equal to 10^4 plague forming units (pfu), is the point at which the probability of vertical (parent to offspring) transmission of IHNV is believed to greatly increase.

Tables 24. Adult returns and catches of enhanced and wild sockeye for the Stikine River 1993 to 1999.[a]

Table 24 (a). Run size, catches[b], and exploitation rates for wild and enhanced Stikine River sockeye.

Year	Total run	Total Enhanced Component	Total Enhanced Tahltan	Total Enhanced Tuya	Total Wild Component	Ratio of Enhanced to Wild	Enhanced Catch	Wild Catch	Total Catch	Enhanced Harvest Rate	Wild Harvest Rate
1993	280730	1205	1205	0	279525	0.0043	38	157328	157366	0.03	0.56
1994	208033	31193	31193	0	176840	0.1764	20323	113569	133892	0.65	0.64
1995	218728	56150	53348	2802	162578	0.3454	44697	98500	143197	0.80	0.61
1996	372785	69018	30418	38600	303767	0.2272	52088	216469	268557	0.75	0.71
1997	226915	93729	27471	66258	133186	0.7037	76386	108558	184944	0.81	0.82
1998	121448	48425	1042	47383	73023	0.6631	40238	48870	89108	0.83	0.67
1999	119138	37261	1900	35361	81877	0.4551	34473	64551	99024	0.93	0.79
Average	211175	55963	24229	31734	155212	0.3679	44701	108420	153120	0.80	0.71

Table 24 (b). Total Canadian and U.S. catches and exploitation rates of enhanced Stikine River sockeye.

Year	Total U.S. catch	Total Canadian catch	Ratio U.S./ Canada	Total enhanced catch	Total enhanced run	Total harvest rate	Harvest rate less ESSR
1993	0	38	n/a	38	1205	0.03	n/a
1994	18305	2018	9.07	20323	31193	0.65	0.61
1995	27845	16852	1.65	44697	56150	0.80	0.72
1996	36010	16078	2.24	52088	69018	0.75	0.73
1997	50503	25883	1.95	76386	93729	0.81	0.79
1998	16369	23869	0.69	40238	48425	0.83	0.70
1999	17562	16911	1.04	34473	37261	0.93	0.85
Total	166594	101649		268243	335776		
Average	23799	14521	2.77	38320	55963	0.80	0.74

[a] Source: 1999 Transboundary Technical Committee report on Preliminary Estimates of Transboundary River Salmon Production.

[b] All catches including, commercial, aboriginal, test fisheries, and ESSR.

Table 25. Catches and production of enhanced Taku River sockeye salmon, 1995 to 1999[a].

Table 25 (a). Canadian and U.S. catches of enhanced Taku River sockeye, 1995 to 1999.

Year	U.S. CATCH			CANADIAN CATCH			Ratio U.S. vs. Canada	Total Enhanced Catch
	Dist 111 Commercial		Total U.S.	In-River Commercial		Total Canadian		
	Trapper	Tatsamenie		Trapper	Tatsamenie			
1995	1017	3049	4066	331	1003	1334	3.05	5400
1996	1920	2859	4779	331	401	732	6.53	5511
1997	1031	1006	2037	456	201	657	3.10	2694
1998	570	250	820	533	56	589	1.39	1409
1999	858	313	1171	170	120	290	4.04	1461
Total	5396	7477	12873	1821	1781	3602		16475
Avg.	1079	1495	2575	364	356	720	3.62	3295

Table 25 (b). Estimates of enhanced and wild Taku River sockeye production, 1995 to 1999.

Year	Total Enhanced Catch	Total Wild Catch	Total Enhanced and Wild	Total Run	Total Enhanced production	Total Wild Production	Harvest Rate	Ratio of Enhanced to Wild
1995	5400	120377	125777	239514	10283	229231	0.53	0.043
1996	5511	226698	232209	324835	7709	317126	0.71	0.024
1997	2694	102086	104780	175866	4522	171344	0.60	0.026
1998	1409	69699	71108	145559	2884	142675	0.49	0.020
1999	1461	83093	84554	182691	3157	179534	0.46	0.017
Total	16475	601953	618428	1068465	28555	1039910		0.027
Avg.	3295	120391	123686	213693	5711	207982	0.56	0.027

[a] Source: 1999 Transboundary Technical Committee report on Preliminary Estimates of Transboundary River Salmon Production.

Table 26. Sockeye fry hydroacoustic estimates in transboundary lakes.

Tatsamenie Lake

Survey Year	Survey Date	Hydroacoustic Estimate			
		Total	95% CI	Wild	Enhanced
1990	no survey	n/a[a]	n/a	n/a	n/a
1991	13-Sep	821,688	289,562	767,347	32,653
1992	1-Aug	1,795,965	772,015	n/a	n/a
	28-Sep	n/a	n/a	n/a	n/a
1993	14-Sep	1,146,100	409,859	1,000,409	145,691
1994	15-Sep	1,053,200	358,658	1,034,393	18,807
1995	19-Sep	940,100	366,896	852,649	87,451
1996	19-Sep	831,900	324,400	772,479	59,421
1997	4-Sep	2,695,092	869,666	2,411,398	283,694
	1-Oct	1,260,199	488,833	1,132,906	127,293
	Average	1,977,646	679,250	1,773,765	203,881
1998	2-Sep	689,376	263,792	n/a	n/a
	22-Sep	754,923	281,627	697,653	57,270
	12-Oct	504,397	286,169	425,585	78,812
	Average	629,660	283,898	561,619	68,041
1999	16-Oct	352,000	94,076	321,376	30,624

Tuya Lake

Survey Year	Survey Date	Hydroacoustic Estimate		
		Total	95% CI	Sculpins
1990	no survey	n/a	n/a	n/a
1991	no survey	n/a	n/a	n/a
1992	18-Sep	596,537	196,156	
1993	2-Sep	437,304	228,578	
1994	5-Sep	1,995,119	1,114,417	
1995	9-Sep	1,526,065	1,429,780	
1996	12-Sep	2,109,019	498,881	
1997	25-Sep	2,066,449	550,088	
1998	19-Sep	659,606	280,102	n/a
1999	14-Sep	1,026,517	314,830	n/a

Tahltan Lake

Survey Year	Survey Date	Hydroacoustic Estimate			
		Total	95% CI	Wild	Enhanced
1990	3-Oct	272,330	77,016	n/a	n/a
1991	9-Sep	995,918	182,411	513,618	482,300
1992	29-Jul	no estimate due to technical problems			
	3-Oct	no estimate due to technical problems			
1993	19-Sep	817,400	158,828	417,489	294,440
1994	19-Sep	377,408	154,969	355,200	22,200
1995	no survey	n/a	n/a	n/a	n/a
1996	19-Sep	615,321	95,940	396,055	219,252
1997	29-Sep	298,773	47,232	96,404	189,097
1998	no survey	n/a	n/a	n/a	n/a
1999	12-Oct	220,000	61,500	n/a	n/a

Trapper Lake

Survey Year	Survey Date	Hydroacoustic Estimate		
		Total	95% CI	Enhanced
1990	no survey			
1991	16-Sep	139,023	85,650	65,340
1992	3-Aug	196,037	55,203	no trawls
1992	30-Sep	sounder not working		
1993	10-Sep	125,459	64,774	94,847
1994	11-Sep	61,978	32,158	small sample
1995	15-Sep	109,723	79,045	small sample

[a] n/a denotes no survey conducted, equipment problems, or insufficient trawl samples were obtained to determine wild/enhanced ratios.

APPENDICES

Appendix 1. Appendix to Annex IV, Chapter 1 of the Pacific Salmon Treaty: Understanding on the joint enhancement of Transboundary River sockeye stocks.

Attachment 1
Appendix to Annex IV, Chapter 1
Understanding on the Joint Enhancement of Transboundary River Sockeye Stocks

Pursuant to Annex IV of the Pacific Salmon Treaty, and recognizing desire of Canada and the United States to continue a joint enhancement program for the transboundary rivers that is carefully planned and coordinated:

1. The Parties agree:

(a) To continue to develop strategies for management of the enhanced stocks prior to the return of adult fish;

(b) To continue to develop an agreed process for conducting periodic review of implemented projects to identify and recommend action regarding, *inter alia:*

(i) Success or failure of a project in a given year or series of years;

(ii) A distribution of benefits that is substantially different than expected; and

(iii) Costs which are substantially greater than expected; and

(c) To recommend a plan, when required, for funding of projects including:

(i) Cost sharing arrangements between the Parties; and

(ii) Long term funding obligations.

2. The Parties agree to maintain an Enhancement Subcommittee of the joint transboundary Technical Committee whose Terms of Reference shall be, *inter alia, to:*

(a) Develop preliminary summaries of various projects which meet the enhancement goals established by the Transboundary Panel;

(b) Develop detailed feasibility studies for projects selected by the Transboundary Panel, including

(i) Estimation of costs and benefits;
(ii) Likelihood of success;
(iii) Schedules for implementation;
(iv) Procedures for evaluation; and
(v) Fisheries management plans for the enhanced stocks; and

(c) Monitor implementation of projects and report progress to the Transboundary Panel.

3. Project Selection:

(a) General Guidelines:

(i) If brood stock is not available to provide the agreed number of eggs, up to 30% 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;

(ii) 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. The joint Transboundary Technical Committee will determine the appropriate stock identification technique for each fishery.

(b) Stikine River:

For the duration of this Chapter, the egg-take goal for the Stikine sockeye enhancement program will be six million eggs. The Tahltan Lake sockeye salmon stock will be used as the source of eggs. 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 joint Transboundary Technical Committee:

a. When the sockeye escapement through the Tahltan Lake weir is less than 15,000 fish or an agreed alternate threshold, all fry will be returned to Tahltan Lake;

b. When the sockeye escapement through the Tahltan Lake weir is greater than 15,000 fish or an agreed alternate threshold, the fry will be distributed to Tahltan and Tuya Lakes in a manner which maximises harvestable production and provides information on the potential production capacity of Tuya Lake.

(c) Taku River

For the duration of this Chapter, the egg-take goal for the Taku sockeye afar program will be five million eggs. The Tatsamenie Lake salmon stock will be used as the source of eggs. Eggs will be incubated at the Port Snettisham central incubation facility (CIF;). Fry will be planted into Tatsamenie Lake.

4. Harvest principles and cost sharing:

(a) The Parties desire to maximise the harvest of enhanced sockeye salmon in their existing fisheries while considering the conservation needs of wild salmon runs. To avoid impacts on co-migrating stocks and species, exploitation rates applied to Taku and Stikine River sockeye salmon in existing mixed stock fisheries in Canada and the United States shall be at levels compatible with the maintenance of wild stocks.

(b) Harvest sharing arrangements for enhanced stocks will be determined prior to the time eggs are taken to initiate production level enhancement.

5. Cost sharing:

(a) In carrying out joint enhancement projects, capital construction and on-site operating costs shall be borne by the country on whose soil the project components are located.

(b) The costs of producing Stikine River enhanced sockeye salmon shall be shared as follows:

(i) To be paid by Canada:

a. Egg take;
b. Egg transport;
c. Smolt sampling;
d. Sampling and numerical analysis necessary to determine the contribution of
enhanced transboundary river sockeye salmon to Canadian fisheries; and
e. Limno1ogy sampling and hydroacoustics.

(ii) To be paid by the United States:

a Construction and operation of that portion of the Port Snettisham CIF that is dedicated to enhancement projects on the transboundary rivers.
b. Transport of fry to enhancement site; and
c. Sampling and analysis necessary to determine the contribution of enhanced transboundary river sockeye salmon to United States fisheries.

(iii) Projects to be conducted jointly:

a. Disease sampling and analysis.

(c) The costs of producing Taku River enhanced sockeye salmon shall be shared as follows:

(i) To be paid by Canada:

a. Egg take;
b. Egg transport;
c. Smolt sampling;
d. Sampling- and numerical analysis necessary to determine the contribution of
enhanced Taku River sockeye stocks to Canadian fisheries;
e. Limnology sampling and hydroacoustics; and
f. Investigations to determine the feasibility of using sockeye from terminal areas,
surplus to brood stock and spawning requirements in enhanced systems, for cost
recovery.

(ii) To be paid by the United States:

a Construction and operation of that portion of the Port Snettisham CIF that is dedicated to enhancement projects on the transboundary rivers;
b. Transport of fry to the enhancement site;

c. Sampling and analysis necessary to determine the contribution of enhanced transboundary river sockeye salmon to United States fisheries; and d. Processing of sockeye otolith samples collected in the Taku River.

(iii) Projects to be conducted jointly:

a. Disease sampling and analysis; and

b. Identification and evaluation of alternative sockeye salmon enhancement opportunities in the Taku River.

Appendix 2. Transboundary sockeye fry and smolt mean lengths with trawl sample means corrected for trawl net avoidance.

Appendix 2 (a). Tahltan Lake sockeye fry and smolt mean lengths, weights, 95% confidence intervals (CI) - beach seine and trawl samples have been corrected for preservative shrinkage (99% denatured alcohol). Trawl sample means have been corrected for trawl net avoidance (except when the mean length is less than 40 mm).

		Wild fry					***Enhanced fry***				
Sampling date	**Capture method**	**Mean length (mm)**	**95% CI**	**Mean weight (g)**	**95% CI**	**# wild fish captured**	**Mean length (mm)**	**95% CI**	**Mean weight (g)**	**95% CI**	**# enhanced fish captured**
15-Jun-90	stocking	.	.	.	.	.	.	.	0.13	0.00	.
in-lake 1990	data could not be located										
15-Jul-90	bs	50.4	.	1.30	.	76	39.0	.	0.56	.	89
25-May-91	smolt	91.1	0.7	5.93	0.13	371	88.9	1.2	5.47	0.23	97
12-Jun-91	stocking	.	.	.	.	.	.	.	0.13	0.00	.
in-lake 1991	data could not be located										
25-May-92	smolt	84.8	0.8	4.77	0.14	211	84.2	0.6	4.62	0.11	243
09-Jun-92	stocking	.	.	.	.	.	.	.	0.13	0.00	.
23-Jun-92	beach seine	31.7	1.2	0.26	0.05	72	29.6	1.8	0.17	0.04	8
29-Jul-92	beach seine	30.7	1.3	0.22	0.06	71	33.3	5.9	0.31	0.25	4
29-Jul-92	trawl	60.3	3.8	2.21	0.35	21	62.7	28.7	2.34	2.47	3
20-Aug-92	beach seine	27.6	0.6	0.11	0.01	12	.	.	.	.	0
03-Oct-92	trawl	73.7	4.0	4.10	0.48	32	76.2	17.2	4.88	1.65	5
25-May-93	smolt	80.6	0.8	4.08	0.15	185	79.7	1.5	3.87	0.20	25
17-Jun-93	stocking	.	.	.	.	.	.	.	0.13	0.00	.
03-Aug-93	beach seine	29.2	0.3	0.15	0.01	95	28.0	.	0.14	.	1
19-Sep-93	trawl	74.2	2.2	4.54	0.27	93	75.0	1.6	4.38	0.21	68
25-May-94	smolt	84.1	1.6	4.93	0.35	117	83.4	1.9	4.74	0.40	64
26-Jun-94	stocking	.	.	.	.	.	.	.	0.13	0.00	.
19-Sep-94	beach seine	54.6	15.7	2.10	1.42	8	.	.	.	.	0
19-Sep-94	trawl	63.1	6.2	2.68	0.65	16	77.1	.	4.66	.	1
18-May-95	smolt	83.5	0.7	4.75	0.13	418	82.0	2.6	4.50	0.48	27
29-Jun-95	stocking	.	.	.	.	.	.	.	0.13	0.00	.
1995	no fry sampling conducted in 1995										
25-May-96	smolt	80.1	0.8	4.26	0.14	318	74.5	1.6	3.27	0.20	30

Appendix 2 (a). continued.

Tahltan Lake sockeye fry and smolt mean lengths, weights, 95% confidence intervals (CI) - beach seine and trawl samples have been corrected for preservative shrinkage (99% denatured alcohol). Trawl sample means have been corrected for trawl net avoidance (except when the mean length is less than 40 mm).

		Wild fry					***Enhanced fry***				
Sampling date	**Capture method**	**Mean length (mm)**	**95% CI**	**Mean weight (g)**	**95% CI**	**# wild fish captured**	**Mean length (mm)**	**95% CI**	**Mean weight (g)**	**95% CI**	**# enhanced fish captured**
15-Jun-90	stocking	.	.	.	.	.	.	.	0.13	0.00	.
in-lake 1990	data could not be located										
15-Jul-90	bs	50.4	.	1.30	.	76	39.0	.	0.56	.	89
25-May-91	smolt	91.1	0.7	5.93	0.13	371	88.9	1.2	5.47	0.23	97
12-Jun-91	stocking	.	.	.	.	.	.	.	0.13	0.00	.
in-lake 1991	data could not be located										
25-May-92	smolt	84.8	0.8	4.77	0.14	211	84.2	0.6	4.62	0.11	243
09-Jun-92	stocking	.	.	.	.	.	.	.	0.13	0.00	.
23-Jun-92	beach seine	31.7	1.2	0.26	0.05	72	29.6	1.8	0.17	0.04	8
29-Jul-92	beach seine	30.7	1.3	0.22	0.06	71	33.3	5.9	0.31	0.25	4

Appendix 2 (b). Tuya Lake sockeye fry and smolt mean lengths, weights, and 95% C.I. Beach seine and trawl sample means have been corrected for trawl net avoidance, (except when mean length is less than 40 mm).

		Enhanced fry				
Date	**Capture method**	**Mean length (mm)**	**95 % CI**	**Mean weight (g)**	**95 % CI**	**Enhanced N**
19-Jun-92	stocking	.	.	0.13	0.00	.
24-Jun-92	beach seine	27.7	0.2	0.14	0.00	150
25-Jul-92	beach seine	32.3	0.6	0.27	0.02	150
24-Aug-92	beach seine	63.2	4.8	2.57	0.66	5
18-Sep-92	beach seine	no fry caught in beach seines				
18-Sep-92	trawl	87.6	4.3	6.90	0.81	10
28-May-93	smolt	99.4	0.5	8.61	0.11	370
27-Jun-93	stocking	.	.	0.13	0.00	.
02-Sep-93	beach seine	no fry caught in beach seines				
02-Sep-93	trawl	69.5	10.5	3.62	1.32	5
28-May-94	smolt	98.7	0.5	9.02	0.13	432
03-Jul-94	stocking	.	.	0.13	0.00	.
05-Sep-94	beach seine	no fry caught in beach seines				
05-Sep-94	trawl	73.4	1.3	4.17	0.17	75
10-Jun-95	smolt	95.5	0.6	9.61	0.16	208
27-Jun-95	stocking	.	.	0.13	0.00	.
01-Aug-95	beach seine	no fry caught in beach seines				
12-Sep-95	beach seine	no fry caught in beach seines				
12-Sep-95	trawl	83.8	2.2	6.40	0.37	20
12-Jun-96	smolt	99.5	0.6	9.69	0.15	236
27-Jun-96	stocking	.	.	0.11	0.00	.
26-Jul-96	beach seine	only 7 fry caught in beach seines (not processed)				
12-Sep-96	beach seine	no fry caught in beach seines				
12-Sep-96	trawl	69.0	1.6	3.14	0.16	51
03-Jun-97	smolt	93.7	0.6	8.36	0.16	178
27-Jun-97	stocking	.	.	0.14	0.00	.
03-Aug-97	beach seine	42.2	0.7	0.75	0.04	129
25-Sep-97	beach seine	no fry caught in beach seines				
25-Sep-97	trawl	90.4	2.5	7.99	0.32	6
07-Jun-98	smolt	103.4	0.5	10.10	0.16	228
26-Jun-98	stocking	.	.	0.12	0.00	.
02-Aug-98	beach seine	no fry caught in beach seines				
19-Sep-98	beach seine	no fry caught in beach seines				
19-Sep-98	trawl	only one fry caught in 8 trawls			.	.
21-Jun-99	smolt	104.1	0.9	11.20	0.29	89
26-Jun-99	stocking	.	.	0.12	0.00	.
1-Aug-99	beach seine	38.4	1.4	0.55	0.07	117
14-Sep-99	trawl	no fry caught in 5 trawls		.	.	.
spring 2000	smolt	.	.	.	.	.

Appendix 2 (c). Tatsamenie Lake sockeye fry and smolt mean lengths, weights and 95% confidence intervals. Beach seine and trawl samples have been corrected for preservative shrinkage (99%denatured alcohol) and trawl net avoidance (except when the mean length is less than 40 mm).

		Wild fry					***Enhanced fry***		
Sampling date	**Capture method**	**Mean length (mm)**	**95% CI**	**Mean weight (g)**	**95% CI**	**# wild fish captured**	**Mean length (mm)**	**95% CI**	**Mean weight (g)**
21-Jun-92	beach seine	33.4	0.4	0.28	0.02	100	.	.	.
24-Jun-92	stocking	.	.	.	.	.	.	.	0.15
01-Aug-92	beach seine	36.0	0.7	0.29	0.02	116	33.4	1.9	0.20
01-Aug-92	trawl	36.0	32.3	0.54	1.78	3	.	.	.
21-Aug-92	beach seine	50.2	2.0	1.33	0.19	89	48.5	57.2	1.14
28-Sep-92	beach seine	35.3	2.7	0.36	0.11	32	30.0	.	0.19
28-Sep-92	trawl	otolith thermal mark data not found							
25-May-93	smolt	75.9	2.0	4.47	0.34	79	65.2	4.4	2.88
10-Jul-93	stocking	.	.	.	.	.	.	.	0.13
01-Aug-93	beach seine	37.4	1.2	0.47	0.05	95	34.3	11.1	0.36
14-Sep-93	beach seine	33.5	2.8	0.28	0.09	10	41.0	.	0.49
14-Sep-93	trawl	55.5	1.2	1.56	0.08	102	49.9	4.1	1.21
30-May-94	smolt	75.9	1.5	3.55	0.23	137	73.0	30.5	3.40
14-Jul-94	stocking	.	.	.	.	.	.	.	0.15
26-Jul-94	beach seine	44.3	1.5	0.89	0.09	119	31.5	6.4	0.21
15-Sep-94	beach seine	38.4	4.8	0.55	0.22	16	55.0	.	1.46
15-Sep-94	trawl	72.7	2.6	4.23	0.32	50	65.5	.	3.16
02-Jun-95	smolt	81.9	1.1	5.06	0.22	167	79.8	8.3	4.53
20-Jul-95	stocking	.	.	.	.	.	.	.	0.15
28-Jul-95	beach seine	36.7	1.4	0.46	0.06	37	29.1	0.7	0.17
19-Sep-95	trawl	56.2	2.5	1.68	0.19	39	53.6	10.3	1.40
11-Jun-96	smolt	75.0	1.2	3.74	0.18	319	69.9	3.9	3.04
20-Jun-96	stocking	.	.	.	.	.	.	.	0.11
23-Jul-96	beach seine	31.4	0.5	0.21	0.02	186	31.4	1.4	0.23
19-Sep-96	beach seine	38.9	1.8	0.54	0.14	52	47.5	16.8	0.98
19-Sep-96	trawl	51.8	1.4	1.51	0.11	51	58.9	16.9	1.77

Appendix 2 (c) continued.

Sampling date	Capture method	*Wild fry* Mean length (mm)	95% CI	Mean weight (g)	95% CI	# wild fish captured	*Enhanced fry* Mean length (mm)	95% CI	Mean weight (g)	95% CI	# enhanced fish captured
22-Jun-97	stocking	.	.	.	.	.	.	.	0.17	.	.
26-Jun-97	beach seine	33.1	0.6	0.27	0.02	126	29.8	0.3	0.16	0.01	78
25-Jul-97	beach seine	36.0	0.6	0.41	0.03	228	35.8	0.5	0.39	0.02	125
4-Sep-97	beach seine	45.5	1.4	0.96	0.13	124	48.6	7.6	1.23	0.83	9
4-Sep-97	trawl	51.4	1.8	1.39	0.17	85	57.7	6.0	1.98	0.59	10
1-Oct-97	beach seine	38.0	2.3	0.55	0.20	42	.	.	.	.	0
1-Oct-97	trawl	68.9	2.2	4.20	0.42	88	76.2	4.1	5.64	1.00	10
6-Jun-98	smolt	76.7	0.9	3.87	0.13	393	81.8	1.9	4.48	0.33	71
22-Jun-98	stocking	.	.	.	.	.	.	.	0.14	.	.
30-Jun-98	beach seine	33.9	1.4	0.29	0.05	93	30.2	0.6	0.17	0.02	87
19-Jul-98	beach seine	36.7	1.4	0.45	0.08	82	36.2	0.9	0.39	0.04	45
5-Aug-98	beach seine	38.8	4.4	0.58	0.28	23	46.1	3.5	0.88	0.17	15
23-Aug-98	beach seine	31.3	1.0	0.22	0.03	52	45.0	7.5	0.74	0.58	3
13-Sep-98	beach seine	48.3	1.8	0.98	0.12	47	51.4	2.9	1.20	0.20	8
23-Sep-98	trawl	49.8	1.0	1.06	0.07	134	50.4	4.5	1.07	0.23	11
3-Oct-98	beach seine	45.0	4.7	1.23	0.44	48	54.2	8.8	1.51	0.66	9
15-Oct-98	trawl	64.2	2.2	2.38	0.27	79	68.7	5.2	2.87	0.77	10
11-Jun-99	smolt	75.2	1.5	3.93	0.24	309	74.3	2.8	3.51	0.38	40
4-Jun-99	stocking	.	.	.	.	.	.	.	0.15	.	.
14-Jun-99	beach seine	31.6	0.4	0.17	0.01	57	29.9	0.5	0.13	0.01	24
2-Jul-99	beach seine	34.2	0.8	0.27	0.03	74	35.3	0.8	0.27	0.04	45
22-Jul-99	beach seine	34.7	1.1	0.35	0.05	65	42.2	1.1	0.66	0.06	17
10-Aug-99	beach seine	37.9	1.6	0.43	0.07	91	44.0	1.7	0.66	0.10	9
31-Aug-99	beach seine	42.6	5.4	0.77	0.35	16	.	.	.	.	0
17-Sep-99	beach seine	37.8	1.5	0.41	0.06	72	50.0	.	0.88	.	1
5-Oct-99	beach seine	37.7	2.2	0.42	0.08	27	.	.	.	.	0
15-17-Oct-99	trawl	55.6	1.8	1.08	0.11	25	.	.	.	.	0
spring 2000	smolt										

Appendix 3. Otolith thermal mark notation.

Marks are coded by the notation **Region:Band.Rings.** Region indicates if the mark was applied to the pre-hatch region (1) of the otolith (embryo stage), to the post hatch region (2) of the otolith (alevin stage), or both (3). Band refers to the number of bands that make up the mark, and rings refer to the number of dark rings in the band. An "n" denotes that the band of rings is narrower than usual. Example: A 1:1.3 notation indicates the mark was applied to the pre-hatch region (1), made up of 1 band containing 3 rings (1.3). A mark with notation 1:1.4+2.3 indicates the mark was applied to the pre-hatch region (1), made up of 1 band containing 4 rings (1.4), and a second band applied to the post hatch region (2) containing 3 rings (2.3).