

**PACIFIC SALMON COMMISSION  
JOINT TRANSBOUNDARY TECHNICAL  
COMMITTEE REPORT**

**TRANSBOUNDARY RIVER SOCKEYE  
SALMON ENHANCEMENT ACTIVITIES  
FINAL REPORT FOR SUMMER 1992  
TO SPRING 1995  
REPORT TCTR (98)-1**

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## EXECUTIVE SUMMARY

Joint Canada/U.S. enhancement of transboundary river sockeye stocks began in 1989, when eggs were taken at Tahltan Lake on the Stikine River, incubated at Snettisham Central Incubation Facility (CIF) located near Juneau, Alaska, and the resulting fry back-planted to Tahltan Lake. In 1990, eggs were again taken at Tahltan Lake and enhancement of Taku River sockeye salmon stocks began, with egg-takes at Little Trapper and Little Tatsamenie lakes to produce fry for outplanting to Trapper and Tatsamenie lakes, respectively. Annual egg-takes were conducted at all sites from 1991 through 1995, with the exception of Little Trapper, where they were suspended in 1995. Under terms of the Pacific Salmon Treaty,<sup>1</sup> brood years (BY's) 1991, 1992, 1993 and 1994 Tahltan Lake origin fry were divided between Tahltan and Tuya lakes. Activities up to the spring of 1992 have been previously reported (PSC 1994); the present report begins with the egg-takes in the fall of 1992 and continues through to smolt migrations and fry outplants in the spring of 1995. Results of the 1995 egg takes are included as well, for informative purposes. This report does not deal with adult returns, which began with the return of 4-yr-old Tahltan fish in 1993.

Methods are described, including egg-take and hatchery operations, otolith marking, fry outplanting, monitoring of outplants including hydroacoustic/limnological surveys and smolt sampling, and ancillary activities. Hatchery and otolith mark related activities are also described. Results are presented for each lake for the period from egg-take through smolt migration, followed by limnological observations and ancillary activities. No attempt was made to estimate benefit/cost ratios in this report. It is recommended these analyses should be done in the near future, using recently acquired adult return data and actual costs of the projects. The report concludes with a summary of major results and recommendations. Important results are summarized below.

### *Hatchery Operations*

Major modifications to convert the existing hatchery building at Port Snettisham into central incubation facility (CIF) for sockeye were completed in August, 1993. In addition to more space and better stock isolation, the new facility has improved capability for water treatment. All eggs from brood year (BY) 93 and subsequent years will be incubated in this new facility. The new CIF is fully modularized, with four of ten modules committed to transboundary sockeye salmon incubation, allowing for much improved isolation of separate stocks. The physical plant is also much improved, with thermal marking, water quality, and egg and fry handling methods modernized.

### *Otolith Marking and Reading*

A laboratory has been established in Juneau to examine thermal marking techniques and develop methods for mass processing of otoliths from returning adults. Marks have been recovered from Alaskan domestic sockeye stocks and transboundary sockeye juveniles and smolts arising from the outplants. In addition, marks from the first returns of sockeye salmon adults resulting from enhancement activities at Tahltan Lake were recovered in 1993 (BY 89). Initial problems regarding the clarity of some of the marks during the initial years of the program and the ability to identify these fish in mixed stock fisheries have been identified and are

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<sup>1</sup> Within attachment 2 of the letters to government prepared by the Canadian and U.S. sections of the Pacific Salmon Commission it specifies that for a given brood year Tahltan Lake origin fry will be outplanted to Tuya Lake only when the escapement into Tahltan Lake for that year exceeds 15,000 adult sockeye (PSC 1989, Appendix 2).

being worked on. At this time it is clear that in-season recovery and analysis of thermally marked fish is possible and that results of these analyses can be made available to fishery managers in a timely manner.

#### *Tahltan Lake Outplant Project*

There were no problems meeting egg-take goals and outplanted fry have grown and survived well. The maximum carrying capacity of Tahltan Lake has not been defined. The lake is capable of supporting current levels of outplanting, but abnormally high wild fry production could result in fry densities which may not be sustainable on a continued basis. Caution is therefore advised, and outplant numbers should be reviewed annually through analysis of data sets from ongoing limnological and fry and smolt monitoring programs.

#### *Tuya Lake Outplant Project*

Tahltan Lake provides a ready source of broodstock for fry outplants to Tuya Lake. As expected, growth of outplanted fry was exceptional. Survival, although not precisely determined, appears to be good. Final confirmation of this depends on adult returns. The lake appears capable of supporting outplants in excess of those to date. Current outplant levels are considerably below those allowed by the euphotic volume model. However, it may be prudent to proceed cautiously until changes in the observed zooplankton community structure induced by current fry outplant levels, stabilize.

#### *Tatsamenie Lake Outplant Project*

Escapement levels in several years have restricted availability of broodstock. Because of genetic concerns, the egg-take site was moved from Little Tatsamenie to Tatsamenie Lake in 1994. It is recommended that fishery management strategies be refined to allow greater escapements in the future. Outplanted fry grew well; survival has been difficult to determine but there are indications it is less than expected; confirmation by adult returns is required. Tatsamenie Lake appears capable of supporting fry outplants considerably in excess of those to date at current escapement levels; however, increased wild production in combination with outplants could conceivably tax nursery lake carrying capacity. The number of natural spawners may have to be considered in future when determining appropriate numbers for outplant.

#### *Trapper Lake Outplant Project*

Although there were no problems obtaining sufficient eggs, this stock appears to be more susceptible to Infectious Haematopoietic Necrosis Virus (IHNV) than others. Outplanted fry have grown well but it has not been possible to determine survival with any degree of accuracy. Egg-takes were suspended in 1995 because of survival uncertainty as well as concerns about the early outmigration of outplanted fry. The early outmigration of enhanced fry could have a detrimental affect on wild stocks of sockeye fry rearing in Little Trapper Lake. It is recommended this suspension remain in effect until adult returns from initial outplants are assessed. It is also recommended the lost production be replaced by increasing outplants to Tatsamenie, and/or by beginning outplants to other Taku drainage lakes, such as Nakina Lake.

## **1.0 INTRODUCTION**

Joint Canada/United States enhancement of transboundary river salmon stocks began in 1989, when 3.3 million sockeye salmon eggs were taken at Tahltan Lake in the Stikine River watershed (Figure 1). These eggs were incubated at the Snettisham temporary Central Incubation Facility (CIF) near Juneau, Alaska, and the resulting fry back planted to Tahltan Lake in the spring of 1990. Details of this project, including observations on the planted fry during their first summer and ancillary enhancement activities conducted during 1989 and early 1990, have been previously reported (PSC 1991). In 1990, eggs were again taken at Tahltan Lake and enhancement of Taku River sockeye salmon stocks began, with egg takes at Little Trapper and Little Tatsamenie lakes to produce fry for outplanting to Trapper and Tatsamenie lakes, respectively (Figure 2). Further egg-takes were conducted at all three sites in 1991, 1992, 1993, and 1994. Details and results of these enhancement activities from the fall of 1990 through to the spring of 1992 have been previously reported (PSC 1994). This report presents details and results to the smolt emigration stage, for all transboundary enhancement projects, from the summer of 1992 through the spring of 1995. Adult returns, including a small enhanced component, began in 1993 with returns of 4-yr-old Tahltan fish (4-yr-olds are a minor component of sockeye returns in this area), and will be the subject of later reports.

## **2.0 METHODS**

### **2.1 Egg-takes**

Egg-take methods for 1992 and 1993 were the same as those previously reported (PSC 1994). In 1994 minor procedural changes were implemented at all egg take sites. One of the changes involved secondary rinsing of eggs with a 100 ppm iodophor solution, as per the revised Alaska Department of Fish and Game (ADF&G) protocol to reduce IHNV transmission. A second modification involved transporting the fertilized eggs in plastic bags instead of muslin lined aluminum baskets.

### **2.2 Hatchery Operations**

All eggs from BY 92 were incubated at the Snettisham temporary CIF. All eggs from BY 93 onwards were incubated at the Snettisham permanent CIF. There are no plans to change the incubation site. Hatchery methods documented previously (PSC 1994), have remained constant with the exception of the method of fry ponding. Instead of physically removing the fry when they reach a 3-5% yolk sac ratio, the fry from BY 92 through BY 94 have been allowed to volitionally emerge into temporary holding containers. When the majority of fry have exited an incubator, the remainder are removed and transferred to the holding container. Although this method is less stressful to the fish, emergence is extended over a longer period of time. This delay makes timing of flights to complete outplanting more problematic and may also result in the excessive absorption of yolk sac reserves. As a result, hatchery staff are reviewing the volitional emergence technique and plan to use it for a shorter period before physically removing the remaining fry in future years.

## **2.3 Otolith Marking and Reading**

### **2.3.1 Alaska**

In 1989, the Transboundary Technical Committee agreed to mass mark all sockeye from transboundary river enhancement projects by manipulation of hatchery water temperatures during incubation to induce patterns of ring deposition on otoliths. A central laboratory for processing of otoliths has been developed by ADF&G in Juneau, Alaska. Responsibilities of this laboratory include refinement of techniques for marking and development of methods for mass processing of otoliths taken from returning adults. The laboratory supports the sampling of otoliths in Alaskan commercial fisheries and is capable of supplying estimates of the contribution of enhanced fish to catch and escapement either during or after the fishing season.

### **2.3.2 Canada**

Canada began developing the expertise to examine otoliths for thermal marks in 1994, with the hiring of a technician working under the direction of the Aging Lab at Nanaimo, B.C. Prior to this, marks had been read at either Eric Volk's Washington Department of Fisheries Lab or, later, at the ADF&G Lab in Juneau. In 1995, all Canadian transboundary otoliths from juveniles, adults, and smolts were processed at the ADF&G Lab in Juneau, Alaska.

## **2.4 Outplanting**

Outplanting procedures are consistent with those previously reported (PSC 1994). However, the volitional emergence technique initiated by Snettisham Hatchery with fry from BY 92, has shifted the timing of fry outplants to later in the season (Appendix 3).

## **2.5 Monitoring of Outplants**

### **2.5.1 Hydroacoustic/Limnological Surveys**

1992: Hydroacoustic and limnological surveys were conducted to evaluate the freshwater growth and survival of the fry outplanted to Tahltan, Tatsamenie, and Trapper lakes. Tuya Lake was also surveyed, this being the first year of smolt migration from this lake. This work was contracted to Triton Environmental Consultants, Ltd., with subcontracting to B. Mercer and Associates. Four surveys were conducted: June 18-25 (limnological only), July 24- August 5 (hydroacoustic/limnological), August 20-25 (limnological only), and September 17 to October 4 (hydroacoustic/limnological). All surveys included beach seining in the littoral (near shore) zone to determine the relative proportions of wild and outplanted fry. Trawl sampling in the pelagic (offshore) zone was conducted in conjunction with the hydroacoustic surveys to obtain population estimates of wild and enhanced fish. The limnological surveys included measurements of water clarity, water temperature, dissolved oxygen, total dissolved solids, total phosphorous, total nitrate and chlorophyll *a*, as well as collection of zooplankton and phytoplankton samples.

1993: The first limnological survey, June 16-20, was conducted by B. Mercer and Associates, and included collection of plankton samples, Secchi depths, and temperature profiles. Lakes surveyed included Tahltan, Tuya, Tatsamenie, and Trapper as well as Little Trapper. It was felt closer monitoring of Little Trapper

Lake was required because of the observed early outmigration of Trapper Lake fry outplants. Nakina Lake, on the Taku system, was examined the first time for its suitability for future fry outplants. The two remaining surveys were contracted to Triton Environmental Consultants, Ltd. with subcontracting to B. Mercer and Associates. The second survey, July 28 to August 4, included all lakes surveyed in June. The Nakina Lake survey included only zooplankton sampling. For all other lakes, limnological measurements of water clarity, water temperature, dissolved oxygen, total dissolved solids, total phosphorus, total nitrate, and chlorophyll a were taken. As well, zooplankton and phytoplankton samples were collected. Nitrates and total dissolved solids were not collected at Tuya, Tatsamenie, or Trapper lakes. Beach seining was conducted at all lakes except Nakina. Hydroacoustics and trawling were omitted from this survey since surveys in previous years at this time of the season had revealed large numbers of fry remaining onshore where they are inaccessible to hydroacoustic enumeration. From September 5 through September 21 a final survey of all lakes was conducted following the same sampling regime as the previous survey, although with the addition of hydroacoustics and trawl sampling.

1994: Surveys in 1994 were very similar to those of 1993. Lakes surveyed included Tahltan, Trapper, Tatsamenie, Tuya, Little Trapper, and Nakina. There was also a single survey of Little Tatsamenie Lake; this lake was included since there was the possibility for early outmigration of Tatsamenie fry outplants from Tatsamenie into Little Tatsamenie, as has been observed at Trapper/Little Trapper lakes. The first survey, June 16 to 18, was conducted by B. Mercer and Associates and included collection of plankton samples, Secchi depths, and temperature profiles. Lakes surveyed included Tahltan, Tuya, Tatsamenie, Little Tatsamenie, Little Trapper, and Nakina. Attempts to survey Trapper Lake were unsuccessful due to adverse weather. The second survey, conducted by B. Mercer and Associates (subcontract from Triton Environmental Consultants Ltd.), from July 23 to 29, included Tahltan, Tatsamenie, Tuya, Trapper, and Little Trapper lakes. Nakina and Little Tatsamenie were excluded due to cost considerations. Sampling included beach seining, zooplankton hauls, water clarity and temperature, oxygen profiles, chlorophyll-a, and total phosphorus. Total dissolved solids, Nitrogen, and phytoplankton were not sampled, as has been done in previous years. A final survey was conducted September 2 to 22 on all lakes except Little Tatsamenie, which was excluded because of cost considerations. Measurements and sampling regimes were consistent with the July surveys with the addition of hydroacoustics combined with mid-water trawling to obtain population estimates

Problems associated with obtaining accurate population estimates were discussed extensively in a previous report (PSC 1994). These included fry remaining onshore where they are missed in hydroacoustic estimates and difficulties in obtaining adequate numbers of fish in trawl samples during midsummer surveys, as well as the questionable accuracy of the hydroacoustic surveys. The number of transects was increased in Tahltan, Tuya, and Trapper lakes in 1993 in an attempt to improve accuracy, however, many of the other problems still remain. The large, undetermined, numbers of fry remaining onshore in early summer was a major factor in the decision to discontinue the July hydroacoustic surveys and to do them only in the fall when fry have moved offshore in most lakes. Specific problems encountered in deriving estimates at each lake are described in the appropriate sections to follow.

### **2.5.2 Smolt sampling**

Smolt sampling was conducted at the outlets of Tahltan, Tatsamenie, Trapper, and Little Trapper lakes in 1993, 1994, and 1995. In 1993 smolt sampling commenced at Tuya Lake, following the first fry outplanting in 1992. At Tahltan Lake smolt migrations were enumerated and sampled in a weir program conducted by Fisheries and Oceans Canada (DFO), Whitehorse, as described in a previous report (PSC 1994).

At Little Trapper, Trapper, and Tatsamenie lakes, samples were collected on several occasions over the period of smolt migration by employing a fyke net and procedures documented by Hyatt et al. (1984). This sampling was conducted by B. Mercer and Associates. Sampling at Tuya Lake was conducted by Triton Environmental/Tahltan Tribal Council. Access to Tuya Lake during the early portion of smolt out-migration is often restricted to helicopter and due to the high cost of this mode of travel, it was decided to camp at the lake outlet and trap nightly for several days rather than make intermittent trips. Samples from these lakes provide smolt size, age and thermal mark information. When possible, smolt production is estimated from the in-lake hydroacoustic surveys conducted the fall prior to smolt outmigration.

### **2.6 Ancillary Enhancement Activities**

A number of sockeye enhancement related studies were conducted which included genetic analysis of Tatsamenie river and lake sub-stocks; Tatsamenie Lake broodstock capture, holding and spawning; assessment of Nakina Lake (Taku system) for enhancement potential for fry outplanting; collection of more detailed limnological data from the outplant lakes and Little Trapper Lake; and continued study of changes in diel migration patterns of the zooplankton in Tuya Lake to determine possible response to sockeye introductions. Short term holding studies on outplanted fry to assess mortality after transport and outplanting were conducted at Tatsamenie and Trapper lakes in 1993. A short term feeding experiment was conducted at Trapper Lake with a portion of the BY 1994 outplanted fry with the objective of determining if short term rearing would result in increased fry survival.

## **3.0 RESULTS**

### **3.1 Hatchery Operations**

The construction of a larger, permanent CIF at Snettisham (renovation of the existing main hatchery building) was completed in August, 1993. All transboundary sockeye eggs from brood years 1993 to the present have been incubated in this new facility.

The new CIF has ten modules, four of which are dedicated to transboundary river sockeye salmon incubation. The new CIF has improved capability for heating and chilling incubation water, isolating separate sockeye salmon stocks, treating incubation water to increase hardness (with  $\text{CaCl}_2$ ), and controlling gas supersaturation by stripping dissolved nitrogen and adding oxygen. The new CIF is also more spacious, facilitating egg receipt and fry transfer procedures.

Preliminary results of in-hatchery survival in the new CIF were encouraging. For BY 1993 and 1994, only one incubator of fry was lost to IHNV. No Little Trapper Lake fish were lost to IHNV; and the in-hatchery

survival for this stock was improved although still short of the of 80% in-hatchery survival biostandard (BY 1993 in-hatchery survival of 78.1%). In-hatchery survivals for Tahltan Lake eggs, (those destined for both Tahltan and Tuya stocking), exceeded the in-hatchery biostandard (BY 1993 and 1994 in-hatchery survival's were 91% and 89%, respectively). BY 1993 Tatsamenie Lake sockeye salmon eggshad a poor in-hatchery survival of 46%, due to IHNV losses and poor green to eyed-egg survival, but BY 1994 had an improved in-hatchery survival of 73%. The reasons for the poor green to eyed egg survivals are not known, but since other stocks had good in-hatchery survivals it seems unlikely that the poor Tatsamenie Lake in-hatchery survivals were due to water quality or other hatchery factors.

### **3.2 Otolith Marking and Processing**

#### **3.2.1 Alaska**

##### ***Development of Marking Procedures***

Successful otolith marking is directly related to the ability of a hatchery to maintain at least two levels of rearing temperatures, and to provide control for rapidly switching between temperatures to induce a unique banding pattern. Successful marking is also influenced by the proportion of fish in a group that can be simultaneously marked, and the extent that marking can be completed within a particular time frame. At the Snettisham hatchery, learning to induce recoverable marks has been a gradual process, with each year of marking fish providing a new example of what factors can confound the marking process.

A number of early attempts to identify Transboundary River stocks at Snettisham were limited to three and four ring marks (Appendix 1.) We have since learned that three ring patterns can appear in wild stocks. In addition, many of these early markings took place during hatching. Hatching can induce variable patterns in otoliths; it may mask the appearance of the marks or may induce additional rings which look similar to thermal marks. Marking protocols now include increasing the number of thermal rings, and completing the marking before hatching or starting the marking soon after hatching.

Difficulties also arise when trying to balance schedules to uniquely mark a number of different groups given limited availability of heated and chilled water. Separating different brood years by unique thermal marks has added to this problem. The ADF&G otolith laboratory has since modified marking protocols to include an accessory band of marks that identifies brood year. In addition the lab has started to investigate counting annuli patterns in the otolith while processing for thermal marks and use of that information to identify brood year.

To increase understanding of the processes that control thermal marking, the laboratory entered into a cooperative project with the University of Alaska. The project involved experimenting with different marking protocols that would have been too risky to apply to the Snettisham releases. The results confirmed the laboratory's concerns about marking during hatching and provided indications that applying less than two Temperature Units between thermal rings can produce a ring spacing that is less than one micron. A one micron ring spacing requires more effort to resolve ring count than can be accomplished using rapid mass processing methods.



### *Development of laboratory procedures*

The laboratory has explored various options for mass processing otoliths. During this investigation it became apparent that manual processing of individually mounted otoliths by trained personnel was the fastest means of accurately detecting thermal marks from mixed stock fisheries. The primary reason why manual processing is the most expedient approach is that the morphology of otoliths are quite variable. In an examination of the shape of left and right otoliths from various individuals it was found that individual variation accounted for almost half the amount of variation found between the individual fish. Because recovery of the thermal marks requires grinding enough material away to get to an optimum viewing plane within an otolith, this high degree of shape variation precludes using a machine based processing approach in which a standard amount of material is removed for each otolith.

In addition to the high degree of shape variation, otoliths also contain a good deal of variation in the background of natural patterns in their microstructure. When preparing to process otoliths, laboratory personnel first examine otoliths from the voucher collection. These voucher otoliths are collected from a sub-sample of marked fry prior to release into lakes. The purpose of examining the voucher otoliths is to develop a visual search image of the thermal mark pattern. By processing otoliths individually, the laboratory personnel are able to make a judgment about the presence or absence of the particular mark as the otolith core is gradually exposed. Development is underway to utilize image processing as an aid to the recovery of marks, but for this application the human eye is still the most sophisticated tool for pattern recognition.

In addition to examining voucher otoliths, the laboratory also examines samples from smolts or fry that are captured in the lakes targeted for enhancement. Information from these samples is used to determine survivorship of the marked fish. These samples also provide an opportunity for personnel to develop skills in recognizing the thermal mark patterns of the juveniles in preparation for adult returns.

The summer of 1993 also provided the first opportunity to recover thermal marked adult sockeye returning to Alaska's district 108 fisheries. These marked fish were the returning 2-ocean age class and as a result did not constitute a significant portion of the catch. Notwithstanding, 1000 sockeye were collected in an effort to gain experience in sampling the commercial fishing catches and dissecting fish and removing the otoliths in the ports. From these samples the laboratory recovered seven marked Tahltan otoliths from the 1989 brood year.

The 1994 fishing season marked the first test of the ADF&G's otolith processing facility to meet the objectives identified as part of the US/Canada agreements in enhancing sockeye production. The lab was able to provide fisheries managers with an in-season estimate of the proportion of enhanced sockeye caught in 52 commercial openings over a 10 week period. These initial estimates were made by processing 4,653 otoliths taken from seven different districts and sub-districts, with the information given to managers in time for their next weekly opening. The program continued in a similar manner in 1995.

Following the in-season estimates, post-season processing continues during the summer and fall. The post-season processing is intended to confirm the initial estimates, allow for replicate readings as part of a quality control program, and provide overall estimates of contribution of the enhanced fish to the commercial fisheries. To help prioritize the samples to process during the post-season period, the U.S. implemented and

evaluated an approach developed by ADF&G's statewide Salmon Biometrician. This approach uses an adaptive sampling scheme which involves periodically updating the estimates on stock contribution as new fisheries come in and more otoliths are processed. The method determines which mix of the remaining otoliths will minimize the overall uncertainty on the numbers of enhanced fish. The approach was evaluated and utilized on the District 108 and 106 fisheries. Because it involves Bayesian sampling theory, the uncertainty estimates from those fisheries are in the form of credible intervals. For all practical purposes a credible interval can be treated essentially the same as a confidence interval. Further work on this approach will be conducted, and the extent to which it will be more fully utilized in the lab depends, in part, on the development of a database system.

Development of an otolith processing quality control program continued. The program involved blind replicate readings as well as occasional planting of marked otoliths during training periods. Overall, there was consistency in detecting the Tahltan and Tuya marked fish. More work is needed to develop the analytical approach to evaluate the data quantitatively.

The Tatsamenie 1990 mark was very poor and an expansion factor by which estimates of the number of enhanced fish based on the readability rates has yet to be developed. It is uncertain if this is possible. Based on observations from voucher samples, it was estimated that about a quarter of the enhanced Tatsamenie stock may be completely unreadable and a significant number of the others may be difficult to interpret. Similarly, the Trapper 1990 stocks are poorly marked with over 40% considered difficult to distinguish with certainty. Therefore, contribution estimates for the BY 1990 Taku Transboundary enhanced stocks must be considered preliminary at this time.

### **3.2.2 Canada**

Fisheries and Oceans Canada began developing capabilities to examine for otolith marks in 1994, with the hiring of a Technician to work under the direction of the Aging Laboratory staff at the Pacific Biological Station Nanaimo, B.C. This lab has extensive experience aging both salmonid and non-salmonid fish by otoliths but had not previously worked with thermally marked otoliths. The Technician visited the otolith labs in both Juneau and Olympia (Washington Department of Fisheries) to observe processing techniques and to develop standardized terminology.

In 1994 a portion of the transboundary juvenile and smolt otoliths were read in the Nanaimo lab; and all adult otoliths and the remainder of the juvenile and smolt otoliths were read in Juneau. In 1995 all Canadian transboundary juvenile, smolt, and adult sockeye otoliths as well as chinook otoliths from three southern British Columbia hatcheries were read at the Nanaimo lab. A manual explaining thermal marking and processing techniques has now been written (Hoyseth 1995). Although the lab is not presently funded as a support service, this is the eventual goal.

### **3.3 Disease Testing and Outplant Dates, all Lakes**

Levels of IHNV in the broodstock varied dramatically between brood-years for all lakes, for reasons not clearly understood. Levels of BKD varied much less, being relatively low in all cases. Broodstock disease testing results for brood years 1988 through 1994 for all lakes are presented in Table 26, and discussed in detail in Appendix 2. Stocking dates for all brood years for each lake are summarized in Appendix 3.

Outbreaks of IHNV occurred in alevins from Little Trapper Lake BY 1990, 1991 and 1992, but the prevalence of the virus in the sampled brood stock varied from 96.1% for BY 1990, 13.3% for BY 1991, and 97.3% for BY 1992. The prevalence of the virus in BY 1993 adult spawners, which had no losses to IHNV, was 60.0%. No outbreaks occurred in Little Tatsamenie Lake alevins of BY 1990 and 1991; the prevalence of the virus in these years varied from 64.0% (BY 1990) to 3.3% (BY 1991). There were losses to IHNV for Tatsamenie sockeye from BY 1992 and 1993, the prevalence of the virus in these groups of fish was 63.3% and 63.1% respectively, very close to BY 1990. BY 1994 had no losses to IHNV after virus prevalence dropped to 1.0%. For BY 1992 through 1994 Tahltan eggs, no IHNV losses were experienced for BY 1993 and 1994 (virus prevalence was 71.8% and 50.0%, respectively) but approximately 500,000 alevins were lost from BY 92 (virus prevalence was 91.6%).

### **3.4 Egg-takes, Incubation, Outplanting, Growth and Survival, by Lake**

Results of egg takes, incubation, outplanting, and egg to outplant fry survival for all enhancement sites are presented in Tables 1 through 3. Details of juvenile samples obtained by beach seining (onshore) and trawling (offshore) in evaluation surveys during the summer and fall of 1992 through 1995 are presented for all lakes in Tables 4 through 13 and Figures 3 through 11. It should be noted that supplemental beach seining was performed on those surveys where a sufficient number of juveniles were not captured at the index sites. Therefore in some instances the total number of juveniles sampled may exceed the actual total index catch as given in Tables 4 through 13.

Population estimates based on hydroacoustic and trawl surveys for the summer and/or fall of 1992 through 1994 for all lakes are presented in Table 14. Total estimates are apportioned to enhanced or wild and to age class based on the trawl catches detailed in Tables 4 through 13. Survival values for enhanced fish, based on these numeric estimates, are presented in Table 15. Smolt observations are summarized in Tables 16 through 20 and Figure 12. Results for each individual lake are discussed below.

#### **3.4.1 Tahltan Lake**

##### ***Egg-take Through Outplant Activities (Tahltan and Tuya)<sup>2</sup>***

Results for egg take to outplant activities for BY 1992 through 1995 are summarized in Table 1a (Tahltan) and 1b (Tuya). Project details for BY 1989 to 1991 have been previously reported (PSC 1991; PSC 1994), and details for BY's 1992-1995 are given below. Annual reports detailing the activities and results of the Tahltan egg takes (Triton Environmental Consultants Ltd. 1989 - 1995), have been prepared by the contractor and submitted to the DFO contracting authority. As previously noted, under terms of the existing Pacific Salmon Treaty, a portion of the fry resulting from Tahltan Lake egg-takes are to be planted to Tuya Lake provided the BY escapement to Tahltan Lake exceeds 15,000; this occurred for the first time in 1991 and has continued each year during the 1992-1995 period.

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<sup>2</sup> Eggs for outplants to both Tahltan and Tuya lakes are taken at Tahltan Lake and share a common history to the fry stage.

### *1992 Brood year*

The total number of fish utilized for brood stock was 3,694, (1,847 females and 1,847 males), captured from an escapement of 59,907 fish. Eggs were shipped in ten lots during the period September 2 to September 20. All eggs were shipped the day they were taken. The average fertilization rate was 93%. The goal of 5.4 million was not met based on the hatchery adjusted green egg estimate of 4.9 million eggs.

Since the Tahltan escapement exceeded 15,000 in 1992, the 1992 BY Tahltan eggs were divided into two groups and marked distinctively for planting to Tahltan and Tuya lakes. Survival at the hatchery was 90% from green egg to outplanted fry for the Tahltan Lake group, which was well above the established biostandard.

The otoliths of all 1992 BY Tahltan fry planted in Tahltan Lake were marked with a 7 ring pattern (7 cycles of 48 h warm/ 48 h chilled water) at the pre-hatch stage. A total of 1,947,000 fry were planted on June 23 and 26 and July 2, 1993.

The Tuya lake green egg to survival was 72%; this low survival rate was due to the loss of approximately 520,000 fish to IHNV prior to stocking. The otoliths of all BY 1992 fry planted in Tuya Lake were marked with a 5 ring pattern (5 cycles of 48 h warm / 48 h chilled) at the pre-hatch stage. A total of 1,990,000 fry were planted on June 16 and 25 and July 7, 1993.

### *1993 Brood year*

The total number of fish utilized for brood stock was 4,506, (2,253 females and 2,253 males), captured from an escapement of 53,362 fish. Eggs were shipped in ten lots during the period September 2 to September 21. The average fertilization rate was 95%. Brood stock was readily captured due to the high escapement and the egg-take target of 6.0 million was marginally exceeded with the adjusted green egg estimate being 6.1 million.

Since the Tahltan escapement exceeded 15,000 in 1993, the BY 1993 Tahltan eggs were divided into two groups and each marked distinctively for planting to Tahltan and Tuya lakes. Survival at the hatchery from green egg to outplanted fry was 93% which was the highest in-hatchery survival to date.

The otoliths of all 1993 BY Tahltan stock planted in Tahltan Lake were marked with a 6+5 ring pattern, 6 rings prior to hatching with 5 rings post hatching. A total of 904,000 fry were planted on June 24 and 28, 1994.

The Tuya Lake destined fry had a green egg to fry survival of 91%. The otoliths of all BY 1993 fry planted in Tuya Lake were marked with a 4+5 ring pattern, a 4 ring pattern during pre-hatch stage and a 5 ring pattern during post-hatch. A total of 4,691,000 fry were planted on June 24, 28 and 30 and July 1, 12, and 13, 1994.

### *1994 Brood year*

The total number of fish utilized for brood stock was 3,378, 1,689 females and 1,689 males, captured from

an escapement of 46,363 fish. Eggs were shipped in 9 lots during the period September 1 to September 22. Although brood stock was readily captured because of the high escapement, the egg-take target of 6.0 million was not met, resulting in an adjusted green egg estimate of 4.2 million (The 1994 egg take at Tahltan was stopped after the crash of the egg transport plane on September 22).

Since the Tahltan escapement exceeded 15,000 in 1994, the 1994 BY Tahltan eggs were again divided into two groups and marked distinctively for planting to Tahltan and Tuya lakes. Survival at the hatchery was 94% from fertilized egg to outplanted fry for those fry planted in Tahltan.

The otoliths of all 1994 BY Tahltan stock planted in Tahltan Lake were marked with a 6 ring pattern. A total of 1,143,000 fry were planted on June 26 and July 3, 1995.

The Tuya Lake destined fry had an in-hatchery survival of 82%. The otoliths of all BY 1994 fry planted in Tuya Lake were marked with a 4 ring pattern. A total of 2,267,000 fry were planted on June 21, and 25 and July 3, 1995.

#### *1995 Brood year*

The total number of fish utilized for brood stock was 4,850, (2,425 females and 2,425 males), captured from an escapement of 42,317 fish. Eggs were shipped in 13 lots during the period August 31 to September 25. The fertilization rate was 95%. As brood stock was readily captured because of the high escapement, the egg-take target of 6.0 million was exceeded and the adjusted green egg estimate was 6.9 million. A higher than average fecundity resulted in an egg take larger than the original estimate of 6.1 million eggs.

Since the Tahltan escapement exceeded 15,000 in 1995, the 1995 BY Tahltan eggs were divided into two groups and marked distinctively for planting to Tahltan and Tuya lakes. The otoliths of all BY 1995 fry destined for Tahltan Lake were marked with a 6 ring pattern, while fry destined for Tuya Lake were marked with a 4 ring band. Fry will be planted in June and July of 1996.

### ***Growth and Survival***

#### *Juvenile observations*

From 1992 through 1994, beach seine index catches from Tahltan Lake indicated relatively low numbers of fry remained onshore by the end of July and almost none by late August and early September (Tables 4, 5). Trawl catches in both July and October of 1992 were poor; however, catches at Tahltan are generally small and appear to be attributable more to high trawl net avoidance in the extremely clear water, rather than low abundance. No hydroacoustic population estimates were obtained in 1992 due to equipment problems. Only age 0+ juveniles (BY 91) were captured, and the percentage of enhanced fish (Table 4, Figure 3) ranged from 0 to 18% (Table 4, Figure 3). Part of this variability is likely attributable to small sample sizes. Average lengths of both enhanced and wild juveniles were very similar.

In 1993 (Table 5, Fig. 4), the percentage of enhanced fish was very low in the early August beachseines, but increased to 36% for age 1+ and 13% for age 2+ in the September trawls. This is likely a good estimate for the total population, since very few fish remained onshore and the sample size was large. A hydroacoustic

estimate of 817,429 juvenile sockeye was made on September 18 (Table 14). Based on the trawl sample composition, this was made up of approximately 294,274 age 0+ enhanced, 417,706 age 0+ wild, and 105,448 age 1+ wild (Table 14), indicating a survival of 15% for enhanced fish from time of outplanting (Table 15). As discussed at the end of this section, hydroacoustic estimates at Tahltan usually vastly underestimate the true population size and survivals based on smolt estimates, presented below, are generally considered to be more accurate. As in 1992, the size of enhanced and wild fish of the same age was very similar.

In 1994 (Table 5, Fig 4) there were no fish captured in July. A small trawl sample in the September survey indicated 5.9% enhanced among age 0+ juveniles. Very few fish, all wild, were captured in beachseining. A hydroacoustic population estimate of 436,634 was estimated to contain 25,761 age 0+ enhanced juveniles (Table 14), indicating a survival of only 2.8% from time of outplanting (Table 15). Enhanced and wild fish were again of similar size.

### *Smolt Observations*

Detailed observations of Tahltan smolt migrations for 1991 through 1995, as well as migration estimates are presented in Table 16. The total numbers emigrating each year, separated into enhanced or wild (all ages combined), are plotted in Figure 15. The percentage of enhanced smolts has ranged from 6.7% (1995) to 51.7% (1992).

Survivals of planted fry to fall juvenile and to age 1+ and age 2+ smolts for each brood year are presented in Table 21. Survivals of outplanted fry have been quite high, averaging 18.7% to age 1+ smolt. The notable exception is the 1993 brood year (1994 outplant), where survival was only 4.9%. The average smolt survival excluding the 1993 BY is 22.1%. The low percentage of enhanced smolts in the 1993 migration (12.7%) is the result of exceptionally high survival from wild fish of the 1991 brood year, rather than poor survival of outplanted fry (26.2% to age 1+ smolt). Survival of juveniles from the time of outplanting to the fall are based on hydroacoustic estimates. Comparison of the values for age 0+ juveniles with those for the associated age 1+ smolts the following spring show they generally underestimate the smolt values, even without allowing for any mortality between the time of the two observations (presumed to be quite low). The exception is the brood year 1992, when the fall and spring estimates were identical. The abnormally low survival to age 1+ smolt for the 1993 brood year is supported by the exceptionally low associated fall fry survival estimate based on the hydroacoustics survey.

Tahltan Lake smolt size in relation to juvenile abundance in the spring of the first year of lake rearing is given in Table 22 and plotted in Figure 13. Smolt observations include two years when the lake was artificially fertilized (1986 and 1987). Estimates of spring juvenile abundance were calculated using known numbers of fry outplanted and/or smolt estimates back-calculated using the Tahltan Lake mortality curve presented in a previous report (PSC 1994). There is a noticeable relationship (Figure 13) between juvenile abundance and smolt size for the 1990 brood year only, when the 1991 spring juvenile population was exceptionally high (estimated at 12.4 million). However, even then the age 1+ smolt sizes of 3.9 g (wild) and 3.8 g (enhanced), are not dramatically different from other years and actually exceed a 1983 value of 3.8 g. (Table 22).

The average age 1+ smolt size for each lake based on all years of observations (from Tables 16 through 20) are plotted in Figure 12. As in all lakes where wild sockeye are present, the size of wild smolts slightly

exceeds that of enhanced smolts. It is likely this is a function of earlier emergence and commencement of feeding for wild fry, rather than differences in growth rate. As can be seen, Tahltan smolts are large in comparison to most other lakes, being second only to Tuya Lake (Figure 12).

### *Hydroacoustic Estimates*

Accuracy of the hydroacoustic estimates at Tahltan Lake was discussed extensively in a previous report (PSC 1994). Based on associated spring smolt counts and estimated fall to spring mortality, it was calculated that fall juvenile populations were underestimated by a factor of 2 to 3 times. However, it was found that there was a significant correlation between the fall hydroacoustic estimates and total associated smolts; (i.e., for a fall hydroacoustic estimate in year  $t$ , the total of all age 1+ and age 2+smolts in year  $t+1$ , all age 2+ smolts in year  $t+2$ , and all age 3 smolts in year  $t+3$ ). This relationship was re-examined, with inclusion of two additional years of observations from 1993 and 1994 (Fig. 14). Excluding the 'outlier' 1990 hydroacoustic estimate, there is a highly significant relationship ( $p=.02$ ); slightly better than that previously calculated ( $p=.03$ ). Thus, the hydroacoustic estimates at Tahltan lake appear to have some predictive value for estimating the magnitude of annual smolt migrations.

### **3.4.2 Tuya Lake**

#### *Egg-take Through Outplant Activities*

No egg takes occur at Tuya Lake, broodstock for these outplants is obtained at Tahltan Lake. Fry outplants to Tuya Lake are detailed in the previous section on Tahltan Lake and presented in Table 1b.

#### *Growth and Survival*

##### *Juvenile Observations*

The first outplant was made in 1992. As previously mentioned, there are no wild sockeye in Tuya Lake. The June survey of 1992 was the only occasion when substantial numbers of fry were captured onshore, in beachseine catches (Table 6). In later 1992 surveys and in 1993 and 1994, when surveys did not begin until late July (Table 7), virtually all fry had moved offshore. Trawl catches in 1992 and 1993 were very low. This was likely due to low fish density, since in 1994 when the number outplanted (4.7 million) was more than doubled, the catch was substantial. Fry grew extremely rapidly (Table 6 and 7; Figures 5 and 6), and by the time of fall surveys Tuya fry lengths generally exceeded those of Tahltan Lake fry, even though Tahltan surveys were conducted about two weeks later.

Hydroacoustic estimates (Table 15), indicate survivals from time of outplant to the time of fall surveys ranged from 22% to 41%, (average 33%). It is not possible to assess the accuracy of this estimate, since there was no smolt enumeration program conducted at Tuya Lake. It should be noted that the estimated survival for this period at Tahltan Lake using the smolt estimate derived mortality model (PSC 1994) is 63%, while the survival, derived from hydroacoustic estimates, averages only 10.4% (range 2.8% - 15.1%, Table 15). There are reasons why hydroacoustic estimates might be expected to be more accurate at Tuya Lake, notably higher water turbidity and lower fish densities (PSC 1994). However, given the magnitude of the fry underestimation at Tahltan Lake, it seems probable the Tuya Lake estimates are low as well, and actual

survival values may be higher than the acoustics based survival index, and perhaps closer to that predicted by the Tahltan smolt estimate mortality model.

### *Smolt Observations*

Details of the smolt emigrations observed at Tuya Lake in 1993, 94, and 95 are given in Table 17. Tuya smolts (originating from Tahltan stock) are exceptionally large due to the rich zooplankton forage base, the structure of which indicated low vertebrate predation levels prior to the first outplant in 1992. Age 1 smolts average about 9 g and 98 mm fork length, approximately twice or more the size of enhanced smolts from any other lake (Figure 12). While smolt emigrations at Tuya lake have not been enumerated, survival to the fall fry stage, as estimated from hydroacoustic surveys, is relatively high (average 33%, range 22.0% - 33.3%, Table 15). Given that fry survival derived from hydroacoustic surveys are probably underestimated, it is possible that survival to the smolt stage at Tuya Lake could be similar to the 63% value determined by the Tahltan Lake smolt count mortality model discussed above.

### **3.4.3 Tatsamenie Lake**

#### *Egg-take Through Outplant Activities*

The first egg-take was conducted in 1990. Results of the egg-take and outplant activities from BY 1990 and 1991 are summarized in earlier documents (PSC 1994), activities conducted from BY 1992 through 1995 are summarized in Table 2 and discussed in detail below. Detailed annual summary reports on the Tatsamenie egg takes have been prepared by the contractor and submitted to the DFO contracting authority (B. Mercer & Associates Ltd. 1990 - 1995).

#### *1992 Brood Year*

Brood stock for outplants to Tatsamenie Lake was captured at the Little Tatsamenie Lake weir located 1 km downstream of the outlet of Little Tatsamenie Lake. Little Tatsamenie is situated approximately 5 km. downstream from Tatsamenie Lake. The connecting stream is passable to adult salmon and spawning occurs in both Tatsamenie Lake and the connecting stream. The proportion spawning in each location is uncertain but instream foot surveys by the Little Tatsamenie weir personnel and egg take crews suggest a connecting stream spawning population of 500 - 1500 through the period 1990 - 1994.

The total number of fish used for brood stock in 1992 was 791; with 435 females and 356 males spawned. From an escapement of 6,576 fish, 610 females and 475 males were captured and held. Female pre-spawn mortality was 9.0% (55 of 610) and male pre-spawn mortality was 6.5% (31 of 475). Eggs were shipped in six lots during the period September 12 to October 10. The overall fertilization rate was 86%.

The egg-take target of 1.75 million was not achieved primarily due to a bear which tore a hole in one of the holding pens, resulting in the release of 56 females. The adjusted green egg estimate was 1.5 million eggs.

Survival at the hatchery was 71.2% from fertilized egg to outplanted fry. The relatively poor survival was due in part to a loss of approximately 246,000 alevins to IHNV. This was the first time that Tatsamenie Lake stocks have had an in-hatchery mortality associated with IHNV.



The otoliths of all 1992 brood Little Tatsamenie stock were marked with a 4+3 ring pattern, 4 rings at the pre-hatch stage and 3 at the post-hatch stage. A total of 909,000 fry were planted into Tatsamenie Lake on July 9 and 14, 1993.

#### *1993 Brood Year*

The total number of sockeye captured for brood stock was 1,041 from an escapement of 5,028 through the Little Tatsamenie weir. A total of 331 females and 312 males were spawned from the held broodstock. Pre-spawn holding mortality was 90 females and 65 males; 18% and 12% of held fish respectively. The eggs were shipped in six lots during the period September 8 to October 6. One lot of eggs was held overnight at the lake because of poor weather, the remainder were shipped on the day of spawning.

Included in the total number of fish captured listed above, 96 females and 75 males were captured and held near the outlet of Tatsamenie Lake. From these fish 45 females and 44 males were spawned as part of a pilot program undertaken to determine the feasibility of capturing, holding and spawning brood stock at the outlet of Tatsamenie Lake. Holding mortality for this group of fish was similar to that experienced at the Little Tatsamenie site (13% for females and 9% for males). These results indicate that it is possible to collect eggs from fish which would have spawned in Tatsamenie Lake, thus eliminating potential genetic concerns of stocking Tatsamenie Lake with fry from the inter-connecting stream sub-stock or lake/stream hybrids.

The 1993 egg take target was increased from 1.75 million (1992 target) to 2.5 million. The egg-take target was not achieved due to lower than expected escapement; resulting in an adjusted green-egg estimate of 1.1 million. The average fertilization rate was 62%, the lowest for this broodstock group to date. Based on the results of the pilot brood stock collection program carried out near the outlet of Tatsamenie Lake in 1993, it was decided to collect brood stock for this project at a weir at this location in future years. This eliminates any potential for genetic concern with regard to mixing of the two sub-stocks.

Survival at the hatchery for BY 1993 eggs was poor, 45% from green egg to planted fry. This was due to poor green to eyed egg survival and an IHNV loss of 169,000 alevins. Reasons for the poor green to eyed egg survival are unknown.

The otoliths of all BY 93 Little Tatsamenie stock were marked with a 5+5 ring pattern. A total of 521,000 fry were planted on July 14, 1994.

#### *1994 Brood Year*

Brood stock for outplants to Tatsamenie Lake was captured in a weir at the outlet of Tatsamenie Lake. The total number of fish captured for brood stock in 1994, from an estimated escapement of 4,371, was 1,035, with 381 females and 332 males spawned. There were 51 female pre-spawn mortalities and 29 male pre-spawn mortalities for a combined total of 7.7% of held fish. Eggs were shipped in five lots during the period September 16 to October 20.

The egg-take target of 2.0 million was not achieved primarily due to low brood stock availability; the adjusted green egg estimate was 1.2 million eggs.

Survival at the hatchery was 73% from green egg to outplanted fry. The relatively poor survival was due in part to low survival to the eyed stage.

The otoliths of all 1994 brood Tatsamenie stock were marked with a 5 ring pattern. A total of 898,000 fry were planted on July 18 and 21, 1995.

### *1995 Brood Year*

The total number of fish utilized for brood stock was 1,329, made up of 726 females and 603 males captured from an estimated escapement of 8,000 fish. There were 26 female pre-spawn mortalities and 38 male pre-spawn mortalities. Eggs were shipped in 8 lots during the period September 15 to October 16. The fertilization rate was 84%. Brood stock was readily captured because of the high escapement, the egg-take target of 2.5 million was almost met, with an adjusted green egg estimate of 2.4 million. Slightly lower than average fecundities were responsible for missing the egg take goal, original estimate was 2.6 million eggs. The otoliths of all 1995 brood Tatsamenie stock were marked with a 5 ring pattern and were planted in June of 1996.

### *Growth and Survival*

#### *Juvenile Observations*

As at Tahltan and Tuya Lakes, the numbers of fry remaining onshore in Tatsamenie Lake declined over the season in all years, as evidenced by declining beachseine catches (Tables 8 and 9). However, compared to Tuya and Tahltan Lakes, at Tatsamenie (and at Trapper Lake), relatively more fry remained onshore at the time of the fall surveys. In 1992, the June survey preceded the outplants, accounting for the absence of enhanced fry in the beachseine catches. Proportions of enhanced age 0+ fry in the remaining catches in 1992 ranged from 2.2% to 7.3 %. The early August trawl catch was only 4 fry, all wild. The fall trawl catch was substantial and contained 7.6% enhanced fry. This was probably a better estimate of the enhanced proportion of the population.

In 1993, beachseine catches of age 0+ fry contained 4.1 and 9.1% enhanced fry, the latter being based on a very small sample. The fall trawl catch was substantial, with 12.4% of the age 0+ fry of enhanced origin.

In 1994, observed proportions of enhanced fish in age 0+ fry were lower, 1.7% and 5.9% in beachseine catches and only 1.8% in the fall trawl sample (two of these were relatively small samples, Table 9). Reasons for this include the relatively low number outplanted and are discussed below.

In all years, outplanted fry grew well (Figures 7, 8) but wild fry were generally slightly larger at any time, probably indicating the presence of earlier emerging fry in the wild population.

Hydroacoustic estimates (Table 14, 15) indicate survivals from time of outplant to the time of fall surveys ranged from 3.6% to 29.9%, with an average of 16.4%. As at Tuya Lake, the accuracy of the Tatsamenie fall survival estimates based on hydroacoustics cannot be assessed, since there is no smolt enumeration program for comparison. Evaluating accuracy of the enhanced fry survival estimates at Tatsamenie Lake is

particularly difficult since the number of natural spawners in the lake is not accurately known, consisting of an uncertain portion of the enumerated Tatsamenie total system return<sup>3</sup>. Therefore, it is difficult to say whether the wild population survival estimates are reasonable, which would give some indication of accuracy of the enhanced fry estimates. Another complicating factor at Tatsamenie Lake is the presence of a relatively (in comparison to Tahltan and Tuya lakes) high, indeterminable number of fry remaining onshore at the time of the fall hydroacoustic estimates. Assuming hydroacoustic estimates are likely to be low, as they are at Tahltan Lake, for the years in which fall estimates are available it appears that fall fry survivals at Tatsamenie could be comparable to the average survival seen at Tahltan. The exception to this would be the 1993 brood year, when spring to fall fry survival was estimated at only 3.6%. Examination of the data indicates this exceptionally low survival is real. Even allowing for 90% of the total enumerated 1993 Tatsamenie escapement spawning in the lake, and exceptionally high wild egg to fall fry survival (46%, the extreme estimate for Tahltan Lake), enhanced fry survival could not have exceeded about 10.5%, given the observed proportion of 1.8% enhanced fry in the trawl sample. Although based on quite a small sample (56 fish), this proportion appears to be realistic, since it agrees quite closely with the proportion of 2.3% enhanced fish in the age 1+ smolts the following spring as discussed below (Table 18). As previously discussed, the 1993 brood-year survival was exceptionally low at Tahltan as well. There may have been a common factor involved, perhaps environmental or some aspect of fish culture procedures. It should also be noted however, that proportions of enhanced smolts outmigrating have been relatively low for all brood-years (1990 - 1994, Table 18); and particularly for BY 1992, do not always correlate with the enhanced fry ratios of the preceding fall.

### *Smolt Observations*

Details of the smolt emigrations observed at Tatsamenie Lake, 1992 through 1995, are given in Table 18. Enhanced smolts are in most cases smaller than wild smolts, as were the juveniles. Again, this probably indicates the presence of some early emerging fry in the wild population. Although mean smolt length and weight have varied considerably, it is difficult to relate these to juvenile in-lake abundance given the uncertainties about the wild spawner abundance and the hydroacoustic estimates. Overall, smolts are of a good size, comparable to those from Tahltan Lake (Figure 12).

Although no attempts have been made to enumerate the smolt run at Tatsamenie Lake, in general the enhanced/wild smolt ratios of age 1+ fish (the numerically predominate age class), have been relatively low for all brood years, ranging from 2.0% - 6.3%. Although the number of wild spawners and their relative production are not known, it appears that enhanced production rates to date have been lower than the wild production rates. For the period 1990-1993 the number of fish used for broodstock purposes has ranged from 10% - 16% of total annual escapements of Tatsamenie Lake and stream spawners combined. (PSC 1994). However, annual production of enhanced smolts from Tatsamenie Lake over the same period has ranged from 2.5% - 6.3% (all age classes combined, Table 18). Several factors could account for the low enhanced smolt ratios and are discussed in section 4.4.3 below. Regardless of the causes, indications are that the enhancement objectives of increased smolt production at Tatsamenie Lake are not presently being met.

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<sup>3</sup> It is currently estimated to be as high as 70% to 80% depending on annual run strength. Foot surveys of the interconnecting stream indicate annual spawning populations of 500 -1500.

### 3.4.4 Trapper Lake

#### *Egg-take Through Outplant Activities*

The first egg take was conducted at Little Trapper Lake in 1990. Results in 1990 and 1991 have been summarized in a previous report (PSC 1994). Egg take and outplant activities from 1992 through 1995 are summarized in Table 3 and detailed below. Detailed annual reports summarizing all Little Trapper egg take activities from 1990 through 1995 have been prepared by the contractor, and submitted to the DFO contracting authority (B. Mercer & Associates Ltd. 1990 - 1995).

Fry for outplanting to Trapper Lake are incubated from eggs collected from Little Trapper Lake broodstock. Little Trapper Lake, located approximately 3 km downstream from Trapper Lake, has experienced average annual wild sockeye escapements of approximately 12,000 (1983 - 1995). Trapper Lake is not accessible to these anadromous spawners since the stream connecting the two lakes appears to be impassable to upstream migration of adult sockeye.

Little Trapper Lake broodstock were captured using a 35 m beach seine. The seine net was deployed around the mouth of the inlet stream where sockeye congregate prior to entering the inlet stream to spawn. Captured fish were held in net pens and sexually mature fish were sorted, removed, and spawned at intervals that precluded the formation of over-ripe gametes in held fish, and/or provided the requisite number of fertilized eggs for delivery to the hatchery.

#### *1992 Brood Year*

The total number of fish utilized for brood stock was 1,566, with 784 females and 782 males spawned. A total of 1,080 females and 1,013 males were captured and held from an escapement of 14,372 fish. Pre-spawn holding mortality was 39 and 34 (3.5% total) of held females and males respectively. Eggs were shipped in eight lots during the period August 29 to September 12. All eggs were shipped the day they were taken. The average fertilization rate was 90%. The egg-take goal of 2.75 million was not met due to a misunderstanding between the field crew and hatchery crew regarding incubator loading density resulting in the collection of 2,521,000 eggs (92% of the goal).

Survival at the hatchery for this group of eggs was 44% from green egg to outplanted fry. The poor survival was due to IHNV; approximately 917,000 alevins were destroyed when the prerelease screening was positive for the virus.

The otoliths of all 1992 BY Trapper fry were marked with a 7+3 ring pattern, 7 rings in the pre-hatch stage and 3 in the post-hatch stage (Appendix 1). A total of 1,113,000 fry were planted June 25 and July 2, 1993 (Appendix 3 and Table 3).

#### *1993 Brood Year*

The total number of fish utilized for brood stock was 700, with 350 females and 350 males spawned. A total of 646 females and 457 males were captured and held from an escapement of 17,432 fish. Male and female pre-spawn holding mortality was 18 and 23 fish respectively (3.7% of held fish total). Eggs were shipped in

three lots during the period August 29 to September 5. The fertilization rate was not determined by hatchery personnel, however the green egg to planted fry survival was calculated to be 78%. Brood stock was readily captured because of the high escapement, the egg-take target of 1.0 million was marginally exceeded, and the adjusted green egg estimate was 1.2 million.

Survival in the hatchery for this group of eggs was 78% from green egg to outplanted fry which is the highest in-hatchery survival to date for this stock and the first group of Little Trapper eggs not to have mortality associated with IHNV.

The otoliths of all 1993 BY Trapper fry were marked with a 4+5 ring pattern, 5 rings prior to hatching with 5 rings post hatching (Appendix 1). A total of 916,000 fry were planted on June 16 and 24, 1994 (Appendix 3 and Table 3).

#### *1994 Brood Year*

The total number of fish utilized for brood stock was 704, with 353 females and 351 males. A total of 667 females and 477 males were captured and held from an escapement of 13,438 sockeye. Pre-spawn holding mortality was 12 females and 5 males (1.5% of total broodstock held). Eggs were shipped in three lots during the period August 30 to September 7. The fertilization rate was not calculated by hatchery personnel. Brood stock was readily captured because of the high escapement, the egg-take target of 1.0 million was marginally exceeded, and the adjusted green egg estimate was 1.06 million.

Survival in the hatchery for this group of eggs was 72% from green egg to outplanted fry, below the biostandard of 80%. For the second year in a row, the Little Trapper origin eggs did not experience mortality associated with IHNV.

The otoliths of all 1994 BY Trapper fry were marked with a 7 ring pattern (Appendix 1). A total of 773,000 fry were planted on June 21 and 28, and July 3, 1995 (Appendix 3 and Table 3).

#### *Growth and Survival*

Note: Since fry outplanted to Trapper Lake have been observed to migrate prematurely into Little Trapper Lake, this lake has been monitored quite closely as well. These observations are included in this section.

#### *Juvenile Observations*

##### *a) Trapper Lake*

Unlike fry in other outplant lakes, fry outplanted into Trapper Lake remained abundant onshore throughout the season in some years, as evidenced by beachseine catches in 1992 and 1993 (Tables 10, 11; Figures 9, 10). This phenomenon did not occur in 1991 (PSC 1994) or 1994, when onshore abundance remained high throughout most of the season, but declined sharply in the final fall surveys. In 1992, all beachseine catches, including those for late September, were 100% age 0+ enhanced fry. However, the September trawl catch contained 43% age 1+ juveniles and approximately equal numbers of wild and enhanced fish. In 1993, fewer age 1+ fry were observed in the trawl catch and the proportion of age 0+ fry was much higher. Results were

similar in 1993, however, the proportions of older juveniles and wild fry in the September trawl catches was not as high. Results for 1991 were similar to 1992 but with fewer older fish in the September trawls. (PSC 1994). The only substantial sample collected in 1994 was in the July beachseine; in which the proportion of wild fry in this sample was slightly higher than in other years. Little can be said regarding the 1994 September trawl survey since the total number of fish captured was so small.

These results indicate outplanted fry generally remain onshore in substantial numbers throughout most or all of their first year in the lake but are probably entirely pelagic in their second and subsequent years. The much higher proportions of age 0+ wild fish observed in trawl catches compared to beachseine catches suggests this behaviour differs from that of wild fish, with wild fish making much less use of onshore (littoral) regions. Sizes of wild and enhanced juveniles of the same ages were very similar (Figures 9, 10).

The validity of the August 1992 hydroacoustic estimate (Table 14) is doubtful due to the indeterminable numbers of fry onshore, where they would not have been accessible to the sonic gear. This figure almost certainly substantially underestimates the true population. This would be true for the September, 1993 estimate, also. The September, 1991 estimate (PSC 1994), and the September 1994 estimates, may be reasonably accurate since very few fry were observed onshore at the time of the surveys. Estimated enhanced age 0+ fry survivals from time of outplanting to time of the fall surveys are given in Table 15. These are 24.8% for the 1990 brood year (based on 1991 surveys) and 8.5% for the 1992 brood year (1993 survey), although as mentioned above, the latter is probably substantially underestimated. The 1993 brood year survival estimate (0%) cannot be considered valid because of the extremely small trawl catch (3 fish) used in apportioning the total population.

Regarding the 1993 brood year survival, it should be noted that while a valid fall survival estimate could not be made, survival appears to have been poor relative to other years. This is indicated in the 1994 fall surveys by the apparent absence or very low abundance of fry onshore, difficulties capturing fish in trawls, and the low total population estimate compared to other years, even allowing for differences in numbers outplanted. As discussed in previous sections, survival of the 1993 brood year appears to have been low at Tahltan and Tatsamenie lakes as well.

#### b) Little Trapper Lake

As reported previously (PSC 1994) a sample of fry collected in Little Trapper Lake in July 1991, approximately 1 month after the first fry plants to Trapper Lake, contained 12% outplanted fry. This indicated a substantial amount of early outmigration had taken place. These fry were competing with wild fry for the already heavily utilized food supply in Little Trapper. Because of this, Little Trapper was surveyed once again in 1992 in order to more closely monitor what was occurring. In both 1993 and 1994 Little Trapper was surveyed two times each year, including hydroacoustic surveys in the fall. Results of these surveys are given in Tables 12 and 13 and Figure 11.

The beachseine sample collected at Little Trapper in 1992, approximately 1 month after completion of the outplants to Trapper Lake, contained only age 0+ juveniles, 18% of which were enhanced. A similar July beachseine sample in 1993 contained no enhanced juveniles in either the age 0+ or age 1+ fish captured. This also occurred for a September beachseine sample as well; a trawl sample collected at the same time contained 1 enhanced age 0+ juvenile, however this was less than 1% of the total sample. In 1994, a July

beachseine sample again contained no enhanced fry. In September there were no enhanced juveniles in either age 0+ or age 1+ trawl sampled fish, however one enhanced age 0+ fry (from a sample size of 32), was observed in the beachseined juveniles.

These results indicate the amount of early outmigration was either much reduced in 1993, or outplant survival in Trapper Lake was correspondingly low. To allow more accurate comparisons of outmigration, the percentages of enhanced age 0+ fry were standardized to allow for annual differences in 1) the number of fry outplanted to Trapper Lake, and 2) the relative abundance of wild fry in Little Trapper, using the number of wild female spawners the previous year as an index of abundance. Data was standardized relative to 1991 by dividing fry and spawner numbers by the 1991 values for these parameters<sup>4</sup>. The standardized percents were then calculated as:

$$\text{standardized percent} = \frac{\text{observed percent} \times \text{standardized number of female spawners}}{\text{standardized number outplanted}}$$

The results are given in Table 23. The amount of early outmigration in 1991 and 1992 was approximately 2 to 4 times the maximum observed in following years. It should be noted that this maximum, 6.8% for the September 1994 beachseine sample, was based on a very small sample size and thus the true value could have been lower. It has been suggested that the decreased early outmigration in 1994 may have resulted from changes in hatchery procedures. Beginning in 1993, volitional emergence techniques were employed at Snettisham. With the outplanted fry at a more advanced stage of development they may have been less susceptible to being passively swept from Trapper Lake or may have reduced the tendency to premature outmigration. However, this would not account for the low numbers of enhanced fry observed in 1993 and it should be noted that a host of other environmental factors (water currents, forage base, discharge, temperature, etc.) could influence outmigration behavior of the fry. In addition, the low numbers of enhanced fry in Little Trapper Lake may simply be attributable to low outplant survival. The 1993 and 1994 Trapper Lake hydroacoustic estimates indicated enhanced fry numbers were relatively low (Table 14).

Hydroacoustic estimates for Little Trapper Lake fry are presented in Table 14. These probably substantially underestimate the true population because of technical problems associated with high juvenile densities.

### *Smolt Observations*

#### a) Trapper Lake

Results of smolt sampling at the outlet of Trapper Lake from 1992 to 1995 are summarized in Table 19. In 1992, the first year of expected smolt emigration (age 1+ fish from the 1991 outplant), no smolts were captured<sup>5</sup>. Effort was increased in subsequent years, far above that required at other lakes. Despite this, only one smolt was captured in 1993. Procedures were modified somewhat in 1994, which may have contributed to the capture of the first significant number of smolts (38). In 1995, 165 smolts were captured. The most noticeable feature of Trapper Lake smolts was the predominance of older fish, age 2+ being predominant with substantial numbers of age 3+, and even one age 4+ smolt within the sample.

<sup>4</sup> 1) an outplant of 934,000 fry in 1991 and ; 2) and estimated female escapement to Little Trapper Lake of 3,889 in 1990

<sup>5</sup> The wild sockeye present in Trapper Lake are almost certainly kokanee and apparently do not emigrate out of the lake.

In spite of the highly glacial nature of Trapper Lake and the less than optimal zooplankton forage base, outplanted fish grew to a relatively large size. Age 1+ smolts are comparable in weight to those from Tahltan and Tatsamenie Lakes. A possible explanation for this is that the tendency for fry to remain onshore is associated with feeding on benthic or terrestrial organisms in the littoral zone, which may be a superior food source to the pelagic region zooplankton forage. This phenomenon has been observed in other highly glacial lakes (K. D. Hyatt, Pacific Biological Station, personal communication). Analysis of stomach contents of captured fry would have to be performed to substantiate this hypothesis.

#### b) Little Trapper Lake

Results of smolt sampling at the outlet of Little Trapper Lake from 1992 to 1995 are summarized in Table 20. While the large majority of smolts were of wild origin, in all years there were low proportions of enhanced smolts originating from the outplants to Trapper Lake. A large component of wild outmigrants leaving Little Trapper is to be expected given that smolts leaving Trapper Lake must exit through Little Trapper Lake along with the wild smolts originating there. The exception is the relatively high ratio of enhanced age 1+ smolts outmigrating in 1992. Given the observed early outmigration of fry from Trapper Lake into Little Trapper and the difficulties in capturing smolts leaving Trapper Lake, it seems likely at least some of these enhanced smolts may have reared in Little Trapper. Of relevance to this issue is the difference in the size of smolts known to have reared in each of the two lakes. The average weight of age 1+ enhanced smolts captured leaving Trapper Lake is 4.3 g, range 3.4 - 6.0 (Table 19). The average weight of age 1+ wild smolts leaving Little Trapper is 2.4 g, range 1.7 - 2.9 (Table 20); the average weight for age 1+ enhanced smolts leaving Little Trapper is 2.2 g, range 1.3 - 3.2 g. This would suggest that most of the enhanced smolts captured leaving Little Trapper are more likely to have reared in Little Trapper rather than in Trapper Lake. Results for age 2+ smolts are similar.

The numbers of enhanced smolts captured leaving Little Trapper appear to have been low, as are the fall juvenile estimates. Assuming the fall hydroacoustic juvenile estimates to be reasonably accurate and ignoring any winter mortality, total smolt emigrations in 1993 and 1994 would have been approximately 300,000 and 555,000 respectively. The total number of enhanced smolts (ages 1 and 2 combined) in the 1993 and 1994 emigrations, based on the proportions observed, would have been approximately 8,400 and 16,000, respectively. Having originated from a fry outplant of 1,811,000 (1991 outplants) and 113,000 (1992 outplants), total fry to smolt survival would have been 1.7% and 4.5% for 1993 and 1994 respectively. Even assuming hydroacoustic estimates underestimated smolt migrations by 100% (the approximate maximum discrepancy observed at Tahltan Lake), fry to smolt survival is still only approximately 4% - 9%. Therefore, although smolt enumeration has not occurred it is apparent that enhanced smolt production from Trapper and Little Trapper lakes is very low.

The size of age 1+ smolts emigrating from Little Trapper Lake is plotted against the estimated number of wild female spawners in Little Trapper for the brood year in Figure 16. Assuming fry numbers are directly proportional to spawner abundance, the number of spawners would provide an index of fry abundance during the year spent in the lake. Since there would also be some early emigrating fry from the outplants to Little Trapper, the number of fry from the same brood year planted into Trapper Lake is also shown. Results are irregular with 1993 being an anomaly, but for both wild and enhanced smolts there is an indication (statistically non-significant) of smaller smolts at higher densities. Therefore, although a negative correlation



exists between Little Trapper smolt size and Trapper Lake outplant numbers, evidence indicating Trapper Lake fry outplants have negatively impacted Little Trapper wild sockeye production (based on smolt size), is inconclusive.

### **3.5 Limnological Observations**

#### **3.5.1 Zooplankton<sup>6</sup>**

In this section, zooplankton observations for each of the outplant lakes and those closely associated with them are examined for any impacts resulting from enhanced sockeye fry outplants. Nakina Lake, only recently surveyed for enhancement potential is also included (further details of the Nakina surveys are given in a later section, Ancillary Activities). Zooplankton observations are depicted for all the study lakes in figures 17 through 27. Tables listing the numerical values of zooplankton abundance, length, and biomass from which the figures are derived are located in Appendix 4.

Because sockeye fry typically feed on large bosminid and daphnid cladocerans (Goodlad et al. 1974), changes in zooplankton size and species composition in response to increased sockeye fry recruitment can be used to identify limits to potential sockeye smolt production in nursery lakes and can permit qualitative assessment of the impact of sockeye fry on the zooplankton forage base (Brooks and Dodson 1965; Galbraith 1967; O'Neill and Hyatt 1987).

##### ***Tahltan Lake***

Zooplankton data for 1985 through 1994 are presented in Figures 17 and 18. Zooplankton mean length and biomass have increased slightly in recent years, with relatively little change in total abundance (Figure 17). Increased natural escapements in recent years (1991 - 1994) may have raised lake nutrient levels and helped support this increased zooplankton production even at high sockeye juvenile densities. Species composition data indicate relatively little change among years (Figure 18). Increases in the proportion of daphnids relative to cyclopoids later in the growing season, particularly in 1993 and 1994, may suggest reduced levels of fry predation on more preferable (edible) prey, like cladocerans. Reduced predation pressure through reduced levels of juvenile sockeye may also be responsible for the increased abundance of diaptomids in 1993 and 1994. In summary, these results indicate the zooplankton community has been little impacted by increased densities of juvenile sockeye and appears to be capable of easily supporting present levels of natural and supplemental fry.

##### ***Tuya Lake***

Zooplankton data for 1987 through 1995 are presented in Figures 19 and 20. Sockeye fry outplants to Tuya Lake began in 1992; prior to this there were no sockeye present and it is postulated from the observed plankton community structure that there was very little planktivorous predation. Tuya zooplankton are large and numerically abundant, with resulting high biomass (Fig. 19). Prior to 1994, the community was dominated by large predaceous heterocope and cyclopoid copepods and non-predaceous Diaptomid

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<sup>6</sup> The analyses presented here are for plankton of all sizes, including rotifers and nauplii larvae.

copepods. Cladocerans (Daphnids, Bosmina) were in very low abundance (Fig. 20). At the moderate levels of fry outplanting in 1992 and 1993 this community structure was little impacted by sockeye predation. In 1994, however, with the almost twofold increase in the numbers of fry outplanted, the largest zooplankton were heavily cropped (ie. Heterocope and Diaptomid copepods), resulting in the community being strongly dominated by the smaller, but still relatively large, Cyclopoid copepods. Their high abundance and large size resulted in a very high biomass, despite the increased predation by sockeye. In summary, results indicate that the Tuya Lake zooplankton community has not been negatively impacted by the fry outplants and could support levels even greater than that of 1994.

### *Tatsamenie Lake*

Zooplankton data for 1987 through 1995 are presented in Figures 21 and 22. Zooplankton in Tatsamenie Lake are moderate in size and numerically abundant (Fig. 21). Biomass is moderate to high and shows moderate variation between years, and appears to be unrelated to fry density as determined from hydroacoustic estimates. The proportions of cyclopoid copepods and cladocerans (Fig. 22) indicate a well balanced zooplankton community little impacted by predaceous copepods or fish predators. These results indicate Tatsamenie Lake, at least at current levels of wild production, is capable of supporting fry outplants larger than those made to date.

### *Trapper and Little Trapper Lakes*

Zooplankton data for 1987 through 1994 presented in Figures 23, 24, and 25. Outplants to Trapper Lake began in 1991. Little Trapper Lake is included in these analyses because of the observed premature emigration of outplanted fry from Trapper Lake into Little Trapper Lake and concerns about the impact of this on Little Trapper zooplankton. While total biomass is always lower in Little Trapper Lake, biomass levels for each lake do not exhibit large annual variations. Seasonal variation is also relatively consistent in each lake (Figure 23). Zooplankton densities for both lakes are consistent with those of pre-outplant years (Fig. 24). Mean zooplankton lengths have not declined in recent years, despite the outplants to Trapper Lake (Fig. 25). Species composition data for outplant years (1991 through 1994) are presented in Table 24. Zooplankton species composition differs between lakes: most notable is the scarcity of cladocerans (*Bosmina* sp., *Daphnia* sp.) in Trapper Lake, which is typical of highly glacial lakes. However, composition for both lakes has remained quite constant despite large variations in the numbers outplanted (the 1992 outplant was approximately twice that of any other). In summary, these results indicate the zooplankton communities in both Trapper and Little Trapper Lakes have been little impacted by the fry outplants. Trapper Lake could support higher fish densities. However, since the zooplankton forage in Little Trapper is already heavily utilized by wild fry and the impacts of increased predation may not be immediately evident, and in view of the early outmigration of outplanted fry from Trapper Lake in 1991 and 1992, caution should be used if the level of outplants to Trapper Lake are increased.

### *Nakina Lake*

Results of analyses of Nakina Lake zooplankton data collected in 1993 and 1994 are presented in Figures 26 and 27. Zooplankton is moderate in size and numerically abundant. Biomass is moderate to high with moderate variation over the growing season (Fig. 26). The predominance of calanoid copepods (Heterocopes

and diaptomids, Fig. 27) and lower levels of rotifers, nauplii and cladocerans indicate low cropping by limnetic fish populations. This is consistent with observations from Tuya Lake prior to sockeye fry outplants (see Ancillary Activities, below, for further results of the Nakina Lake surveys).

### **3.5.2 Productivity and carrying capacity estimates**

All available Secchi depth data were examined and average depths for the period of observations calculated. New euphotic volume estimates were calculated using these averages and, from these, revised estimates of maximum adult production and spring fry carrying capacity (see Methods Section). Results are tabulated in Table 25, including those for recently surveyed Nakina Lake; additional information on the Nakina surveys is given under Ancillary Activities. There are no dramatic changes in production estimates from those previously reported (PSC 1988). Of most significance are the slightly lower estimates for Tuya and Tatsamenie. Recent experience in S.E. Alaska suggests that maximum spring fry stocking densities derived from the euphotic volume (EV) model are often too high to be stocked on an annual basis. Because of this, a conservative approach of stocking at one-half the EV model prediction has generally been adopted. The Enhancement Sub-committee agrees with this approach; (i.e. it is the Sub-committee's recommendation that a safe level of outplanting is 50% of that predicted by the EV model; impacts of outplants to this level should be carefully monitored and evaluated before proceeding further).

Other methods of estimating carrying capacity based on zooplankton community structure and abundance, lake nutrients, and phytoplankton production are being examined but these analyses are too preliminary to generate numeric estimates of carrying capacity. However, in terms of relative productivity (i.e. zooplankton production per unit area) for the lakes examined closely, Tuya and Tahltan appear to have similar levels of productivity which are greater than those for Tatsamenie or Trapper lakes.

## **3.6 Ancillary Activities**

### **3.6.1 Tahltan Lake**

#### ***Broodstock Selectivity***

Results of tagging studies conducted in 1990, 1993, and 1994 at Tahltan Lake are inconclusive regarding the potential loss of genetic diversity due to the selection of a narrow temporal component of the run (DFO Whitehorse, unpublished reports 1990, 1993, and 1994). The studies performed in 1990 and 1993 indicate no statistically significant difference in the temporal origin of the broodstock used during those brood years. However, the 1994 tagging study did indicate a difference. This discrepancy, although statistically valid, was not large and perhaps is not unexpected since the egg take operations do not fully span the natural spawning period. Similar tagging studies are scheduled to continue at Tahltan Lake providing a firmer data base to determine the extent that certain temporal and spatial segments of the total escapement are represented in the egg-take brood stock.

### **3.6.2 Tuya Lake**

#### ***Studies of Zooplankton Diel Migration Patterns***

Studies of changes in diel migration patterns of the zooplankton in Tuya Lake in response to sockeye introductions continued. These studies consisted of sampling simultaneously at 7 different depths at mid-day, twilight, and full darkness within a 24 h period. This has been done once annually in the late summer/early fall of every year since 1990. Outplants began in 1992; prior to this there was virtually no piscivorous predation on the zooplankton. Since this work is not of immediate importance analysis of samples and data have had low priority and have been archived at the Pacific Biological Station in Nanaimo for future reference when needed.

### **3.6.3 Tatsamenie Lake**

#### ***Genetic Stock Analysis***

During the course of sockeye egg-takes at Little Tatsamenie from 1990 to 1993, there was an overriding concern regarding the collection of broodstock from mixed stocks. Fish collected at L. Tatsamenie could potentially have been from a river spawning population that spawns in the interconnecting creek between Little Tatsamenie and Tatsamenie lakes. Although fry planted in Tatsamenie Lake have not been observed to exhibit this behaviour, the potential exists that fry originating from this creek spawning population (or mixed stock hybrids), may leave the system early.<sup>7</sup>

Tissue samples collected from the creek spawning and shoal spawning populations in 1993 were analyzed by starch gel electrophoresis. Allozyme allele frequencies at seven loci were calculated for both groups. Significant differences (G-test) existed between the two samples at two separate loci. The results of this analysis indicated that there is reproductive isolation of the two stocks, and thus two distinct sub-populations. In 1994, as a result of the genetic analysis, a temporary weir structure was installed at the outlet of Tatsamenie Lake, and a trial egg-collection conducted to determine if broodstock collection activities could be relocated to this site. Broodstock collection was successful and egg-collection activities were relocated to this site in 1995.

#### ***Enhancement Subcommittee Report to TTC Co-chairs***

In June, 1994, the Enhancement Subcommittee reviewed the broodstock collection procedures within the Tatsamenie system with respect to the genetic characteristics of the stock and also broodstock collection options. Results were reported to the TTC co-chairs, together with recommendations for weir operations/broodstock acquisition (Enhancement Sub-committee of the Transboundary Technical Committee, June 16, 1994). Results and recommendations are summarized below:

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<sup>7</sup> Based on scale pattern analysis, the proportion of 0-check fish is higher for samples collected from the creek spawning population; this implies that these fish leave the system early and do not over-winter (as fry) in freshwater.

## Results:

- 1) The results of genetic analysis of tissue samples (GSI) collected from adult sockeye spawning in the interconnecting creek between L. Tatsamenie and Tatsamenie lakes, and samples collected at a barrier weir located at the outlet to Tatsamenie Lake indicated that there was reproductive isolation, and thus two distinct sub-populations.
- 2) Although behavioral problems have not been demonstrated for fry planted into Tatsamenie Lake, there is potential for fry from creek spawners or from a creek/lake hybrid to leave Tatsamenie Lake early.
- 3) Continued use of these two distinct sub-stocks for broodstock could compromise their genotypic discreteness. Specific attributes that have been selected for as a result of the reproductive isolation of these populations, within their specific environments, could be lost or diminished; subsequently reducing the overall fitness of each population, as well as the fitness of enhanced fish produced from the sub-stock crosses.

## Recommendations:

- 1) The egg-take activities should be entirely relocated from L. Tatsamenie to Tatsamenie Lake in 1995. This would require the construction of a temporary barrier weir. Based on the results of the 1994 program a more permanent structure (i.e. steel tripod weir) may later be established at this site. Operation of the Little Tatsamenie enumeration weir should be continued for one or two years after which its value will be considered.
- 2) The recommended egg-take goal for Tatsamenie of 2.5 million has been previously established by the TTC for 1994. This goal may be constrained by the escapement level to Tatsamenie Lake and by DFO protocol which limits broodstock collection to 30% of the spawning population.

*Note:* In a review of the Trapper Lake Project in February 1996, the Enhancement Subcommittee reported on the suspension of the Trapper Lake project in 1995 and the recommended expansion of the Tatsamenie Lake egg-takes to 5.0 million from 2.5 million, both to occur in 1995. This expansion did not take place due to failure to obtain approval from Province of British Columbia authorities. Details will be presented in a later report.

### **3.6.4 Trapper / Little Trapper Lakes**

#### ***Identification of Kokanee Population in Trapper Lake***

From the time of first survey in 1987 it was known that Trapper Lake contained a small number of wild sockeye juveniles. The origin of these fish was uncertain, since the falls in the stream connecting Trapper and Little Trapper Lakes appear to be impassable, preventing upstream access of Little Trapper Lake origin anadromous sockeye into Trapper Lake. Two explanations are; either the falls were not impassable, or wild fry were in fact non-anadromous sockeye (kokanee). Since all sockeye fry outplanted to Trapper Lake were thermally marked, wild juveniles in samples collected during evaluation surveys could be distinguished by absence of a thermal mark. Differences in measurements of strontium (Sr)/calcium (Ca) ratios in the marked and unmarked otoliths were used to resolve the origin of the unmarked fish. In 1989, Kalish (1989) showed that trout eggs exposed to salt water during egg formation absorb the elevated levels of Sr present in sea

water into the yolk. The strontium is passed onto the progeny via incorporation into the otoliths, thereby increasing the Sr/Ca ratio. Thus, progeny from parents of anadromous origin would have higher ratios than those of non-anadromous origin (e.g. kokanee, in the case of sockeye). A sample of 44 fry collected from Trapper Lake during evaluation surveys was examined for thermal marks; 38 were found to be marked, and therefore had to be outplanted fry, the progeny of anadromous parents. The remaining 6 unmarked fish had to be of wild origin, of unknown parentage. The otoliths of the 6 unmarked fish and those of 6 marked fish were examined for Sr/Ca ratio. In addition, the otoliths from 6 fish from a known kokanee population were examined. Ratios were lowest in the Trapper Lake unknowns and highest in the marked fry; ratios in the known kokanee were intermediate. These results suggest very strongly that the unknown sockeye in Trapper Lake are resident kokanee rather than progeny of anadromous sockeye which might have managed to pass the barrier in the outlet stream.

### ***Enhancement Sub-committee Report to TTC Co-chairs***

In March 1994, the Enhancement Sub-committee of the TTC prepared an extensive review of the Trapper Lake enhancement project for the TTC co-chairs (Enhancement Subcommittee of the Transboundary Technical Committee, March 3, 1994). This included an outline of the project, a summary of outplant evaluation results, a discussion of alternative enhancement projects, and recommendations for the future of the project. Conclusions and recommendations were as follows:

#### **Conclusions:**

- 1) Available outplant evaluation data are inconclusive, are subject to a high degree of uncertainty, and are as yet not sufficiently complete to allow an adequate understanding of the project's success. By the fall of 1994 the first returns of 4 year old enhanced Trapper Lake fish will have occurred and been evaluated, and additional limnological and juvenile stock assessment data will have been compiled. A further review of this project will be made at that time.
- 2) Review of zooplankton data, including 1993 data, for Little Trapper and Trapper lakes, does not indicate any significant negative impacts on zooplankton abundance or population structure as a result of enhancement activities to date.
- 3) Smolt production from the Trapper Lake program appears to be much less than anticipated when the project was planned. Returns of enhanced adults will likely be correspondingly low, resulting in a reduced cost-benefit for the project.
- 4) No alternatives are readily available within the Taku River drainage during the next several years to replace the Trapper Lake enhancement program if it is discontinued. A transfer of enhancement production to ongoing Stikine River enhancement programs could be undertaken in the short-term, to increase returns of enhanced transboundary sockeye salmon and fully utilize incubation capacity at Snettisham Hatchery, but this would delay reaching the goal of producing annual returns of 100,000 enhanced adults to the Taku River.
- 5) Snettisham Hatchery has just completed a major retrofit. The retrofit and changes in hatchery procedures such as using volitional emergence, should improve in-hatchery survivals and fry quality.

#### **Recommendations**

- 1) The Enhancement Subcommittee recommends the continuation of the Trapper Lake program at

the 1.0 million egg-take level in 1994. This level of program will contribute some returns to user groups (although below the agreed upon Enhancement Memorandum of Understanding), free-up money to hasten development of other existing or potential Taku River enhancement projects, and provide additional data on which to evaluate the Trapper Lake program.

2) Also recommend was an egg-take goal of 2.0 million for the Tatsamenie Lake program in 1994. Assessment and refinement of the Tatsamenie Lake program should be accelerated. This lake appears to offer the most potential to achieve the Taku enhancement goal within the shortest time period. The magnitude of egg-takes at this location should be increased as soon as possible, within broodstock limitations, to replace the lost production from reduced egg-takes at Little Trapper. Some of the budgetary savings which occur from reduced egg-takes at Little Trapper will be directed towards additional egg-take (two sites) and assessment efforts at Tatsamenie Lake.

3) There appear to be opportunities within the Taku River which are capable in the long-term of satisfying the current enhancement goal for this drainage. In particular, the potential of King Salmon, Nakina and Kuthai lakes should be investigated to the extent funding allows.

4) The regulatory process and biological assessment requirements that must be satisfied for any new enhancement programs to proceed should be investigated and action initiated where appropriate.

*Note:* At the recommendation of the Enhancement Subcommittee egg-takes at Little Trapper were suspended in 1995, mainly because of continued uncertainties regarding success of the project. This decision was the subject of a report from the Enhancement Subcommittee to the TTC co-chairs in February 1996 (Enhancement Subcommittee of the Transboundary Technical Committee, February 5, 1996) and will be reported upon in a later report.

#### ***Pen Rearing Study at Trapper Lake***

In addition to the planting of 537,800 un-fed fry directly into Trapper Lake in 1995 (BY 1994), an experiment was conducted on a group of approximately 235,600 fry to test the effects on fry to smolt survival of short term rearing in a floating net pen in Trapper Lake. These fry were marked with a strontium band on the otolith, in addition to the seven ring thermal band. They were placed in a pen on June 28 and fed for 22 days. Average weight of the fry increased from approximately 0.13 g to 0.39 g, an increase of 0.26 g (200%).

An estimated 93,000 fry, averaging 0.39 g in weight, were released into the lake from the net pen on July 20. The releases were in lots of approximately 5,000 at several inshore locations around the lake. Release numbers are considered relatively accurate as all released fry were weighed with corresponding sub-samples weighed and the individual fry counted. The large difference between the hatchery estimate of fry placed in the pen and the actual number released is possibly due to the fish being released directly into the lake during the outplant, and/or fry escaping through the net mesh during the first few days of the experiment. Additional details of this experiment will be presented in future enhancement reports when the otoliths from outmigrating smolts and/or returning adults are analyzed.

### 3.6.5 Nakina Lake

Nakina Lake was surveyed for enhancement potential in 1993 and 1994, as described in section 2.5.1. Zooplankton analyses are given above and illustrated in Figure 27; other results can be summarized as follows:

- The relative productivity of Nakina Lake appears to be greater than that of Tatsamenie but slightly lower than that of Tahltan.
- No sockeye or other planktivorous fish have been captured in Nakina Lake; the only species which have been captured or observed are Arctic grayling, cottids, and burbot (freshwater lingcod).

The following observations are presented in Table 25:

- The lake can be classified as clear/stained; the average Secchi depth is 5.6 m and the euphotic depth estimate is 9.41 m.
- The surface area of Nakina Lake is 491 hectares, almost identical to that of Tahltan; the euphotic volume estimate is 46.2 EV units, approximately one-half that of Tahltan, reflecting the reduced light penetration.
- Estimated adult sockeye production potential for Nakina Lake, based on the EV model, is 113,000, approximately one-half that of Tahltan Lake.
- The euphotic volume potential is equivalent to outplants of about 5,667,000 spring fry; although if the conservative approach previously described is taken, a 'safe' outplant level would be 50% of this, or 2,834,000 fry (for a sustained adult production of 56,500 adults).

## 4.0 DISCUSSION

### 4.1 Hatchery Operations

The modifications to the main building of the hatchery, turning it into a permanent CIF, were completed in August, 1993. The new facility has provisions for much better isolation of separate sockeye salmon stocks, greatly reducing the risk of IHNV transmission between groups of fish, as well as several other improvements over the temporary CIF. These improvements include: 1) an oxygen generation system which can be used to reduce super saturation problems and increase dissolved oxygen concentrations; 2) more efficient and higher capacity electric water heaters; and, 3) an additional, much more sophisticated water chiller, which when used in concert with the original chiller greatly increases chilling capacity. The new CIF also has improved provisions for water hardness treatment using  $\text{CaCl}_2$ .

Hatchery staff assume an egg to fry survival of 80%. This assumption was exceeded for BY 1992, 1993, and 1994 Tahltan eggs destined for Tahltan Lake. The assumption was met for BY 1993 and 1994 eggs for Tuya and was nominally met for BY 1993 from Little Trapper. Poor hatchery survival for the 1992 brood Tahltan eggs destined for Tuya Lake were attributed to IHNV outbreaks. Eggs from BYs 1992 and 1994 from Little Trapper Lake had poor egg to fry survival, partly due to IHNV for BY 1992. The poor survivals of BY 1992 and 1993 Tatsamenie Lake eggs were primarily attributable to IHNV. BY 1994 Tatsamenie Lake egg survival was improved over the previous two years, but was still below the hatchery target of 80%.

Outbreaks of IHNV at the Snettisham Hatchery have thus far not been obviously related to the prevalence of



the virus in the parental brood stock, which has fluctuated dramatically at each of the three lakes (refer to section 3.3 above, and Appendix 2). The lack of a clear relationship between incidence of the disease in the parents and offspring suggests that as long as the pathogen is present, outbreaks may take place regardless of the parental incidence of the disease. The probability of an outbreak might be better understood if a representative sample of incidence for each incubator was available, however such information would be very costly to obtain.

## **4.2 Egg-take Operations**

### **4.2.1 Tahltan/Tuya lakes**

All Tahltan Lake egg-takes have come close to or exceeded target levels, largely due to large escapements, and the ease of capture and holding of broodstock.

Concerns had been expressed regarding loss of genetic diversity due to selection of broodstock from a narrow temporal segment of the run. Results from tagging studies are inconclusive, but suggest that the broodstock captured is by and large representative of the entire run (see section 3.7.1). In terms of overall loss of genetic diversity and/or genetic drift, it should be noted there is still the potential that over successive generations of enhancement activity the enhanced component of the run will progressively increase due to the differential survival of the enhanced versus wild offspring.

### **4.2.2 Trapper Lake**

There have been no major problems associated with the Little Trapper Lake egg-takes. Brood stock is readily available at recent escapement levels and all egg-takes have come close to or have exceeded the targets. Nevertheless, other concerns regarding this project resulted in the TTC enhancement sub-committee recommending the project be suspended, (see above memo from Enhancement Sub-committee to TTC co-chairs, February 5, 1996, under 3.7.4 Ancillary Activities: Trapper/Little Trapper Lakes).

### **4.2.3 Tatsamenie Lake**

Escapement levels have been too low in the past several years to allow collection of sufficient broodstock to meet egg-take targets. The possibility of adjusting management strategy to permit larger escapements has been examined, but is complicated by a number of factors such as run timing, stock identification/separation, and annual variations in run strength. Nevertheless, the ability of the contractor to meet expanded future egg take targets is predicated on the availability of sufficient broodstock. A review of egg-take operations, with emphasis on perceived genetic concerns regarding current broodstock collection methods, was done in the spring of 1994. As result, egg-take operations in 1994 were moved from Little Tatsamenie to Tatsamenie Lake (see memo from Enhancement Sub-committee to TTC co-chairs, under 3.7.3 Ancillary Activities: Tatsamenie Lake).

### **4.3 Otolith Marking and Reading**

#### **4.3.1 Alaska**

Otolith marking at Snettisham went well for BY's 1992 through 1994. The hatchery staff worked closely with the otolith lab, providing voucher samples and thermal records for mark validation.

During the period covered by this report, the otolith laboratory gained experience in thermal otolith marking, sampling, and processing. This experience is required in order to successfully recover thermal marks from adult sockeye returning to the Alaskan commercial fisheries. Strategies were developed to identify sample sizes needed to optimize laboratory effort with the objective of minimizing overall uncertainty on the numbers of enhanced fish captured. Other activities included development of an integrated database system which includes an inventory control process using bar-code labeling of samples.

#### **4.3.2 Canada**

In 1995, all Canadian transboundary juvenile, adult, and smolt otoliths were processed at the newly established otolith Lab in Nanaimo, B.C.. At present the otolith work is funded directly by a small number of projects, however, the eventual goal is to develop the otolith laboratory as a support service. Co-operation between this lab and that at Juneau has been excellent and the paired otoliths processed at one lab are available for independent reading by the other, if requested.

### **4.4 Growth, Survival, and Limnology**

#### **4.4.1 Tahltan Lake**

Outplanted fry have grown and survived well, the exception being the poor survival of the 1993 BY (1994 outplant). However, similar poor survivals of outplanted fry for this brood year were noted at Tatsamenie and Trapper Lakes as well. It is possible there may have been a common factor involved, not specific to Tahltan Lake. The average survival to age 1+ smolt is 18.7% or 22.1%, excluding the 1993 brood year. A 20% fry to smolt survival biostandard is used in planning the transboundary enhancement projects. Smolt size and zooplankton have shown little impact from the increased fry densities, which in one year exceeded the maximum predicted by the euphotic volume model. Productivity of Tahltan Lake is judged to be very high, similar to that of Tuya Lake, and well in excess of other outplant lakes.

#### **4.4.2 Tuya Lake**

Outplanted fry have grown exceptionally well, as was predicted from the rich zooplankton forage base, which was characterized by low predation levels by planktivorous fish, prior to the first fry outplant. Smolts from Tuya Lake are approximately twice or more the size of enhanced smolts from any other lake, including Tahltan Lake, the source of the parental stock for the Tuya Lake outplants. Hydroacoustic estimates of fall fry indicate survival to that stage was similar for BY1991 and BY1992 outplants, however, survival for the 1992 brood year, may have been considerably lower. It should be noted that hatchery survival for this group was low as well, as a result of IHNV problems. The poor survival of the 1993 BY outplants noted at other lakes was not apparent at Tuya. Smolt emigrations have not been enumerated at Tuya Lake. However, using

fall fry hydroacoustic estimates as a predictor of smolt numbers, there is no reason to believe survivals to the smolt stage in Tuya have not been as good or better than at Tahltan, since smolt estimates obtained by this method at Tahltan have been shown to be far too low. The zooplankton community structure has been altered by the fry outplants, however this impact has not been negative. The community has now assumed a structure, with a reduced abundance of large predaceous copepods and an increased abundance of non-predaceous copepods as well as the faster reproducing Cladocerans, (*Bosmina sp. and Daphnia sp.*), a desirable sockeye forage base. Productivity of Tuya Lake is judged to be very high, similar to that of Tahltan Lake, and results indicate Tuya could support levels of outplanting greater than those adopted thus far.

#### **4.4.3 Tatsamenie Lake**

Growth of outplanted fry In Tatsamenie Lake has been good, with smolts similar in size to those from Tahltan Lake. Migrating smolts have not been enumerated and survival has been very difficult to estimate. There have been problems obtaining hydroacoustic estimates to calculate survival to the fall fry stage; these include equipment problems and the fact that the number of natural spawners in Tatsamenie Lake was not accurately known in the years involved. The estimated survival to the fall fry stage for BY 1991 through BY 1993, as determined from hydroacoustic estimates and trawl surveys, could be comparable to that for Tahltan Lake. However, estimates of proportions of emigrating enhanced smolts for BY 1990 through BY 1993 are relatively low. Even though the wild sockeye production in Tatsamenie Lake is not known with certainty, the low proportion of emigrating enhanced smolts appears to indicate either a low enhanced fry to smolt survival, or premature emigration of enhanced fish prior to spring smoltification.

The zooplankton in Tatsamenie Lake appears to be lightly impacted by the fry outplants and remains a well balanced community favorable to sockeye production. The productivity of Tatsamenie Lake is judged to be less than that of Tahltan or Tuya but greater than that of Trapper; at current levels of wild production it appears to be capable of supporting levels of outplanting greater than those used to date.

#### **4.4.4 Trapper and Little Trapper Lakes**

Growth of fry outplanted to Trapper Lake has been good, with smolts similar in size to those from Tahltan and Tatsamenie lakes. This has occurred despite the glacial conditions and less than optimal zooplankton forage; with cladocerans, the preferred food, being almost totally absent. As discussed previously, this fry growth may be associated with the tendency for fry to remain onshore, where benthic organisms may provide a food source superior to the pelagic region zooplankton forage. The zooplankton communities in both Trapper and Little Trapper lakes have been little impacted by the outplants; although it should be noted that impacts may be difficult to detect immediately in Little Trapper Lake, where the forage base is already heavily utilized by wild fry.

It has not been possible to obtain good survival estimates at Trapper Lake. Hydroacoustic estimates of fall fry abundance have been complicated by the tendency for fry to remain onshore where they are inaccessible to sounding gear and the difficulty in obtaining representative trawl samples. Another complicating factor has been the tendency for indeterminable numbers of fry to exit the lake prematurely as indicated by the presence of BY 1990 and BY 1991 enhanced fry in Little Trapper Lake. However, in subsequent brood years the number of enhanced fry rearing in Little Trapper is quite low, likely indicating that premature or passive emigration is no longer occurring. The final complicating factor in determining survival has been the

difficulties in capturing smolts leaving Trapper Lake. The reason for this is uncertain. Aside from possible low survival there are a number of other factors listed below which may influence catches:

- 1) Since smolt samples consistently show the majority of fish tend to remain in the lake at least two years, only a small number would be expected to have migrated in 1992, following the first outplant in 1991.
- 2) In 1991 and 1992, the first two years of outplanting, there was substantial early outmigration of fry into Little Trapper Lake which would have affected Trapper Lake smolt emigrations arising from these outplants, most notably in 1992 through 1994.
- 3) The more advanced fry resulting from volitional emergence, initiated with the 1992 BY (1993 outplants), may have survived at significantly higher levels, resulting in correspondingly greater smolt catches in later years.
- 4) Since outplants to Trapper have been relatively small (0.9 to 1.1 million, the outplant of 1.8 million in 1992 being exceptional) and since there are no wild smolts, total smolt abundance would generally be considerably less than at other lakes, making capture more difficult. The first significant capture (38 smolts) was in 1994, the predominant 2-yr-old age class in this migration being associated with the large outplant in 1992.
- 5) Trapping methods were modified in 1994, the first year of significant captures. The most notable changes were the use of two nets instead of one and placement of nets in mid-stream as a result of favourable water conditions. Similar techniques were used in 1995.
- 6) Because of the predominance of older, larger, smolts in the Trapper emigration, as well as the relatively low density of outmigrants, the ability to avoid capture could be greater than at other lakes.

Given the problems in obtaining survival estimates it cannot be said with certainty whether survivals at Trapper Lake differ greatly from those observed at other lakes. However, the most reasonable interpretation of available information is that it has been substantially lower.

In summary, there are questions and uncertainties regarding the Trapper Lake outplants, notably:

- 1) Strong indications that survival has been low.
- 2) Possible negative impacts to the wild sockeye fry in Little Trapper Lake through competition for a limited food supply, should early outmigration of outplanted fry into Little Trapper Lake recur.
- 3) Uncertainties regarding the suitability of the fry forage base of Trapper Lake, even if survivals have been better than estimated.

It was because of these concerns that the Enhancement Subcommittee recommended there be no egg-takes at Little Trapper in 1995, and that this suspension remain in effect until adult return data becomes available to assist in a final evaluation.

#### **4.4.5 Nakina Lake**

Nakina Lake offers considerable potential for sockeye outplanting and could perhaps be used to replace the production lost through suspension of the outplants to Trapper Lake. Estimated adult sockeye production potential for Nakina Lake, based on the EV model, is 113,000, approximately one-half that of Tahltan Lake,

and very similar to that for Trapper Lake (Table 25). If the recommended conservative 50% approach is used, the production potential is 56,500 adults, which could be achieved by outplants of approximately 2,834,000 spring fry. Issues that would have to be examined before proceeding would include a disease profile on resident species, source of broodstock, impact on resident species of outplants, ability to effectively harvest returns including interceptions of co-migrating sockeye stocks and other salmonids, including steelhead, and possibly a full environmental review.

## **5.0 SUMMARY AND RECOMMENDATIONS**

### **5.1 Hatchery Operations**

The permanent Central Incubation Facility constructed at Snettisham in 1993 is working well, with improved capabilities for treating water and isolating stocks. The occasional occurrence of IHNV indicates the continued need for strict observance of sockeye culture protocols.

### **5.2 Otolith Marking and Reading**

The thermal mass marking of otoliths has proved successful and provides a very effective management tool. Efforts should be made to develop an integrated database system, including Canadian data, to increase utility and avoid duplication of marks. The timeliness of results produced by the otolith lab in Nanaimo could be improved upon.

### **5.3 Tahltan Lake Outplant Project**

There have been no problems meeting egg-take goals and outplanted fry have grown and survived well. The maximum carrying capacity of Tahltan Lake has not been defined. The lake is capable of supporting current levels of outplanting, at least on an annual basis, but abnormally high wild fry production could result in fry densities which may not be sustainable on a continued basis. Caution should therefore be used when determining the outplant numbers.

### **5.4 Tuya Lake Outplant Project**

Tahltan Lake provides a ready source of broodstock for outplants to Tuya. As expected, outplanted fry have grown extremely well in Tuya Lake. Survival, although not precisely determined, appears to be good. Final confirmation of this depends on adult returns. The lake appears capable of supporting outplants considerably in excess of those to date. However, it would be prudent to proceed cautiously in order to properly consider changes in zooplankton community structure resulting from the outplants.

### **5.5 Tatsamenie Lake Outplant Project**

Escapement levels in several years have been too low to allow collection of sufficient broodstock to meet objectives. Relocation of the egg-take site from Little Tatsamenie to Tatsamenie Lake, while alleviating genetic concerns, may further reduce broodstock availability. It is recommended that the possibility of special fishery management strategies be considered to allow greater escapements. Outplanted fry have grown well;

survival has been difficult to determine, but indications are that enhanced smolt emigration is less than expected. Confirmation by adult returns is required. Tatsamenie Lake appears capable of supporting outplants considerably in excess of those to date at current escapement levels; however, increased wild production in combination with outplants could conceivably tax the fry carrying capacity of the lake. The number and relative production of natural spawners may have to be considered when determining outplant targets.

#### **5.6 Trapper Lake Outplant Project**

There have been no problems obtaining sufficient eggs to meet objectives, however this stock appears to have a greater susceptibility to IHNV breakouts than others. Outplanted fry have grown well, but it has not been possible to determine survival with any degree of accuracy. Because of this, and concerns about early outmigration of outplanted fry and resulting possible impacts on wild stocks, egg-takes were suspended in 1995. It is recommended this suspension remain in effect until adult returns are assessed. It is also recommended the lost production be replaced by increasing outplants to Tatsamenie, and/or by initiating outplants to other lakes, Nakina Lake being one candidate.

#### **5.7 Benefit / Cost Estimates**

No attempt was made to estimate benefit / cost ratios in this report. One reason for this is lack of sufficient data on adult returns to estimate adult production, this being the true measure of survival and benefit. It is recommended these analyses should be done in the near future, using recently acquired adult return data and actual costs of the projects.

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## **FIGURES**

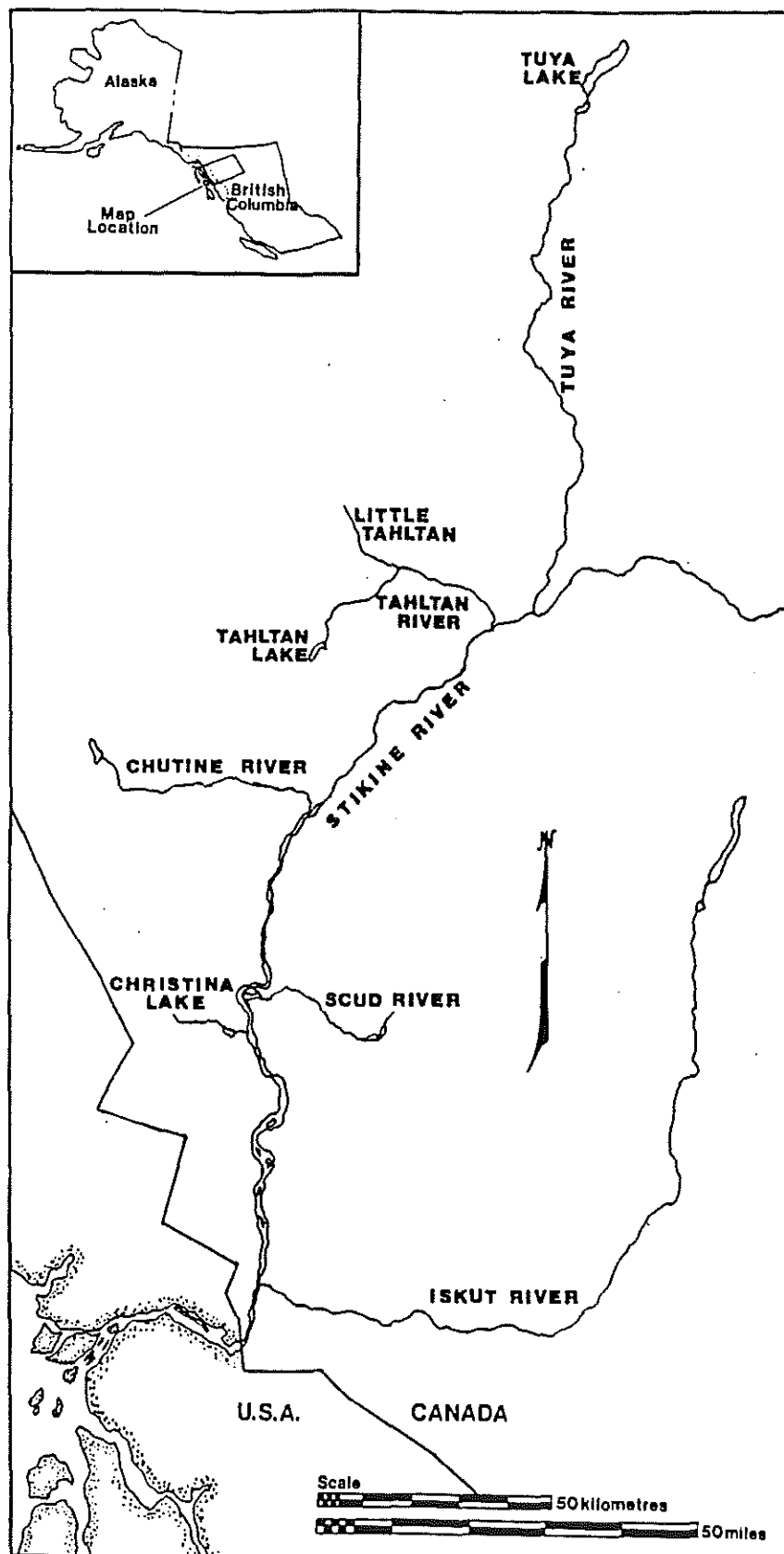


Figure 1. Stikine River drainages.

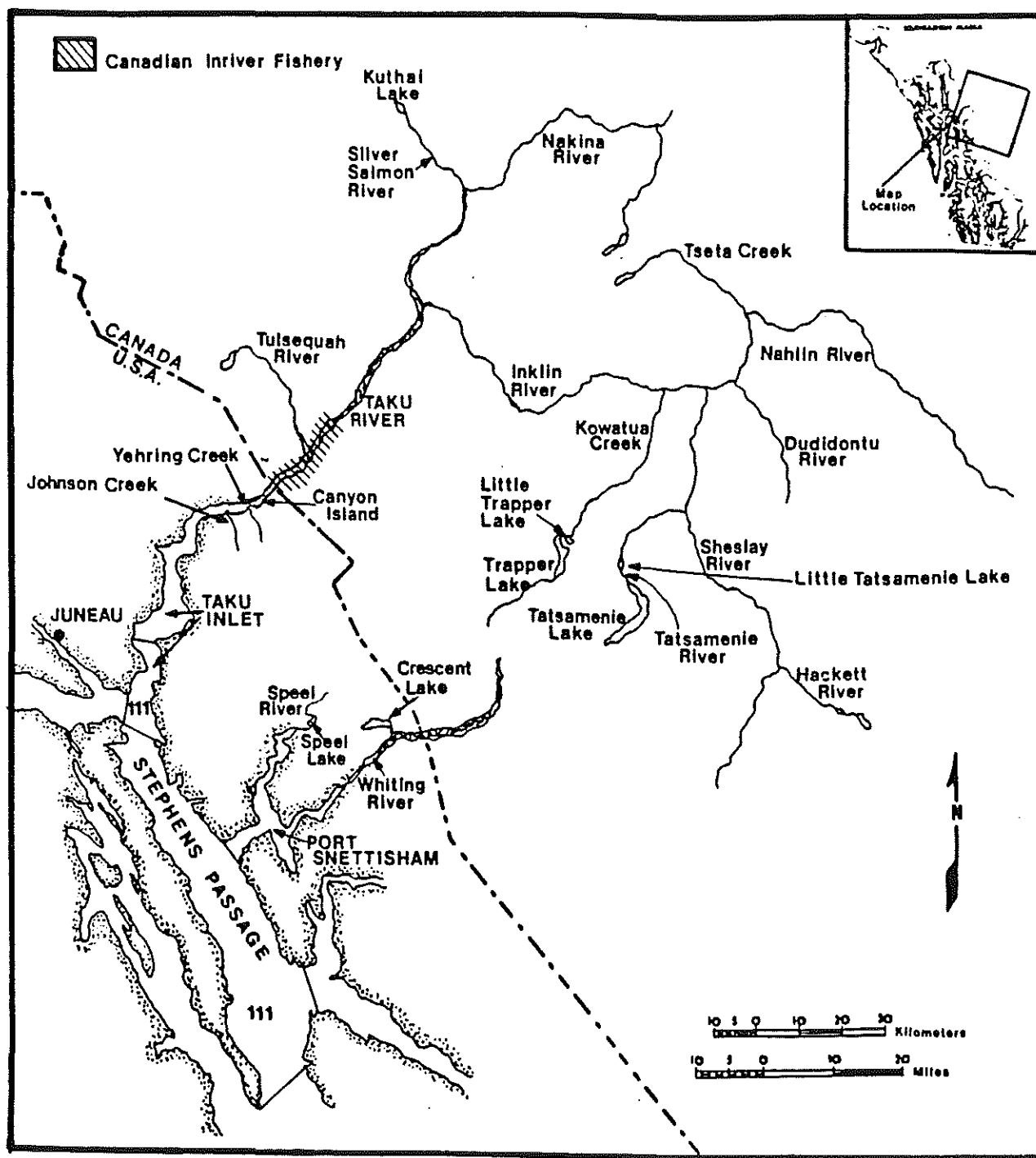


Figure 2. Taku River drainages.

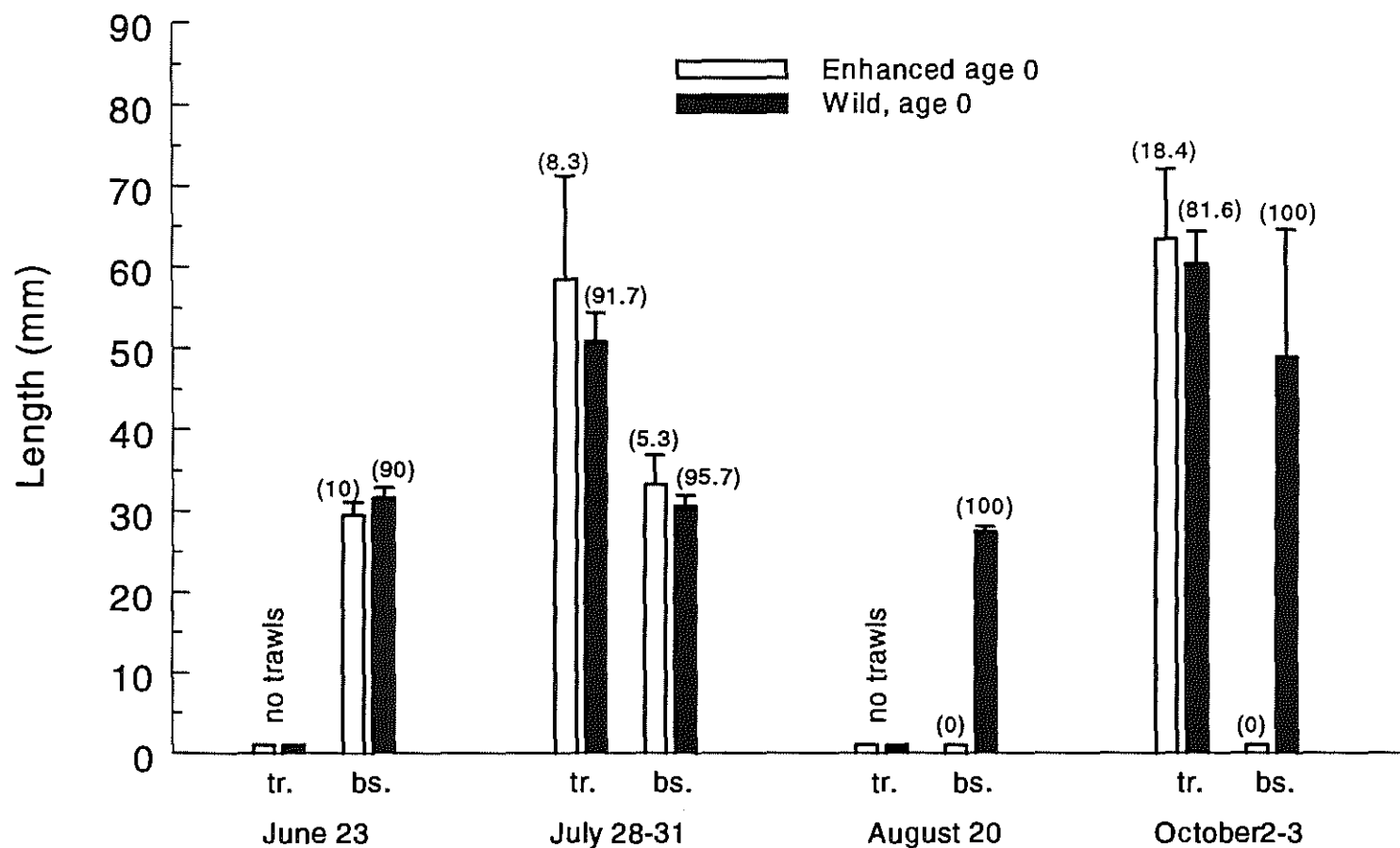


Figure 3. Tahltan Lake surveys, 1992; mean lengths and percentages (in brackets) of enhanced and wild juvenile sockeye in trawl (tr.) and beachseine (bs.) samples. Small length bars (1mm) indicate 0 fish in the category. 95% confidence limits are given except for single fish samples and 0% or 100% values. Measurements are from fish preserved in denatured 94% ethanol.

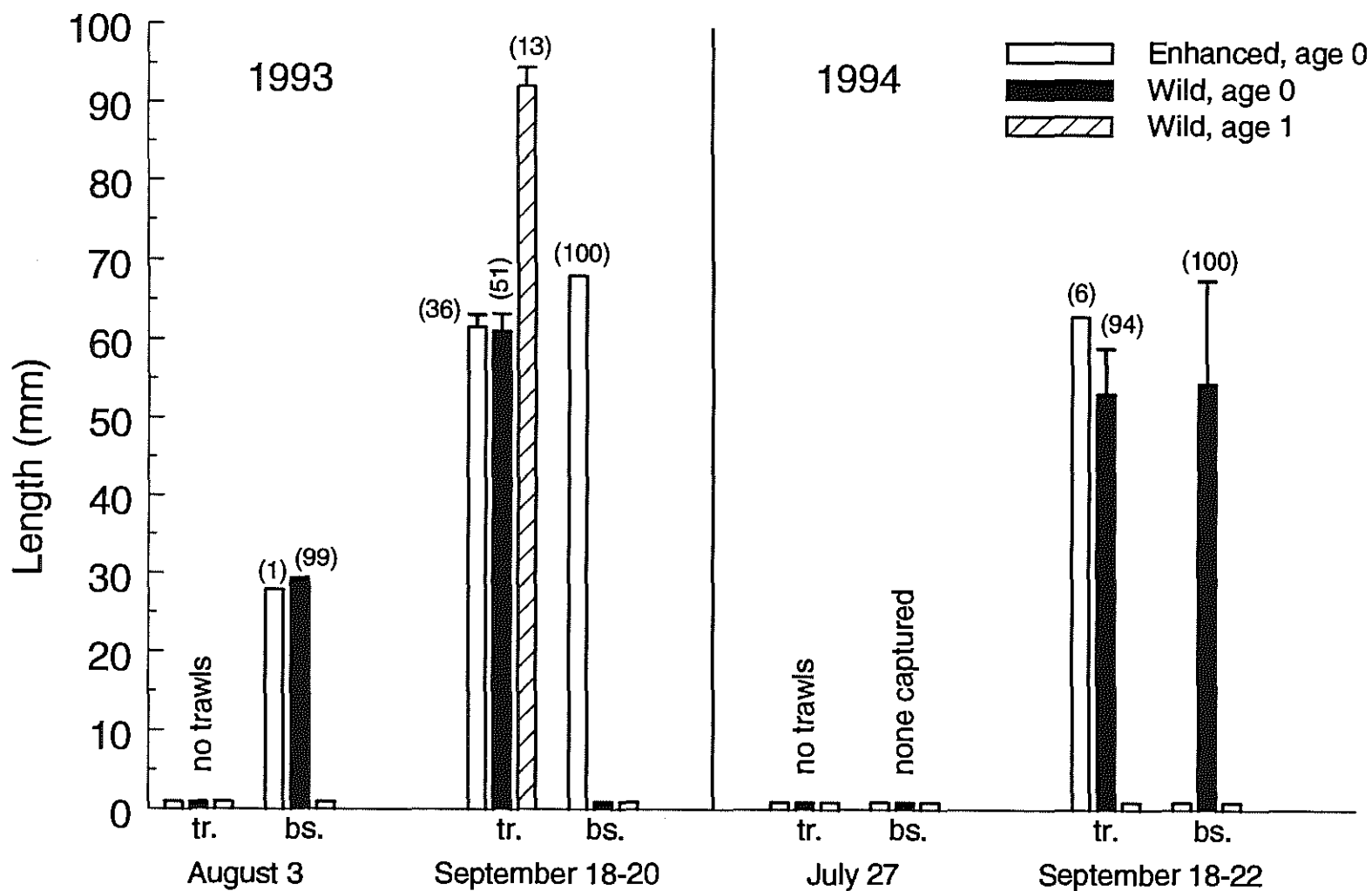


Figure 4. Tahltan Lake surveys, 1993 and 1994; mean lengths and percentages (in brackets) of enhanced and wild juvenile sockeye in trawl (tr.) and beachseine (bs.) samples. Small length bars (1 mm) indicate 0 fish in the category. 95% confidence limits are given except for single fish samples and 0% or 100% values. Measurements are from fish preserved in denatured 94% or 90% ethanol, 1993 and 1994 respectively.

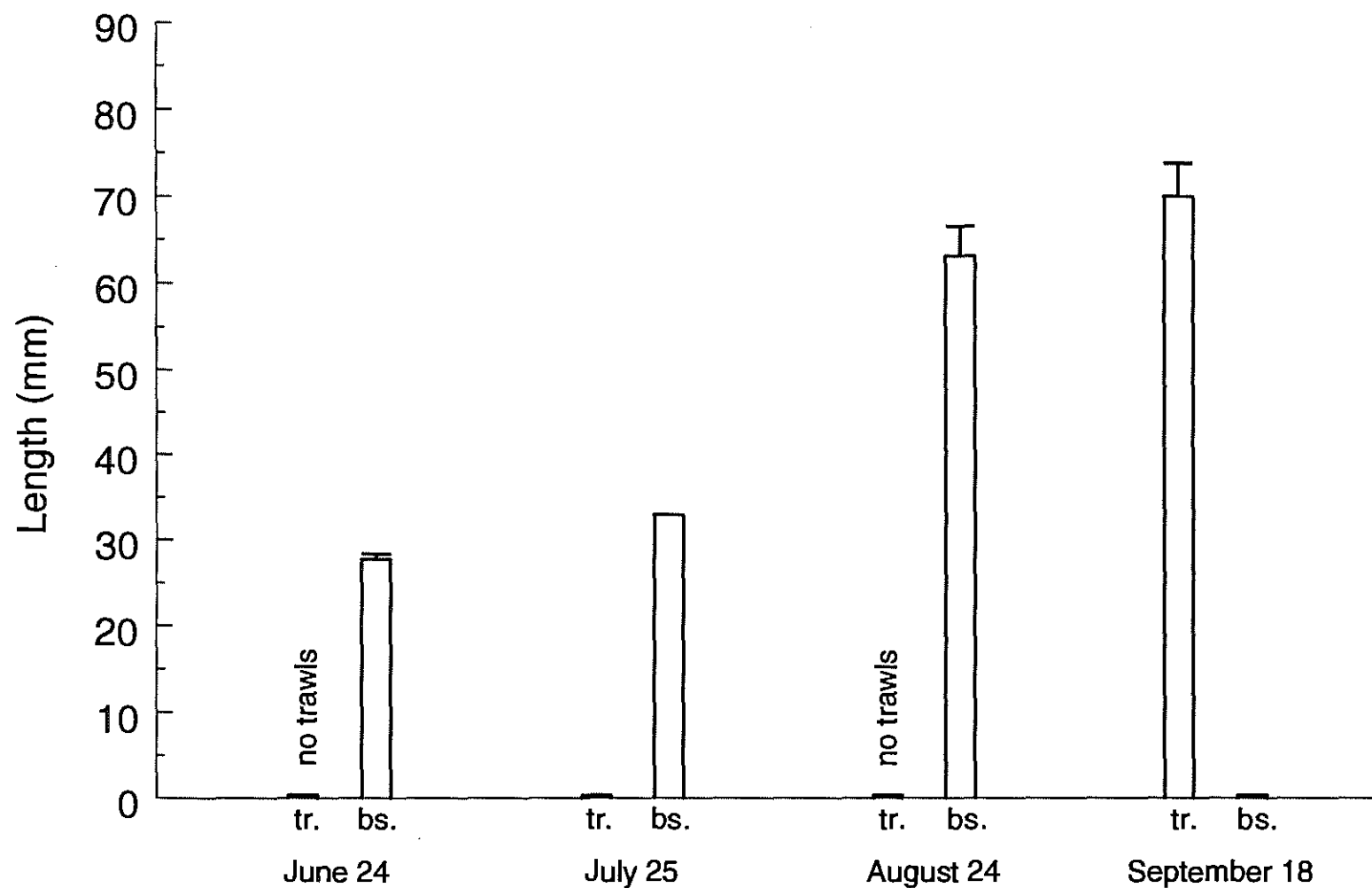


Figure 5. Tuya Lake surveys, 1992; mean lengths of juvenile sockeye in trawl (tr.) and beachseine (bs.) samples. All fish are enhanced as there are no wild sockeye in Tuya Lake. Small length bars (1 mm) indicate 0 fish in the category. 95% confidence limits are given except for single fish samples. Measurements are from fish preserved in denatured 94% ethanol.

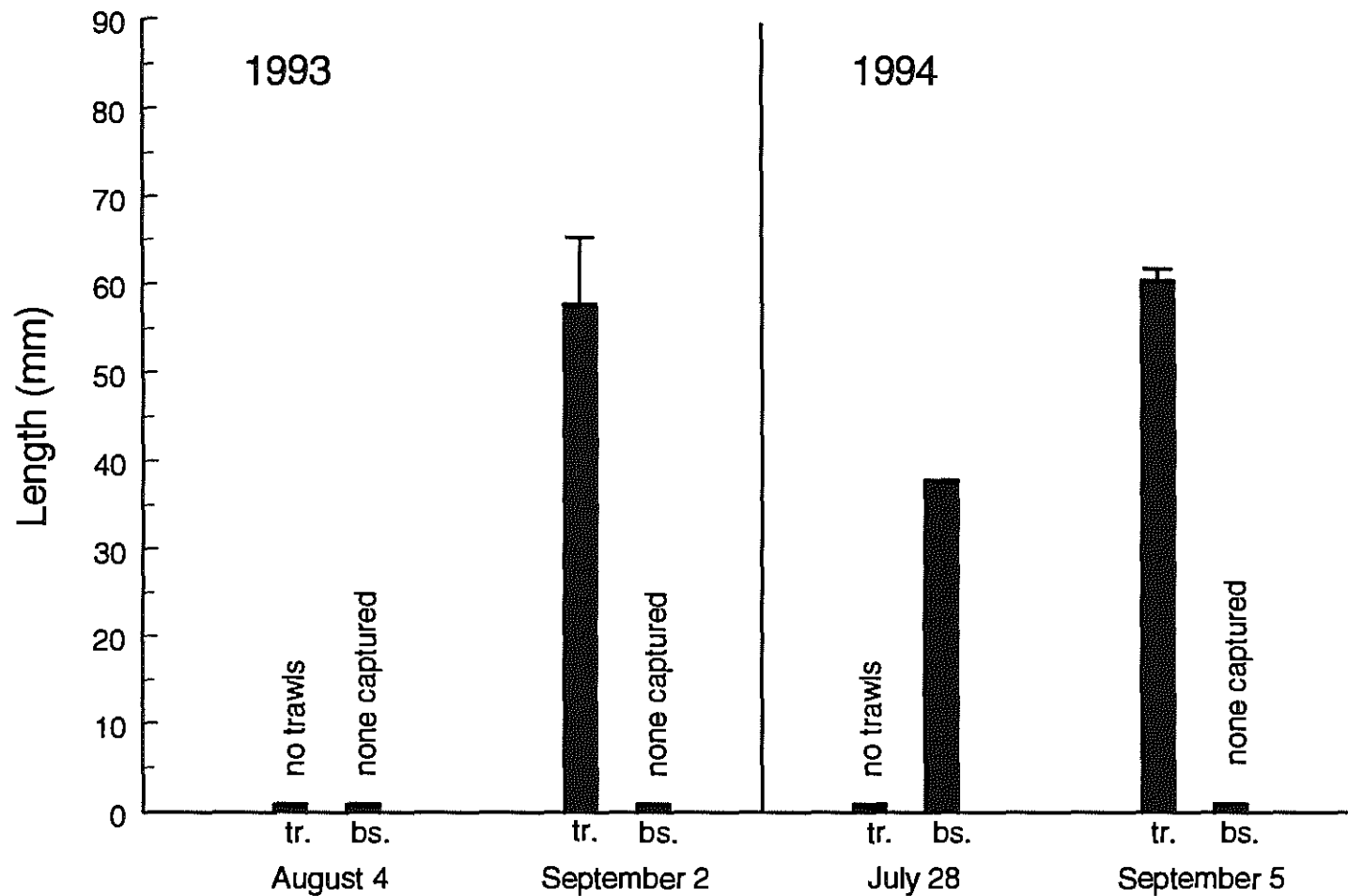


Figure 6. Tuya Lake surveys, 1993 and 1994; mean lengths of juvenile sockeye in trawl (tr.) and beachseine (bs.) samples. All fish are enhanced as there are no wild sockeye in Tuya Lake. Small length bars (1 mm) indicate 0 fish in the category. 95% confidence limits are given except for single fish samples. Measurements are from fish preserved in denatured 94% or 90% ethanol, 1993 and 1994, respectively.

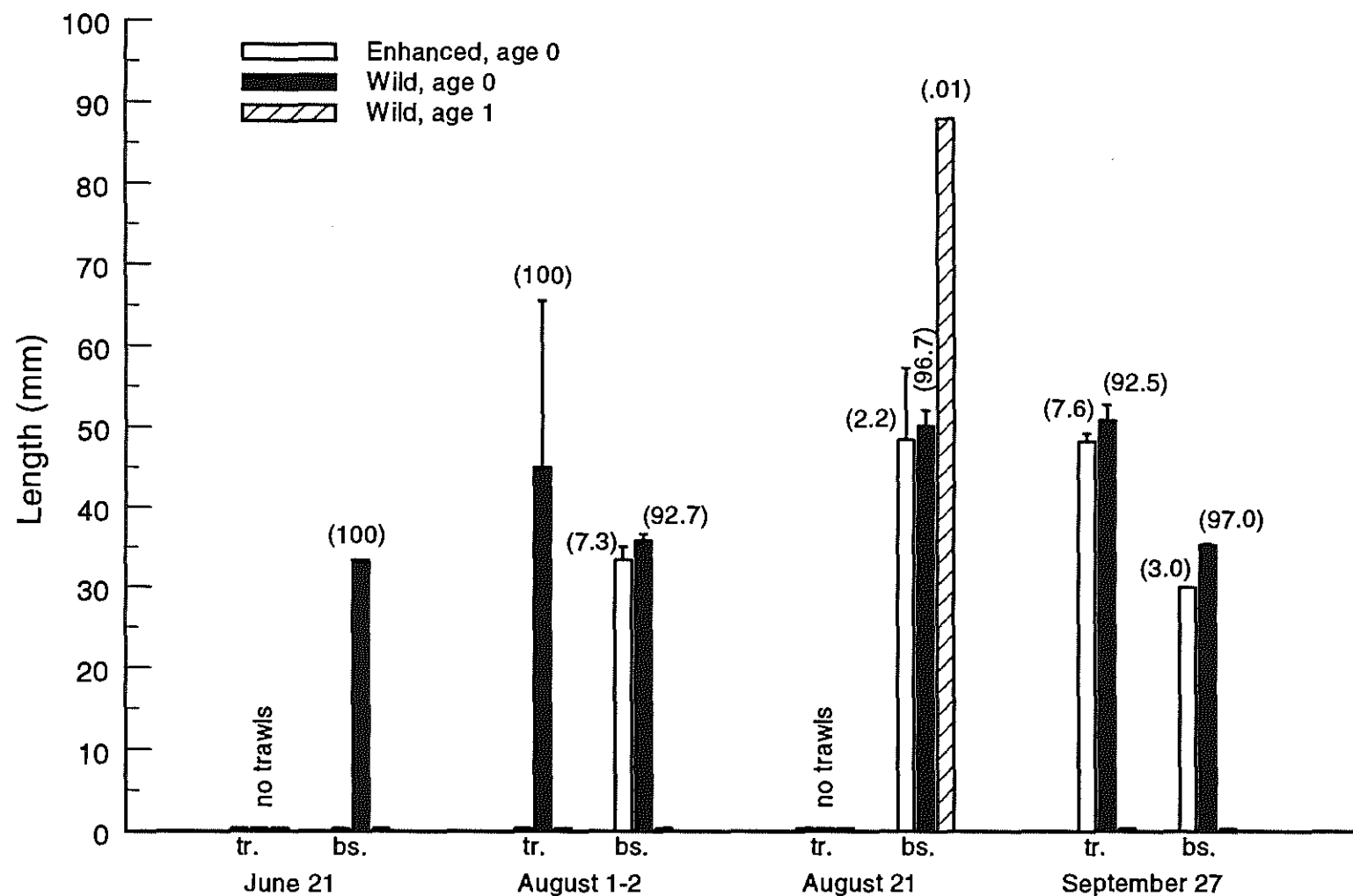


Figure 7. Tatsamenie Lake surveys, 1992; mean lengths and percentages (in brackets) of enhanced and wild juvenile sockeye in trawl (tr.) and beachseine (bs.) samples. Small length bars (1 mm) indicate 0 fish in the category. 95% confidence limits are given except for single fish samples and 0% or 100% values. Measurements are from fish preserved in denatured 94% ethanol.



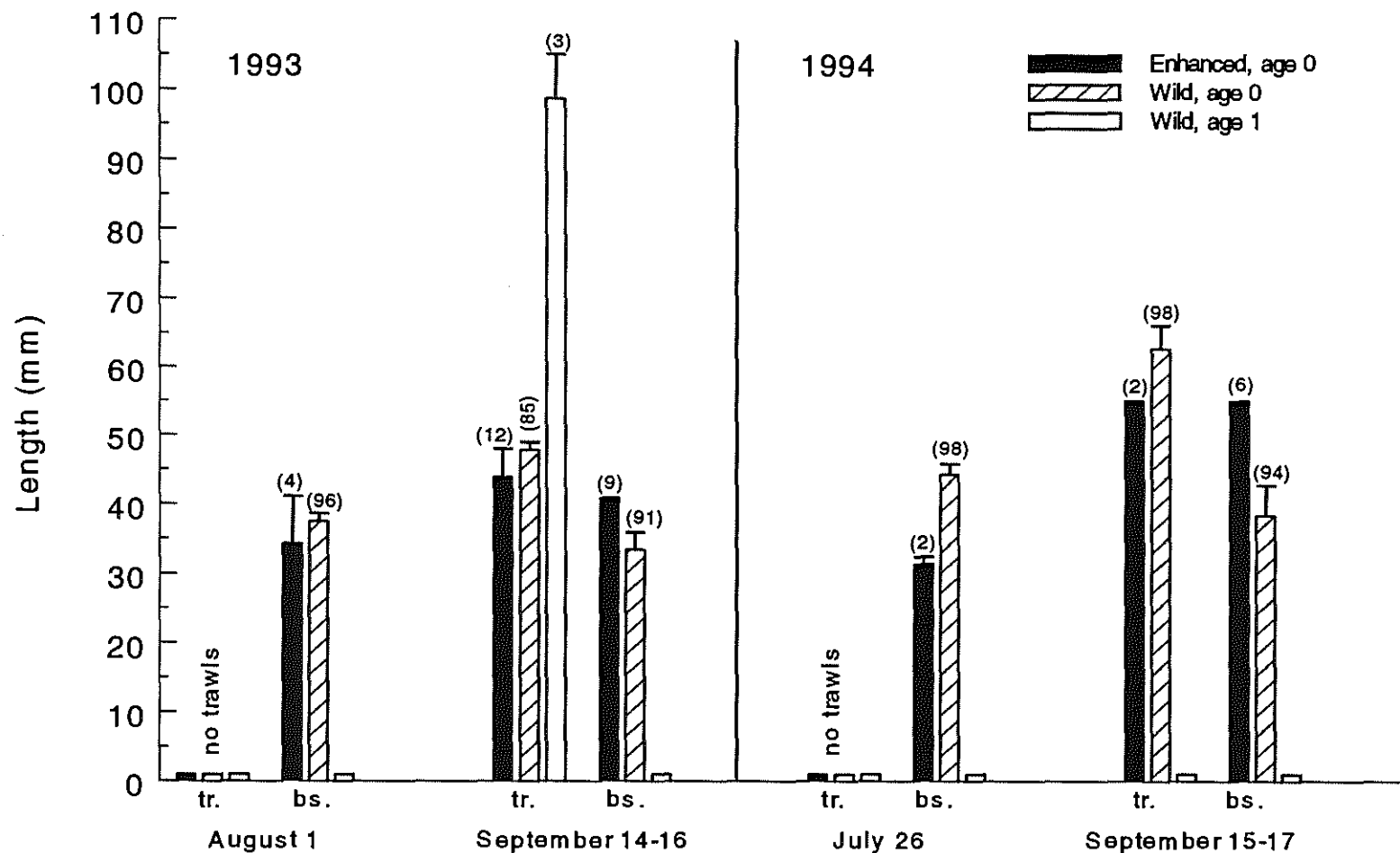


Figure 8. Tatsamenie Lake surveys, 1993 and 1994; mean lengths and percentages (in brackets) of enhanced and wild juvenile sockeye in trawl (tr.) and beachseine (bs.) samples. Small length bars (1 mm) indicate 0 fish in the category. 95% confidence limits are given except for single fish samples and 0% or 100% values. Measurements are from fish preserved in denatured 94% or 90% ethanol, 1993 and 1994, respectively.

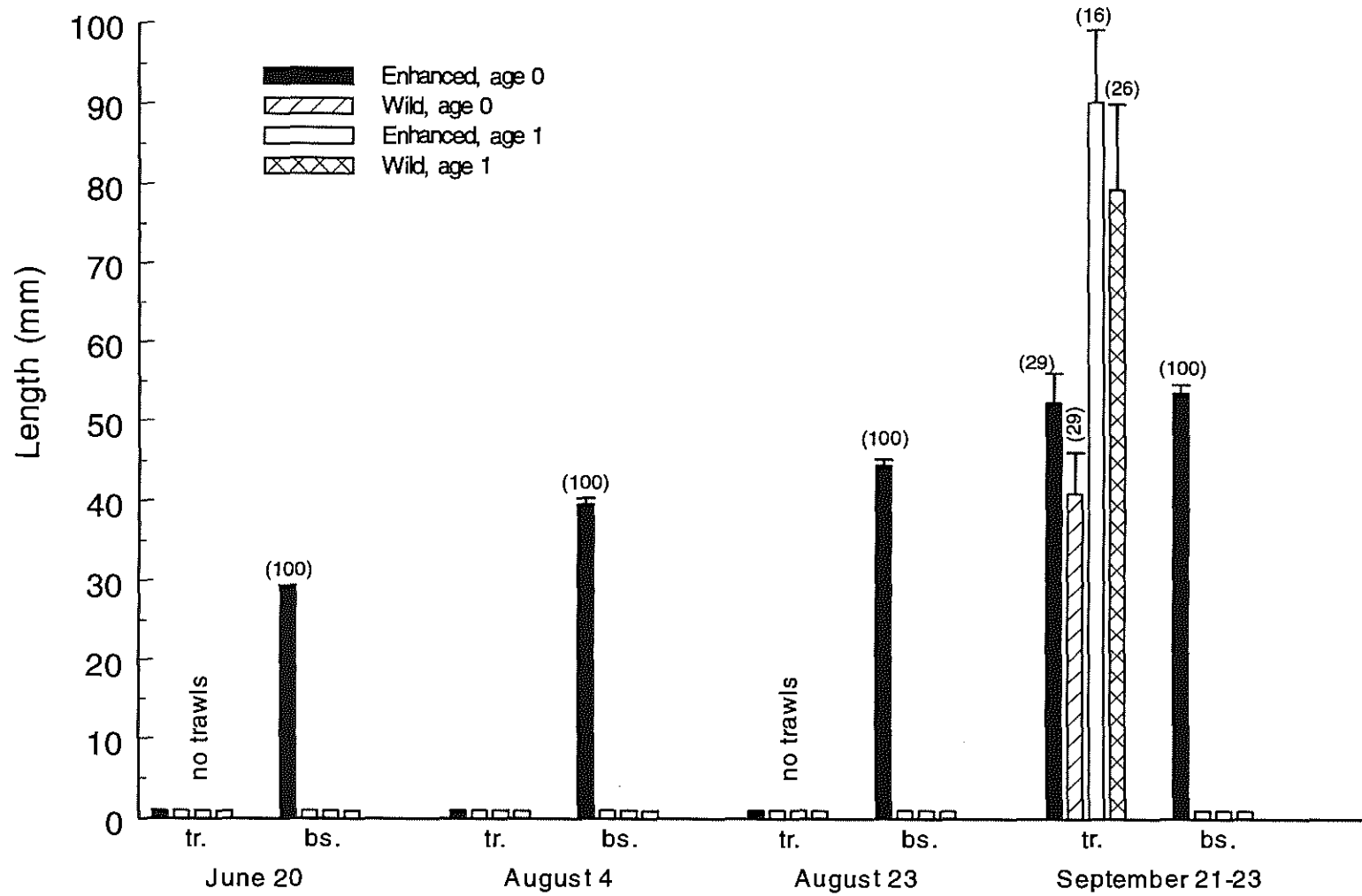


Figure 9. Trapper Lake surveys, 1992; mean lengths and percentages (in brackets) of enhanced and wild juvenile sockeye in trawl (tr.) and beachseine (bs.) samples. Small length bars (1 mm) indicate 0 fish in the category. 95% confidence limits are given except for single fish samples and 0% or 100% values. Measurements are from fish preserved in denatured 94% ethanol.

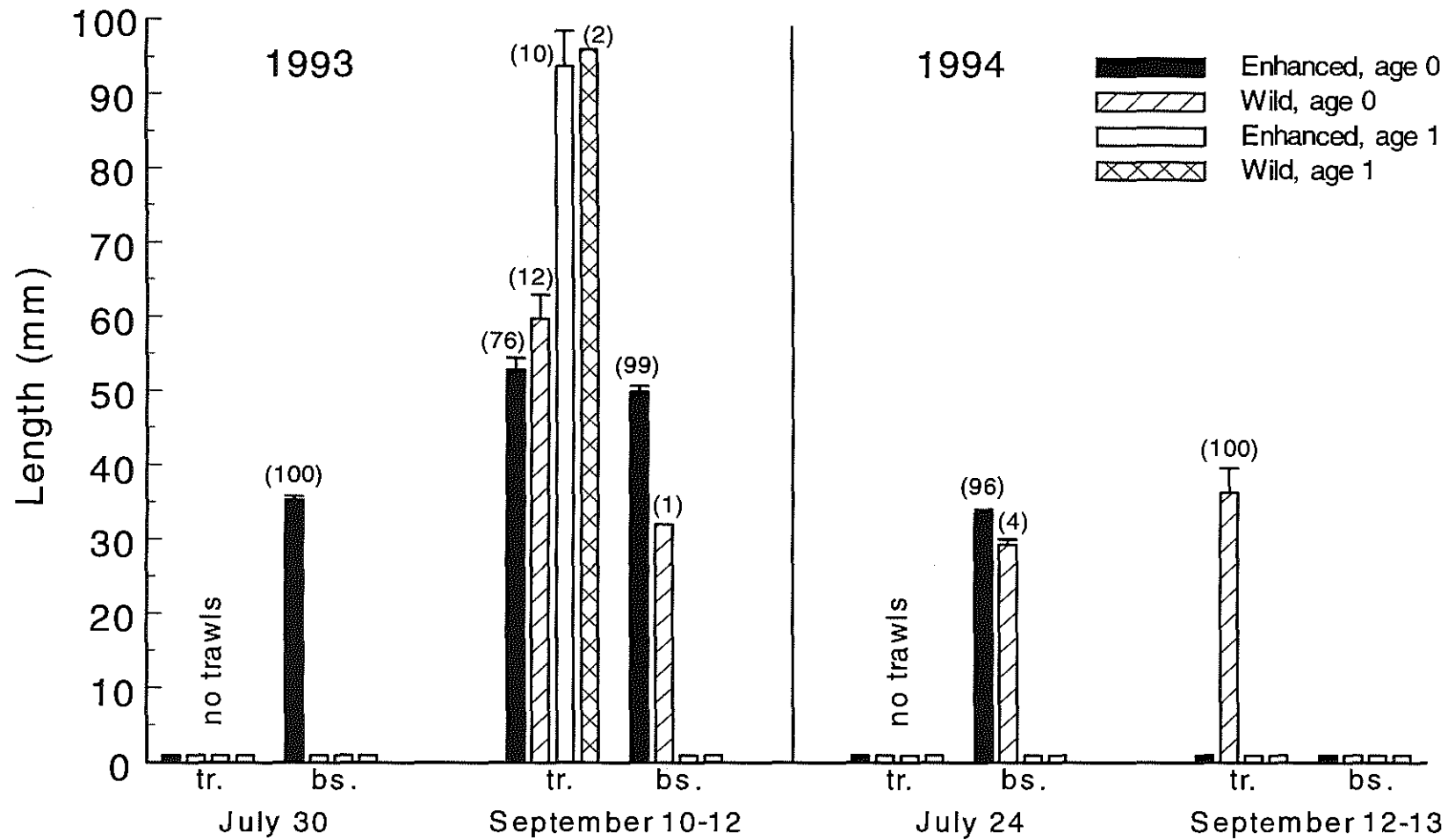


Figure 10. Trapper Lake surveys, 1993 and 1994; mean lengths and percentages (in brackets) of enhanced and wild juvenile sockeye in trawl (tr.) and beachseine (bs.) samples. Small length bars (1 mm) indicate 0 fish in the category. 95% confidence limits are given except for single fish samples and 0% or 100% values. Measurements are from fish preserved in denatured 94% or 90% ethanol, 1993 and 1994, respectively.

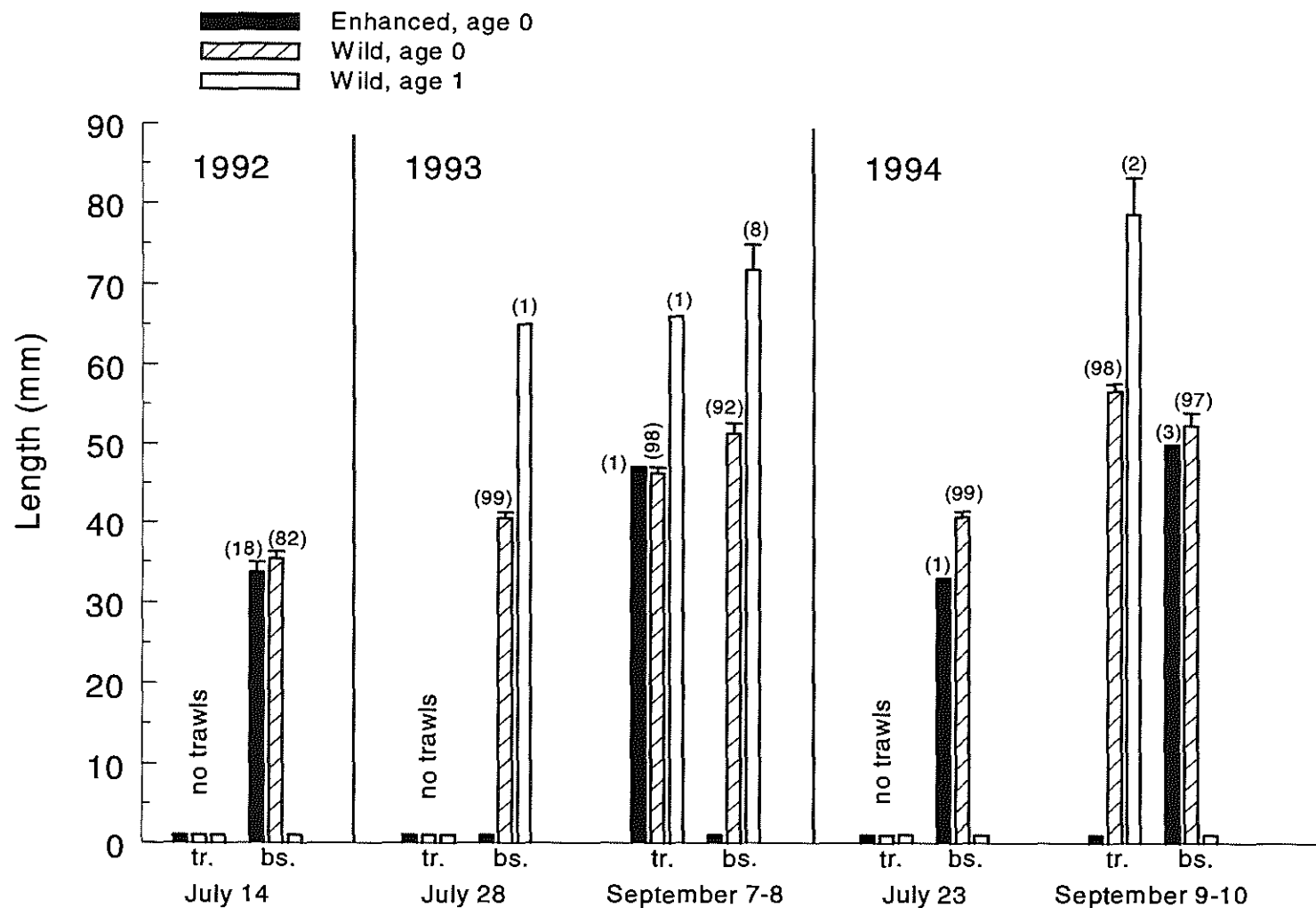


Figure 11. Little Trapper Lake surveys, 1992, 1993 and 1994; mean lengths and percentages (in brackets) of enhanced and wild juvenile sockeye in trawl (tr.) and beachseine (bs.) samples. Small length bars (1 mm) indicate 0 fish in the category. 95% confidence limits are given except for single fish samples and 0% or 100% values. Measurements are from fish preserved in denatured 94% (1992 and 1993) or 90% (1994) ethanol.

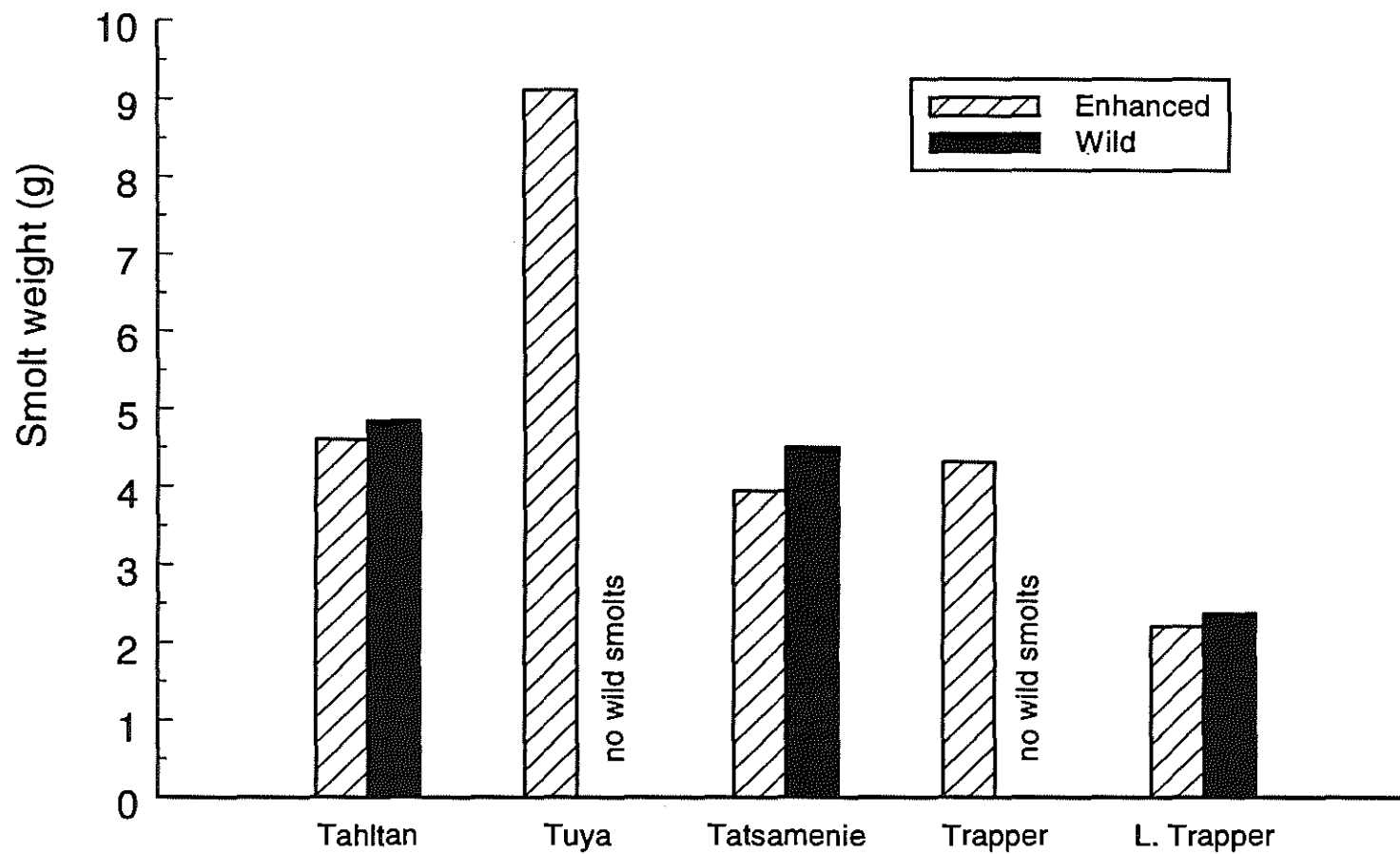


Figure 12. Average weights (g) of enhanced and wild age 1+ smolts for each lake over all years of observation, 1991 to 1995 (see Tables 16-20 for annual observations for each lake).

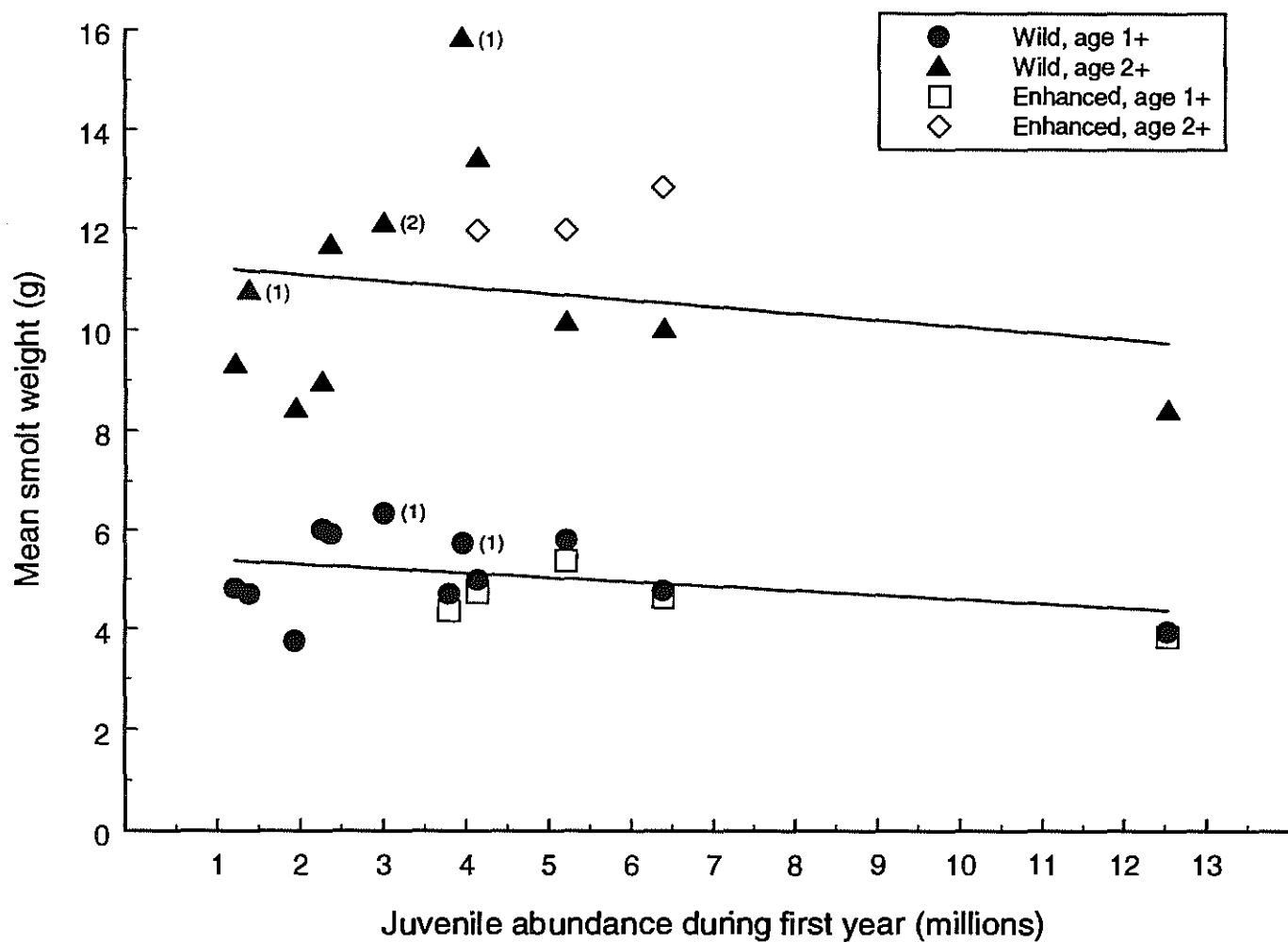


Figure 13. Tahltan Lake smolt size versus estimated juvenile abundance in the first year of lake residency. Data is from the 12 year period of 1982 to 1993 (Table 22). A (1) indicates 1 year of rearing under fertilized lake conditions; (2) indicates 2 years of rearing under fertilized lake conditions.

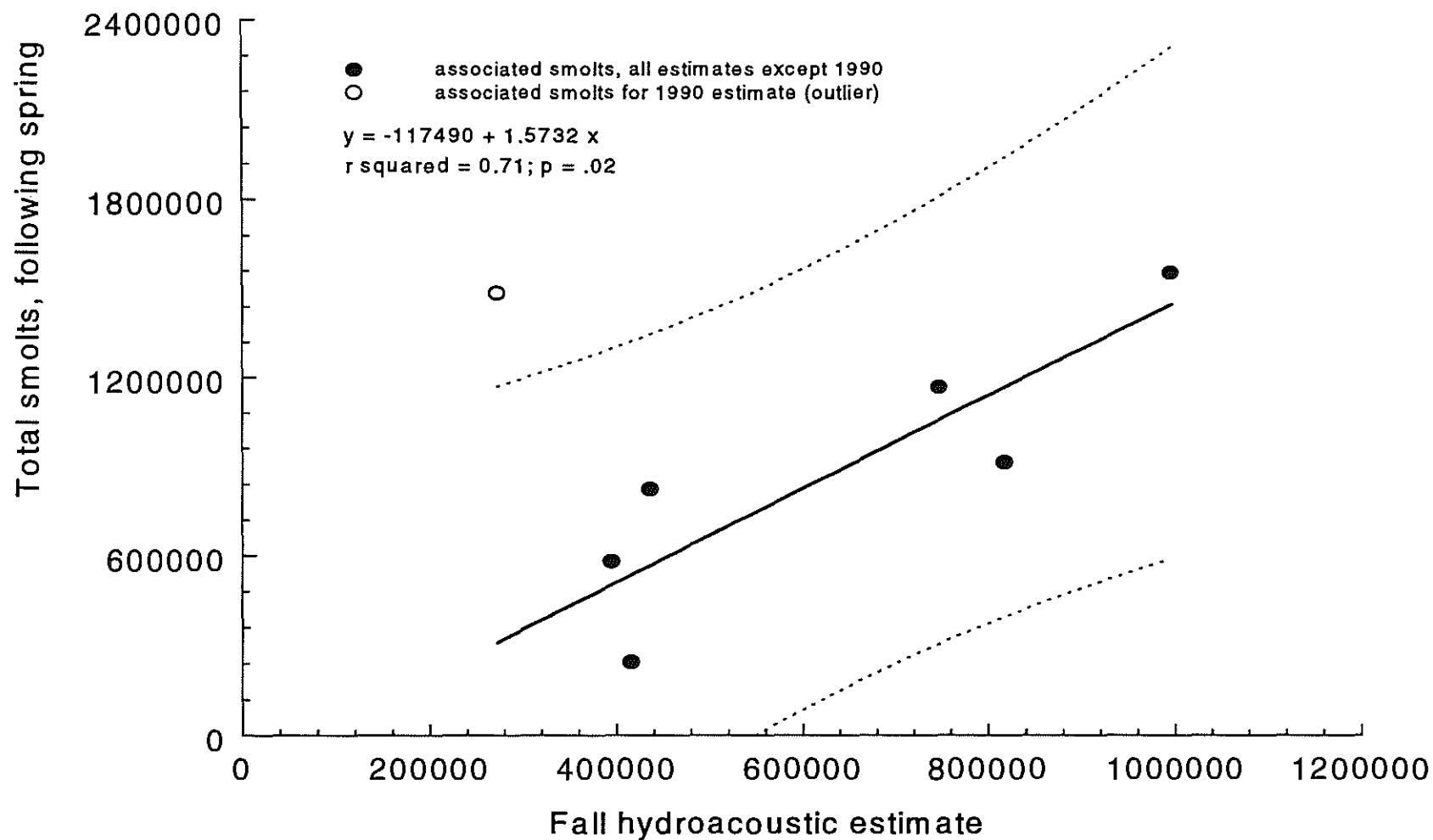


Figure 14. Regression between Tahltan Lake fall hydroacoustic juvenile sockeye estimates and associated smolt estimates. The regression is based on hydroacoustic estimates from 1985, 1987, 1988, 1990, 1991, 1993 and 1994; the 1990 estimate shown was excluded from the regression calculation.

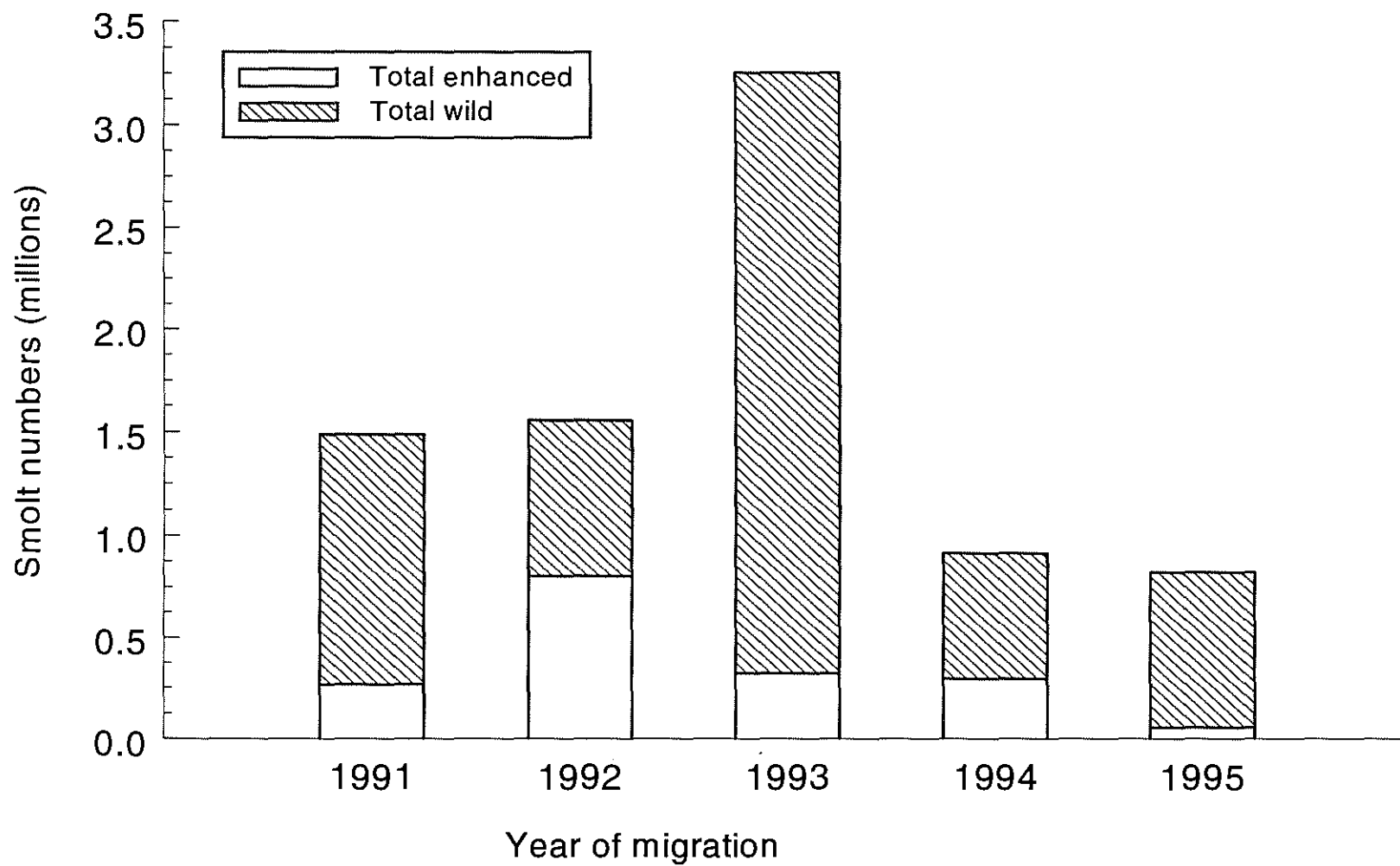


Figure 15. Tahltan Lake smolt emigrations, 1991 (the first year of enhanced smolt production) through 1995; estimated numbers of enhanced and wild smolts, ages combined.



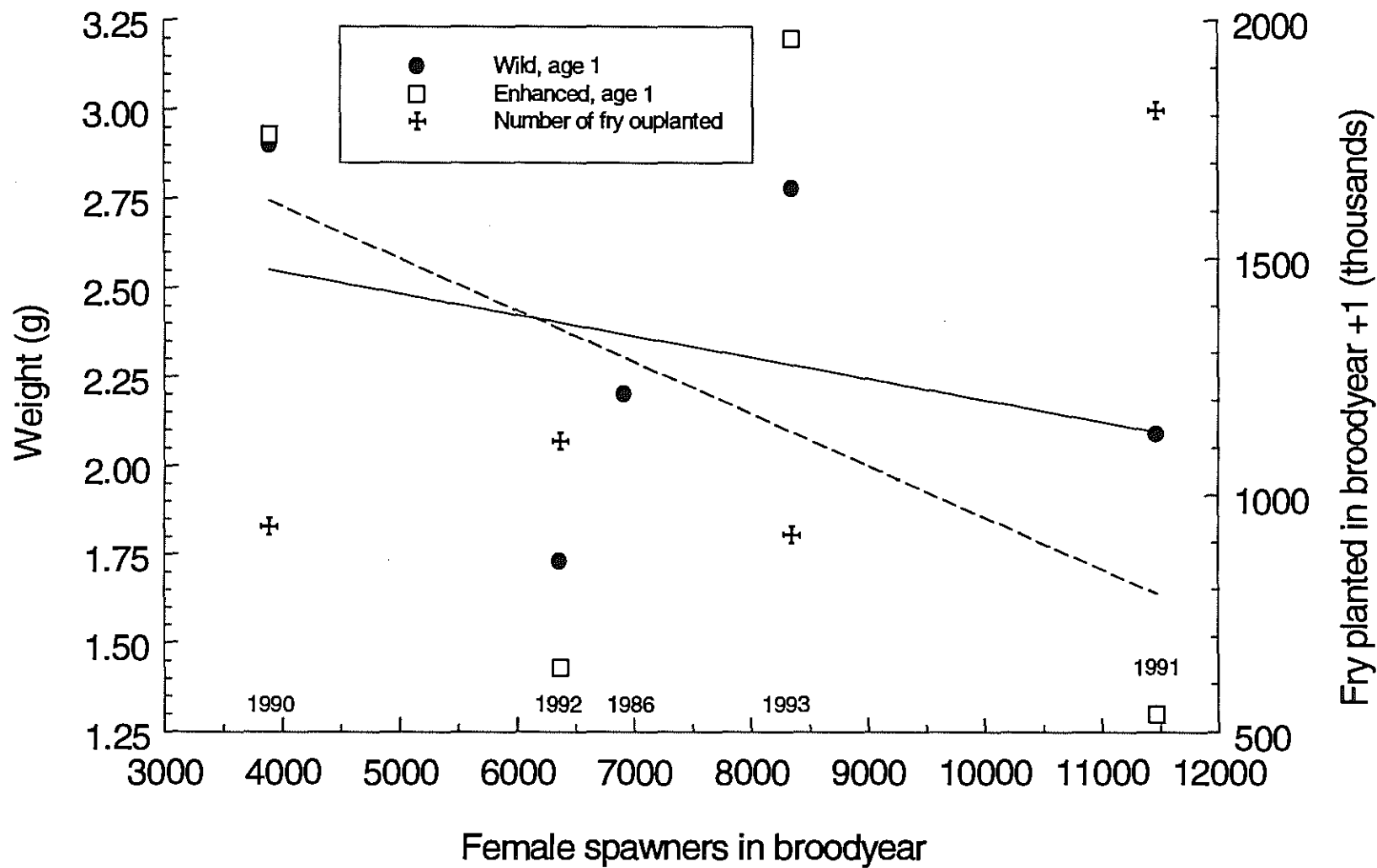


Figure 16. Little Trapper Lake age 1 smolt size in relation to in-lake rearing density, as estimated by the number of wild female spawners for the broodyear. Numbers of fry outplanted to Trapper Lake for the same broodyear are also shown.

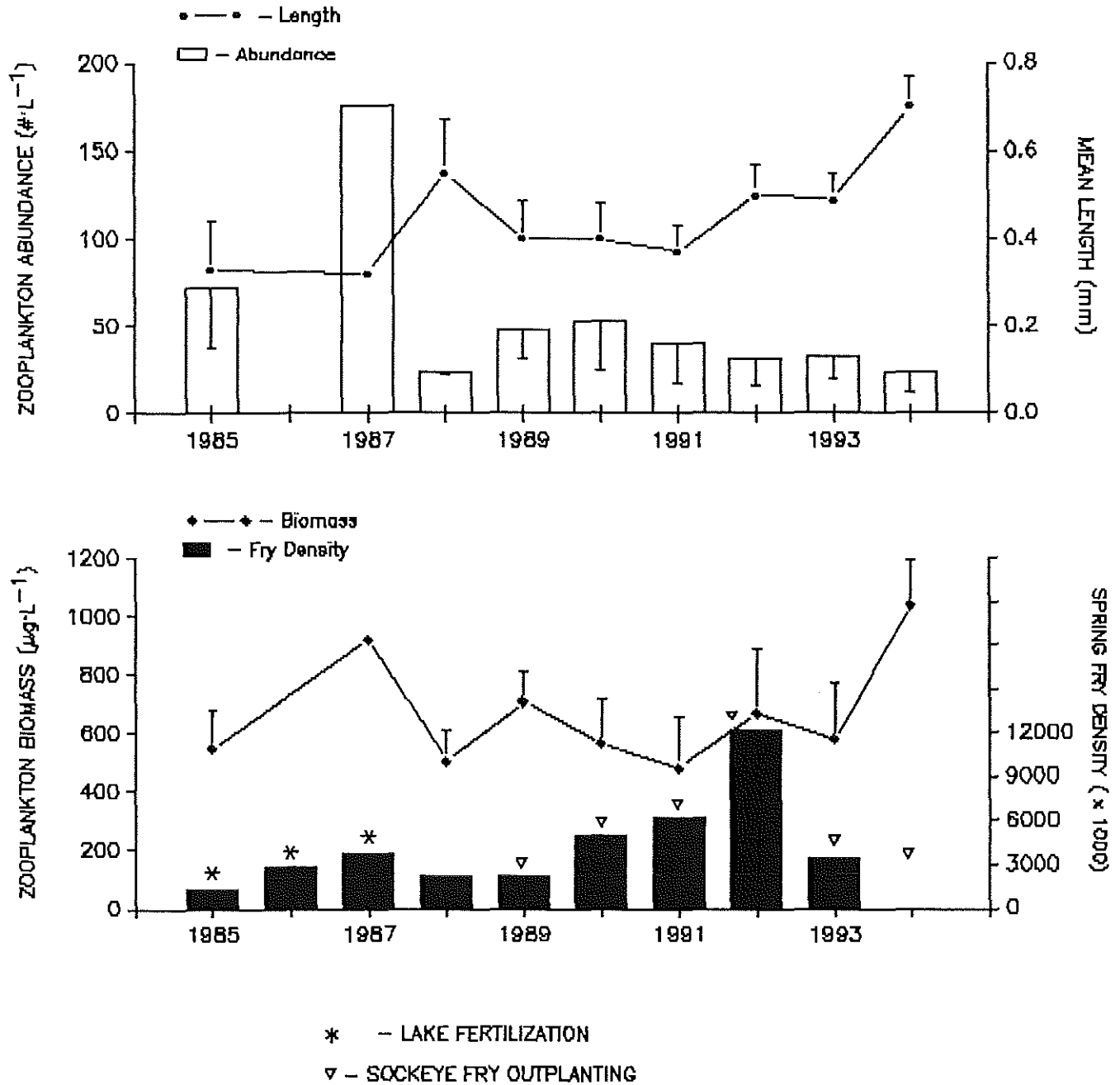


Figure 17. Tahltan Lake. Mean zooplankton abundance (density: #/L), mean length (mm), and total biomass (ug/L) over the summer growing season during 1985, 1987 to 1994, contrasted against estimated total sockeye fry densities (mid June) (1994 estimates not available). 95% Confidence Intervals are indicated on data points and bars.

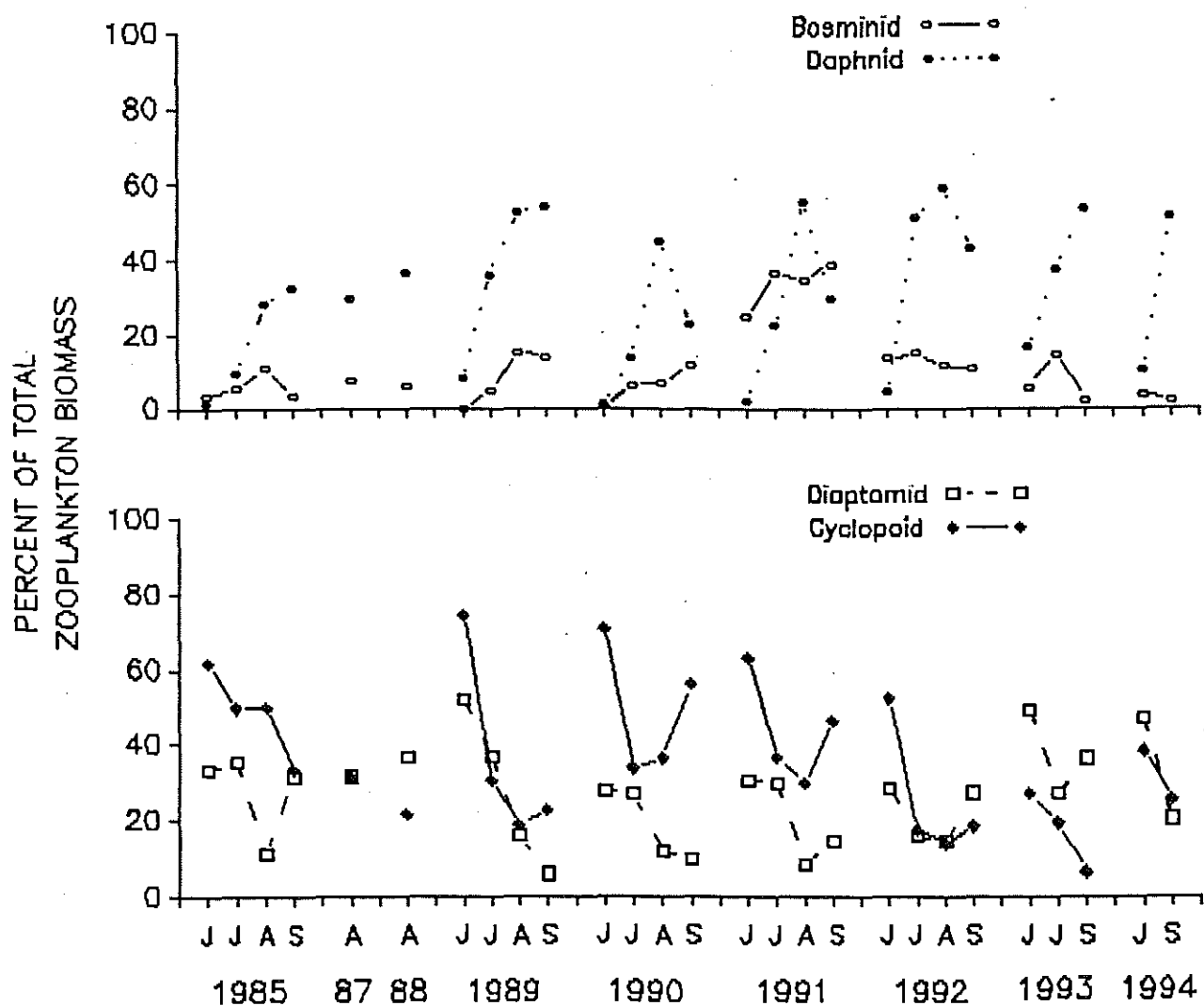


Figure 18. Tahltan Lake. Proportions of total zooplankton biomass comprising bosminids (*Bosmina* sp.), daphnids (*Daphnia*, *Ceriodaphnia*, *Holopedium* sp.), cyclopoids (*Cyclops* sp.), and diaptomids (*Dipatomus* sp.). Nauplii and rotifers (not shown) comprise less than 2% of total biomass in all years.

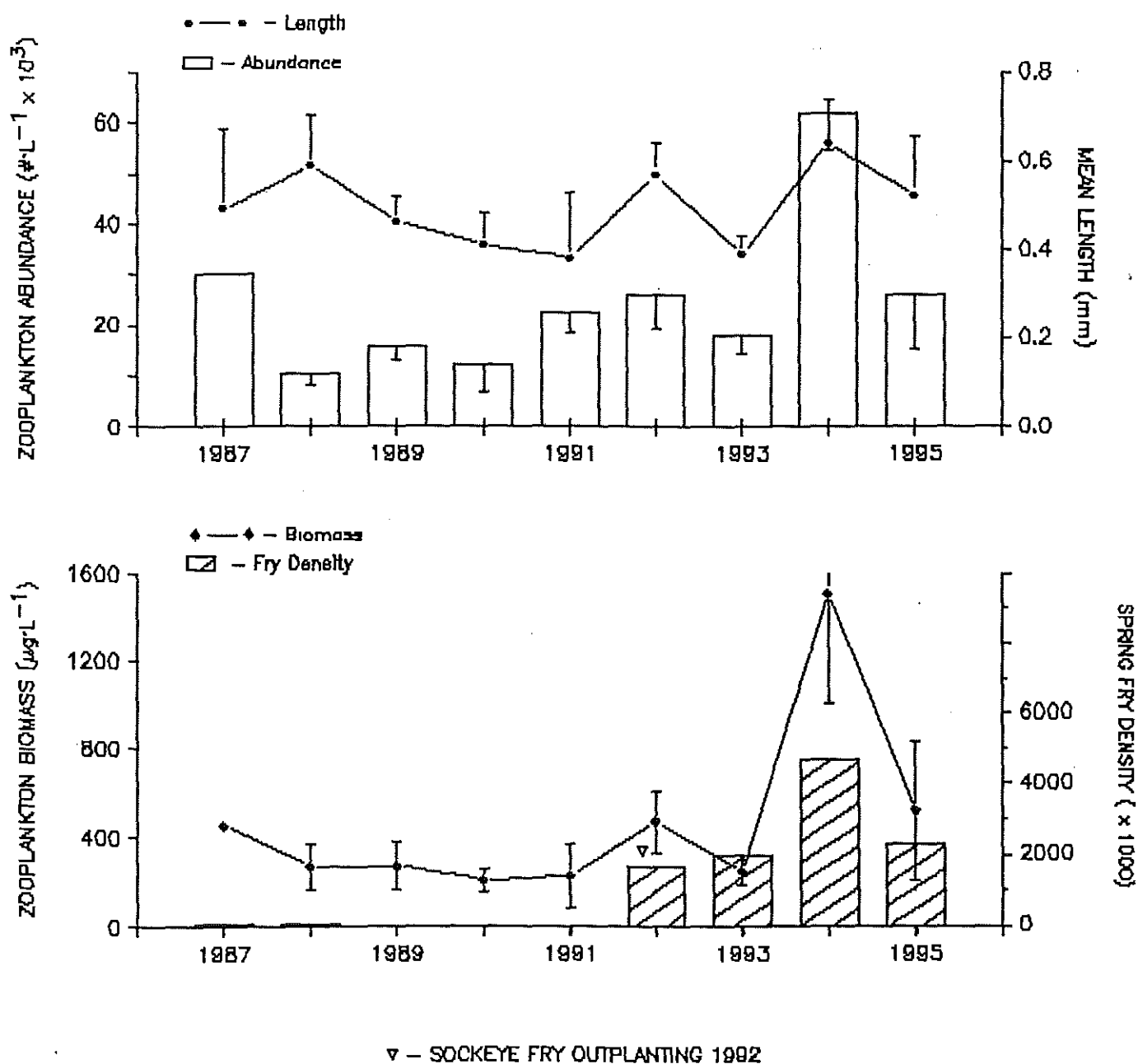


Figure 19. Tuya Lake. Mean zooplankton abundance (density: #/L), mean length (mm), and total biomass (µg/L) over the summer growing season during 1987 to 1995, contrasted against estimated total sockeye fry densities (mid June). 95% Confidence Intervals are indicated on data points and bars.

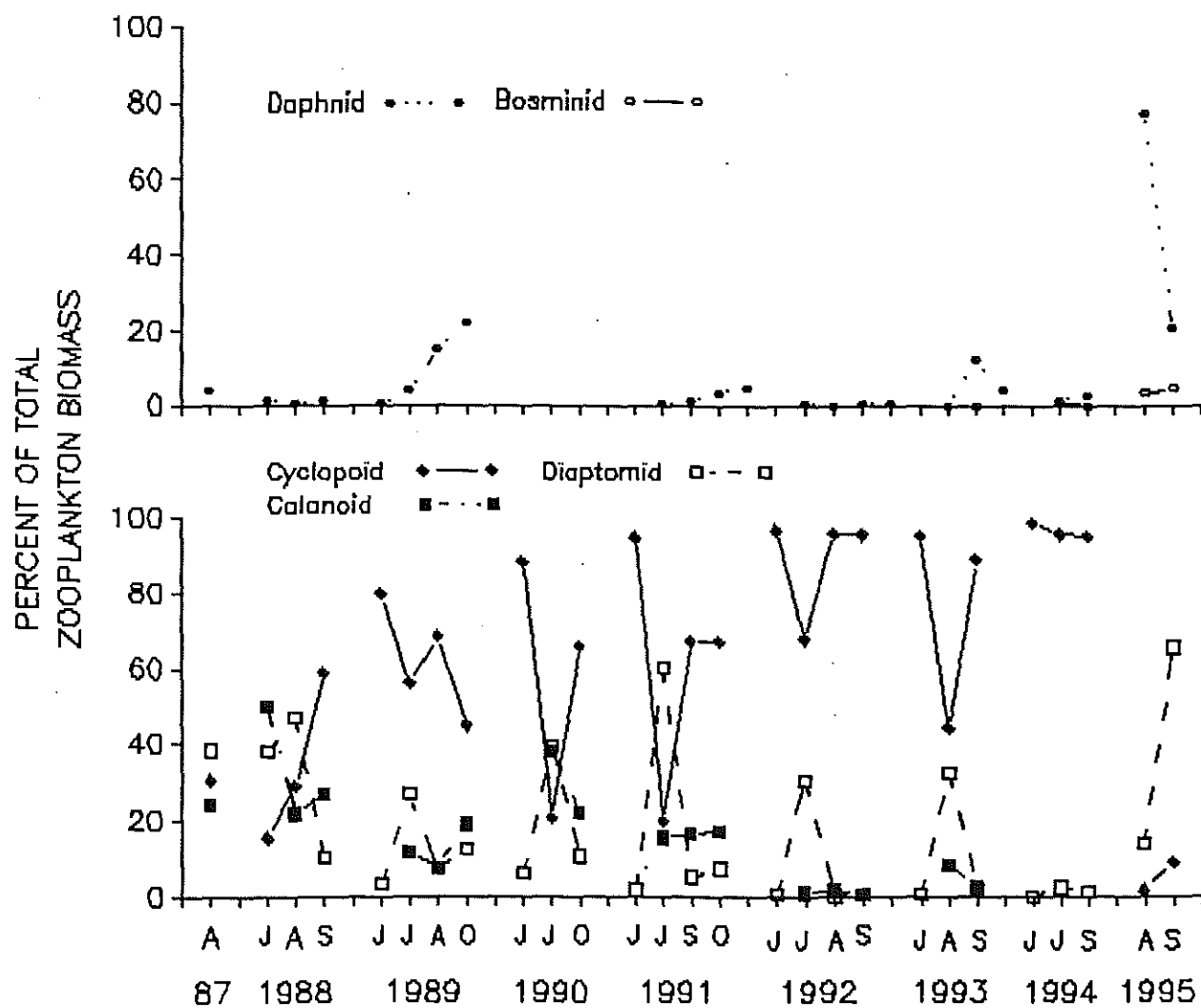


Figure 20. Tuyu Lake. Proportions of total zooplankton biomass comprising bosminids (*Bosmina* sp.), daphnids (*Daphnia*, *Ceriodaphnia*, *Holopedium* sp.), cyclopoids (*Cyclops* sp.), and diaptomids (*Dipatomus* sp.). Nauplii and rotifers (not shown) comprise less than 1% of total biomass in all years.

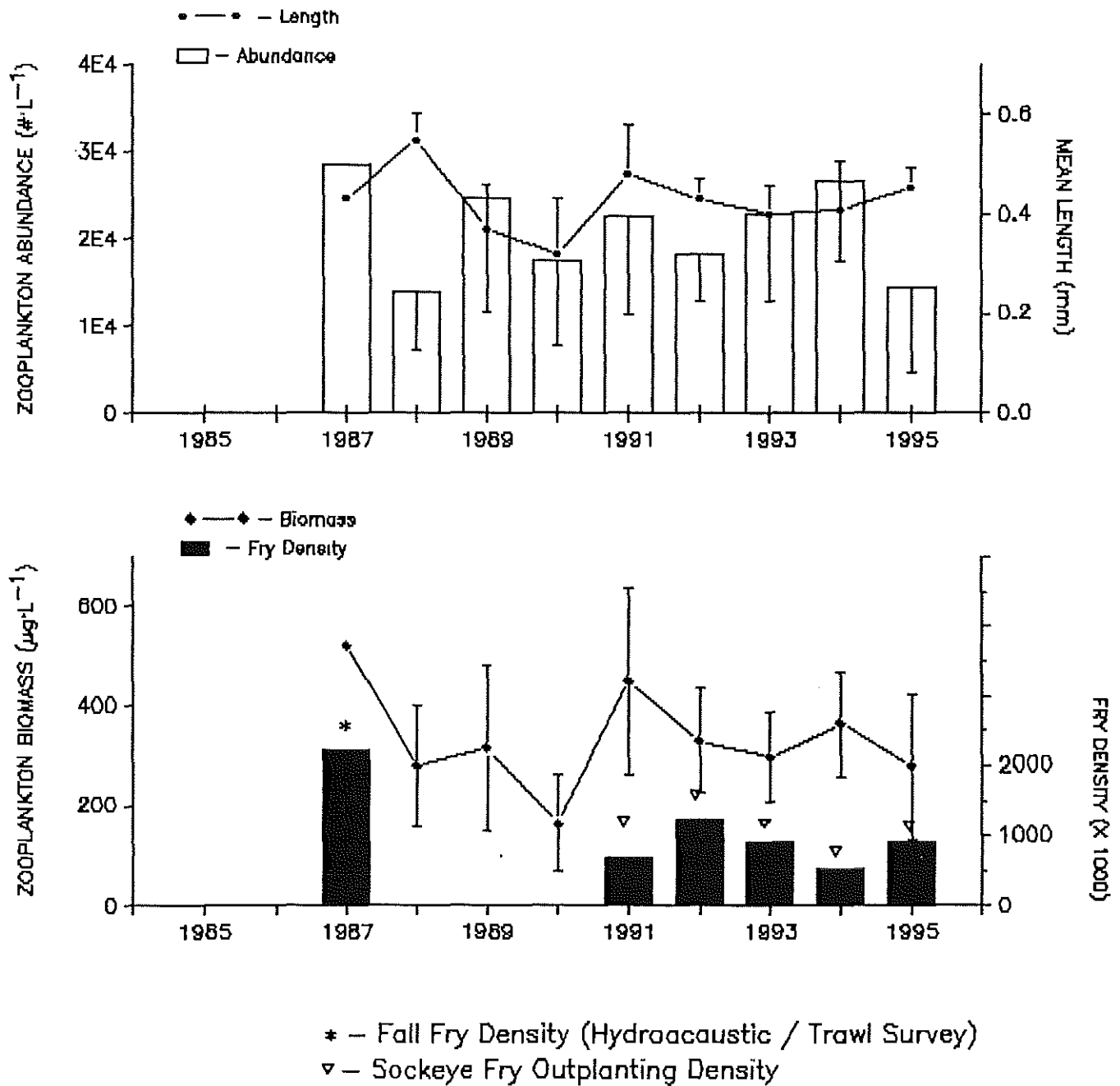


Figure 21. Tatsamenie Lake. Mean zooplankton abundance (density: #/L), mean length (mm), and total biomass (ug/L) over the summer growing season during 1987 to 1995, contrasted against estimated total sockeye fry densities (mid June). 95% Confidence Intervals are indicated on data points and bars.

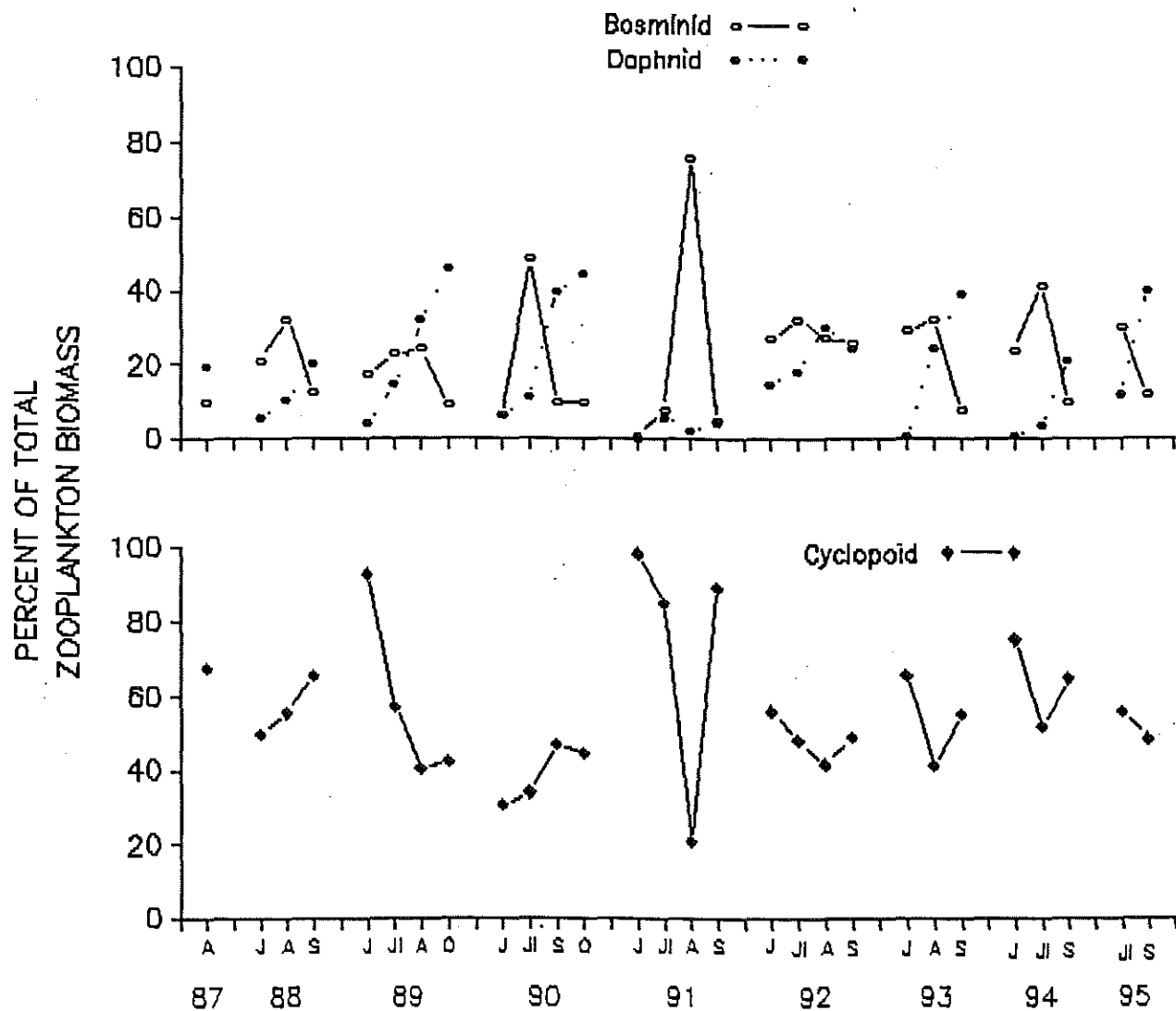


Figure 22. Tatsamenie Lake. Proportions of total zooplankton biomass comprising bosminids (*Bosmina* sp.), daphnids (*Daphnia*, *Ceriodaphnia*, *Holopedium* sp.), cyclopoids (*Cyclops* sp.), and diaptomids (*Dipatomus* sp.). Nauplii and rotifers (not shown) comprise less than 4% of total biomass in all years.

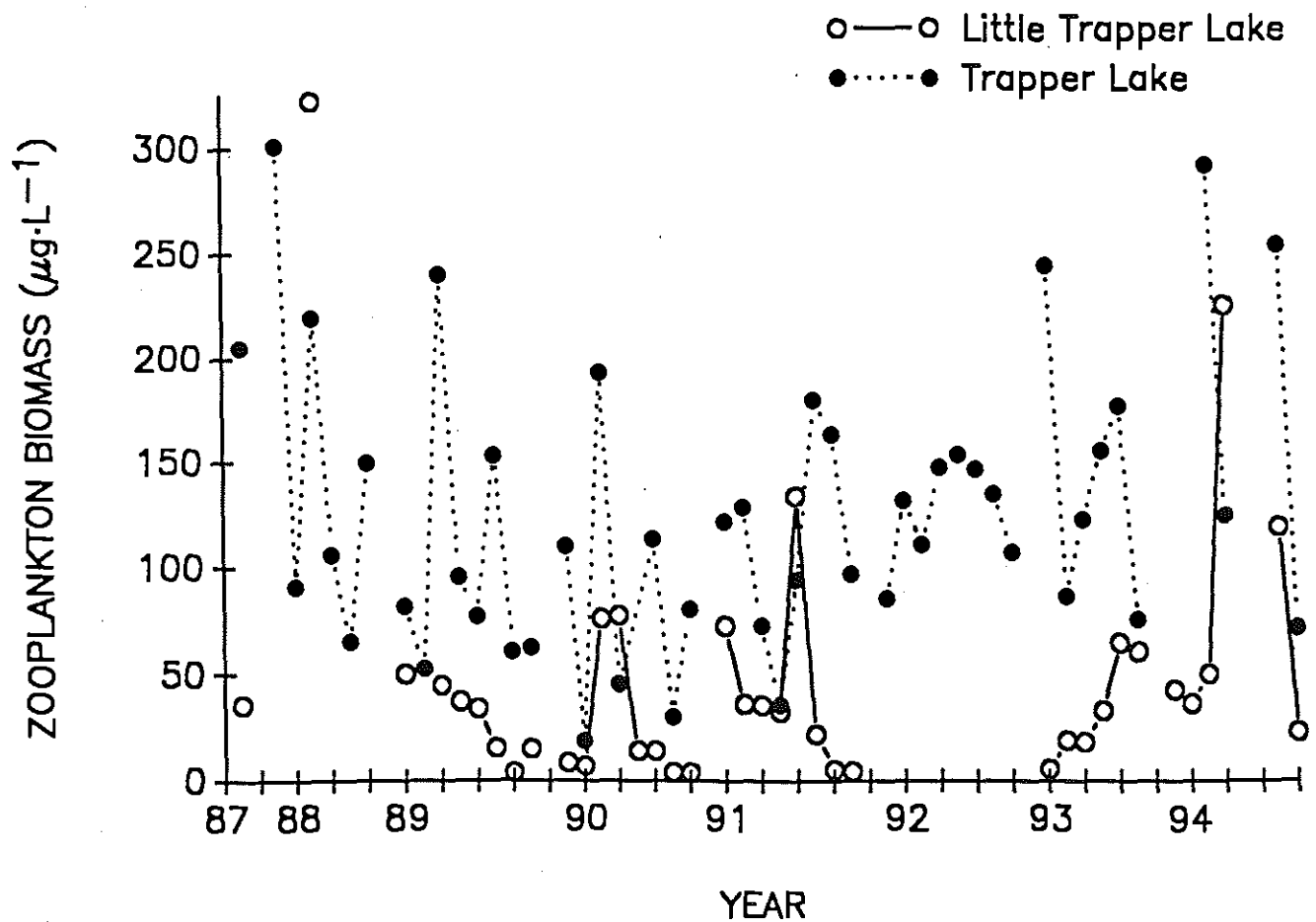


Figure 23. Trapper / Little Trapper Lakes. Total zooplankton biomass over the summer growing season for Trapper Lake (1987 to 1994; 2 sampling sites starting 1988) and Little Trapper Lake (1987 to 1991 and 1993 to 1994; 2 sampling sites starting in 1989).



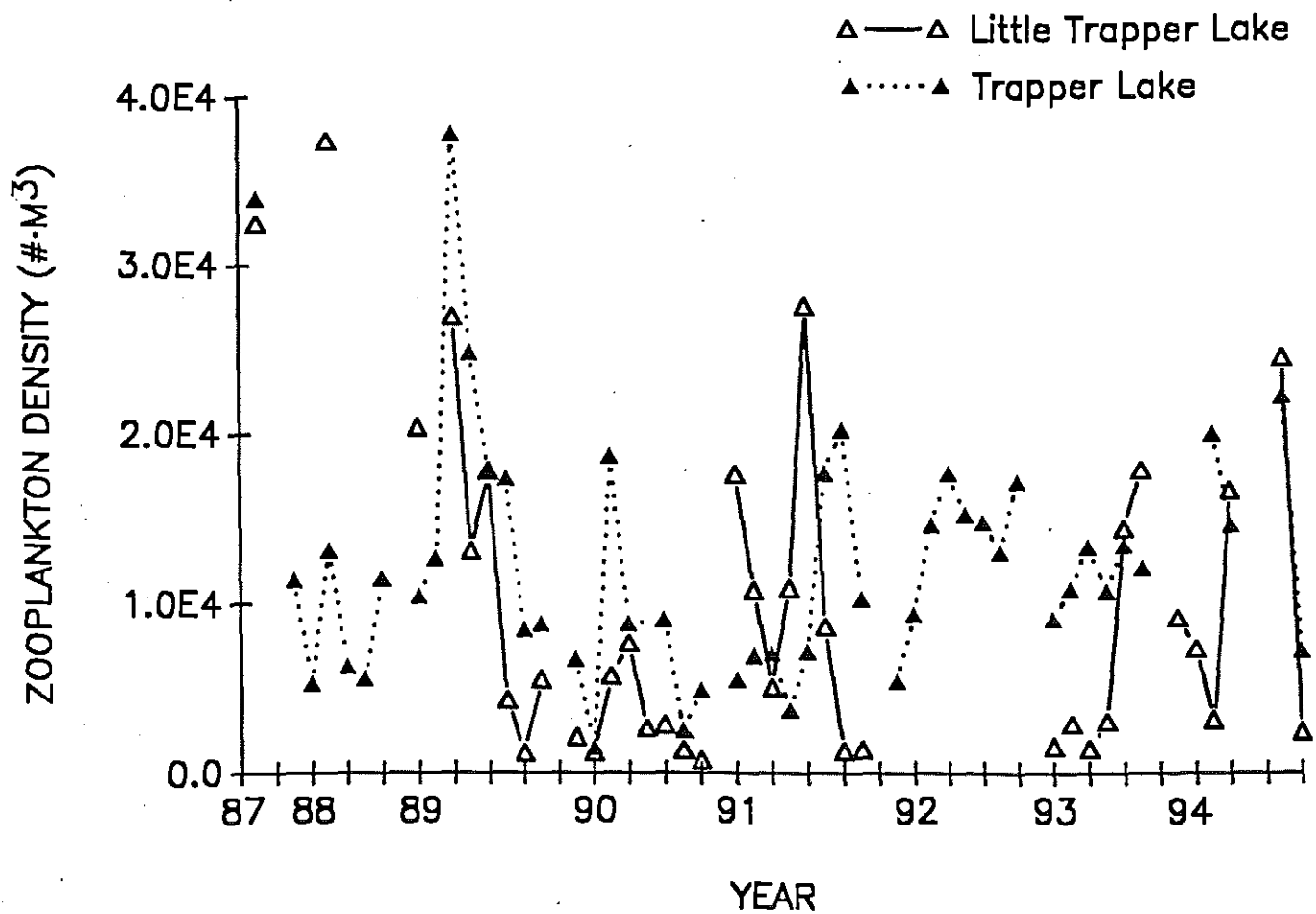


Figure 24. Trapper / Little Trapper Lakes. Total zooplankton abundance over the summer growing season for Trapper Lake (1987 to 1994; 2 sampling sites starting 1988) and Little Trapper Lake (1987 to 1991 and 1993 to 1994; 2 sampling sites starting in 1989).

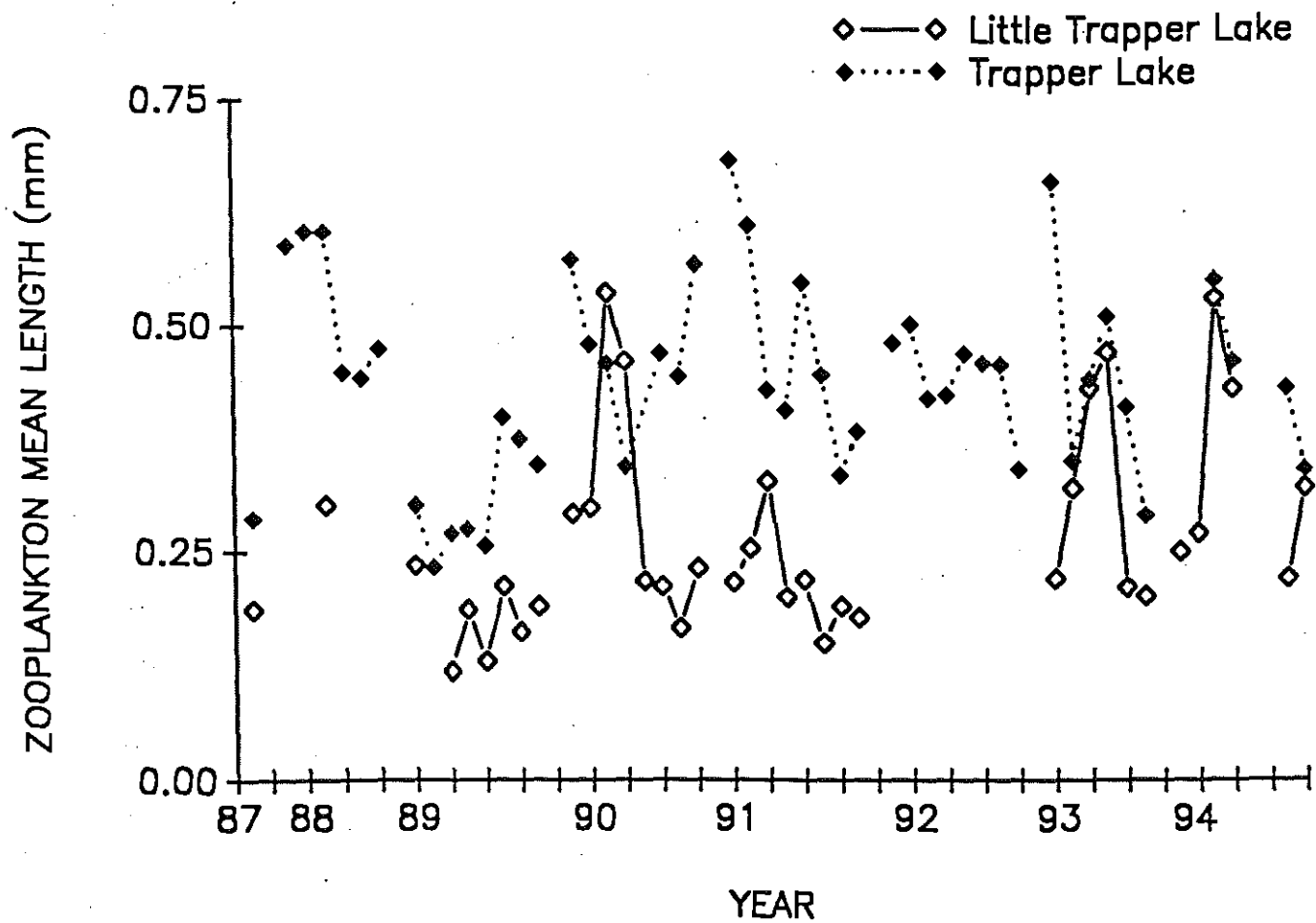


Figure 25. Trapper / Little Trapper Lakes. Total zooplankton mean length (mm) over the summer growing season for Trapper Lake (1987 to 1994; 2 sampling sites starting 1988) and Little Trapper Lake (1987 to 1991 and 1993 to 1994; 2 sampling sites starting in 1989).

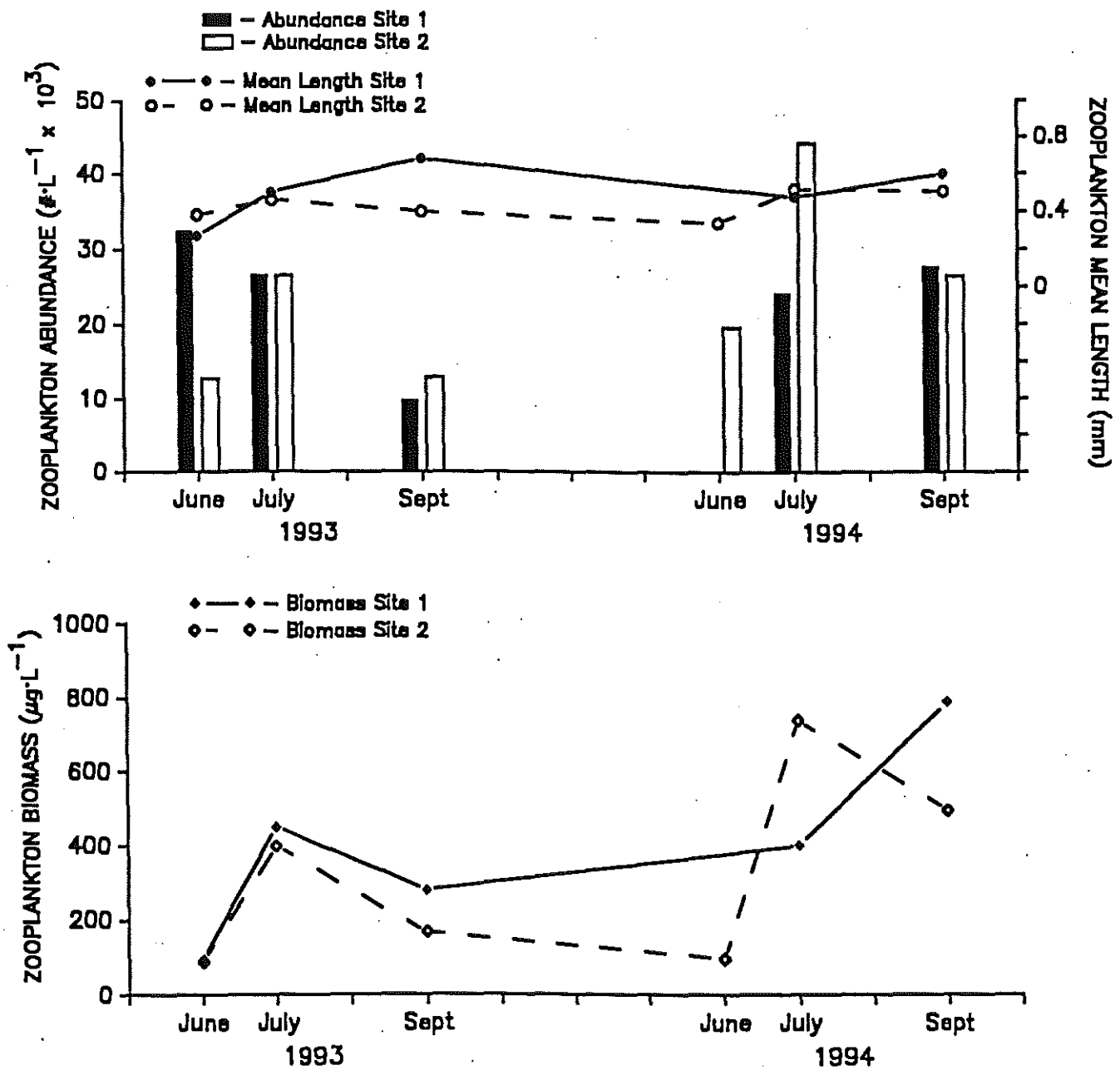


Figure 26. Nakina Lake. Mean zooplankton abundance (density  $\# / L$ ), mean length (mm), and total biomass ( $\mu g / L$ ) over the summer growing season during 1993 and 1994.

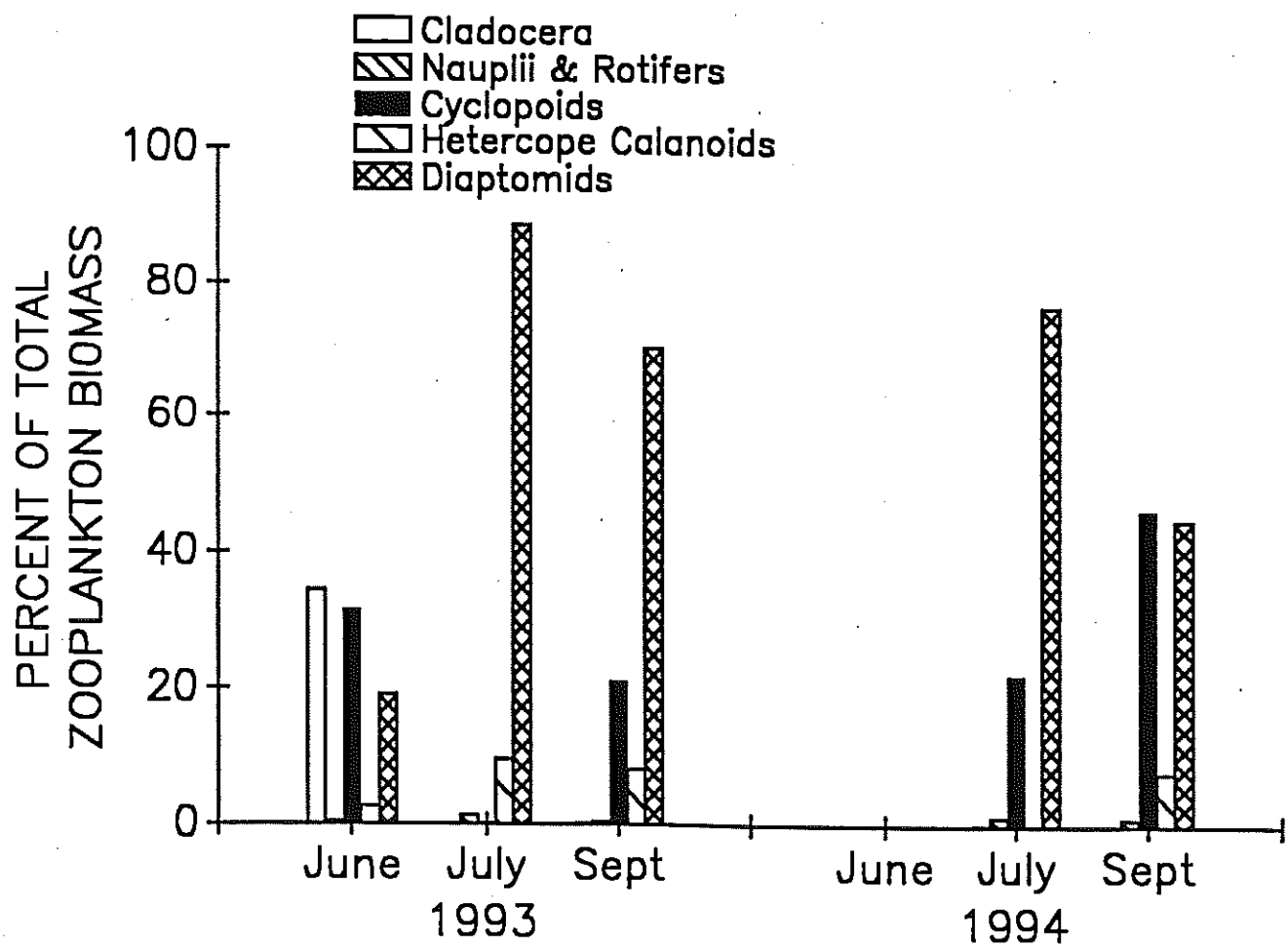


Figure 27. Nakina Lake. Proportions of total zooplankton biomass comprising cladocera (*Bosmina* and *Daphnia* sp.), nauplii, rotifers, cyclopoids (*Cyclops* sp.), calanoids (*Heterocope* sp.) and diaptomids (*Dipatomus* sp.). Nauplii and rotifers comprise less than 1% of total biomass in all years.

## TABLES

Table 1a. Summary of results of Tahltan Lake outplant projects, egg-take to outplanted fry stage.

Broodyear	# eggs taken <sup>a</sup> (x1000)	# fry planted (x1000)	percent fertilized	Survival	
				fertilized egg to planted fry	green egg to planted fry
1989 <sup>b</sup>	2,955 (3M)	1,042	70 %	50 %	35 %
1990	4,511 (5M)	3,585	82 %	96 %	79 %
1991	4,246 <sup>c</sup> (5-6M)	1,415	95 %	98 %	94 %
1992	2,154 <sup>d</sup> (5.4M)	1,947	92 %	98 %	90 %
1993	969 <sup>e</sup> (6.0M)	904	n/a	n/a	93 %
1994	1,326 <sup>f</sup> (6.0M)	1,143	n/a	n/a	86 %
1995	3,008 <sup>g</sup> (6.0M)		95 %		

<sup>a</sup> Egg-take targets in millions (M) are shown in parentheses

<sup>b</sup> The values given here for BY 1989 differ slightly from those reported previously (PSC 1991) as a result of minor corrections to the data.

<sup>c</sup> This value includes eggs taken for outplants to both Tahltan and Tuya lakes; eggs are divided at the eyed stage and percent fertilized is therefore the same for both groups.

<sup>d</sup> This value includes eggs taken for Tahltan Lake only; total number of eggs collected in 1992 was 4,901,000.

<sup>e</sup> This value includes eggs taken for Tahltan Lake only; total number of eggs collected in 1993 was 6,140,000.

<sup>f</sup> For return to Tahltan Lake only; total number taken was 4,182,000.

<sup>g</sup> For return to Tahltan Lake only; total number taken was 6,891,000.

Table 1b. Summary of results of Tuya Lake outplant projects, egg-take to outplanted fry stage.

Broodyear	# eggs taken <sup>a</sup> (x1000)	# fry planted (x1000)	percent fertilized	Survival	
				fertilized egg to planted fry	green egg to planted fry
1991	2,732 <sup>b</sup> (5.6M)	1,632	95%	63 %	60 %
1992	2,747 <sup>c</sup> (5.4M)	1,990	92%	78%	72%
1993	5,171 <sup>d</sup> (6.0M)	4,691	n/a	n/a	91 %
1994	2,765 <sup>e</sup> (6.0M)	2,267	87 %	94 %	81 %
1995	3,883 <sup>f</sup> (6.0M)		95 %		

<sup>a</sup> Egg-take targets in millions (M) are shown in parentheses

<sup>b</sup> This value includes eggs for Tuya only, total number of eggs taken at Tahltan in 1991 was 4,246,000.

<sup>c</sup> This value includes eggs taken for Tuya planting only; the total number of eggs taken in 1992 was 4,901,000.

<sup>d</sup> This value includes eggs taken for Tuya planting only; the total number of eggs collected in 1993 was 6,140,000.

<sup>e</sup> This value includes eggs taken for Tuya planting only; the total number of eggs taken in 1994 was 4, 182,000.

<sup>f</sup> This value includes eggs taken for Tuya planting only, the total number of eggs taken at Tahltan in 1995 was 6,891,000.

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

Broodyear	# eggs taken <sup>a</sup> (x1000)	# fry planted (x1000)	percent fertilized	Survival	
				fertilized egg to planted fry	green egg to planted fry
1990	985 (2.5M)	673	78 %	88 %	68 %
1991	1,360 (1.25- 1.5M)	1,232	93 %	98 %	91 %
1992	1,486 (1.75M)	909	86 %	71 %	61 %
1993	1,144 (2.5M)	521	n/a	n/a	45 %
1994	1,229 (2.5M)	898	n/a	n/a	73%
1995	2,408 (2.5M)		84 %		

<sup>a</sup> Egg-take targets in millions (M) are shown in parentheses.



Table 3. Summary of results of Trapper Lake outplant projects, egg-take to outplanted fry stage.

Brood-year	# eggs taken <sup>a</sup> (x1000)	# fry planted (x1000)	percent fertilized	Survival	
				fertilized egg to planted fry	green egg to planted fry
1990	2,314 (2.5M)	934	87 %	47 %	41 %
1991	2,953 (3M)	1,811	85 %	72 %	61 %
1992	2,521 (2.75M)	1,113	90 %	49 %	44 %
1993	1,174 (1.0M)	916	n/a	n/a	78 %
1994	1,062 (1.0M)	773	n/a	n/a	72 %
1995	egg takes discontinued				

<sup>a</sup> Egg-take targets in millions (M) are shown in parentheses.

Table 4. Numbers captured, mean lengths and weights, and percentages of enhanced and wild fish in samples of sockeye salmon juveniles from surveys of Tahltan Lake during the summer and fall of 1992.<sup>a</sup>

	<u>Trawl</u>		<u>Beachseine</u>	
	Enhanced	Wild	Enhanced	Wild
<u>Trip 1, June 23</u>				
	No trawls conducted		Total Index Catch:	1884
			Total Sampled:	280
Age 0+ (BY 1991)				
Length			29.6	31.7
Weight			0.14	0.22
n			8	72
%			10.0	90.0
Age 1+ (BY 1990)				
n			0	0
<u>Trip 2, July 28-31</u>				
	Total Catch:	24	Total Index Catch:	304
	Total Sampled:	24	Total Sampled:	75
Age 0+ (BY 1991)				
Length	58.5	50.9	33.3	30.7
Weight	1.62	1.19	0.26	0.18
n	2	22	4	71
%	8.3	91.7	5.3	94.7
Age 1+ (BY 1990)				
n	0	0	0	0
<u>Trip 3, August 20</u>				
	No trawls conducted		Total Index Catch:	12
			Total Sampled:	12
Age 0+ (BY 1991)				
Length				27.6
Weight				0.10
n			0	12
%			0	100
Age 1+ (BY 1990)				
n			0	0
<u>Trip 4, October 2-3</u>				
	Total Catch:	38	Total Index Catch:	2
	Total Sampled:	38	Total Sampled:	2
Age 0+ (BY 1991)				
Length	63.6	60.5		49.0
Weight	2.32	1.98		0.80
n	7	31	0	2
%	18.4	81.6	0	100
Age 1+ (BY 1990)				
n	0	0	0	0

<sup>a</sup> Measurements are from specimens preserved in denatured (94%) ethanol and are not directly comparable to fresh measurements. Total beachseine catches are for index sites only and do not include supplemental catches (see Methods, section 3.4). Total sampled refers to no. of juveniles sampled for thermal marks. In some cases, subsamples were selected from the total sampled, proportional to numbers captured in individual sets or trawls. Percentages may not agree exactly with sample sizes for length/weight (n) since some fish observed for marks may not have been measurable.

Table 5. Numbers captured, mean lengths and weights, and percentages of enhanced and wild fish in samples of sockeye salmon juveniles from surveys of Tahltan Lake during the summers and falls of 1993 and 1994. There was no juvenile sampling (beachseining or trawling) conducted on Trip 1 in either year.<sup>a</sup>

	<u>Trawl</u>		<u>Beachseine</u>	
	Enhanced	Wild	Enhanced	Wild
<b>1993 Surveys</b>				
<u>Trip 2, August 3</u>	No trawls conducted		Total Index Catch:	411
			Total Sampled:	231
Age 0+ (BY 1992)				
Length			28.0	29.1
Weight			0.12	0.13
n			1	95
%			1.0	99.0
Age 1+ (BY 1991)				
n			0	0
<u>Trip 3, Sept. 18-20</u>	Total Catch:	186	Total Index Catch:	1
	Total Sampled:	186	Total Sampled:	1
Age 0+ (BY 1992)				
Length	61.6	61.1	68.0	
Weight	2.10	2.17	2.47	
n	67	95	1	0
%	36.0	51.1	100	0
Age 1+ (BY 1991)				
Length		92.2		
Weight		7.44		
n	0	24	0	0
%	0	12.9	0	0
<b>1994 Surveys</b>				
<u>Trip 2, July 27</u>	No trawls conducted		0 sockeye captured	
<u>Trip 3, Sept. 18-22</u>	Total Catch:	23	Total Index Catch:	8
	Total Sampled:	23	Total Sampled:	8
Age 0+ (BY 1993)				
Length	63.0	53.3		54.6
Weight	2.21	1.42		1.77
n	1	16		8
%	5.9	94.1		100
Age 1+ (BY 1992)				
n	0	0	0	0

<sup>a</sup> Measurements are from specimens preserved in 90% denatured ethanol and are not directly comparable to fresh measurements. Total beachseine catches are for index sites only and do not include supplemental catches (see Methods, section 3.4). Total sampled refers to no. of juveniles sampled for thermal marks. In some cases, sub-samples were selected from the total sampled, proportional to numbers captured in individual sets or trawls. Percentages may not agree exactly with sample sizes for length/weight (n) since some fish observed for marks may not have been measurable.

Table 6. Numbers captured, mean lengths and weights, and percentages of fish of different ages in samples of sockeye salmon juveniles from surveys of Tuya Lake during the summer and fall of 1992. There are no wild sockeye in Tuya Lake and the first fry plant was in 1992 (brood year 1991)<sup>a</sup>.

	<u>Trawl</u>		<u>Beachseine</u>	
	Enhanced	Wild	Enhanced	Wild
<u>Trip 1, June 24</u>				
	No trawls conducted		Total Index Catch:	412
			Total Sampled:	410
Age 0+ (BY 1991)				
Length			27.8	
Weight			0.12	
n			25	
%			100	n/a
Age 1+ (BY 1990)				
n			n/a	n/a
<u>Trip 2, July 25</u>				
	Total Catch:	0	Total Index Catch:	1
	Total Sampled:	0	Total Sampled:	1
Age 0+ (BY 1991)				
Length			33.0	
Weight			0.19	
n			1	
%		n/a	100	n/a
Age 1+ (BY 1990)				
n		n/a	n/a	n/a
<u>Trip 3, August 24</u>				
	No trawls conducted		Total Index Catch:	5
			Total Sampled:	5
Age 0+ (BY 1991)				
Length			63.2	
Weight			2.16	
n			5	
%			100	n/a
Age 1+ (BY 1990)				
n			n/a	n/a
<u>Trip 4,</u>				
	Total Catch:	10	Total Index Catch:	0
	Total Sampled:	10	Total Sampled:	0
Age 0+ (BY 1991)				
Length	70.1			
Weight	3.02			
n	10			
%	100	n/a		n/a
Age 1+ (BY 1990)				
n	n/a	n/a	n/a	n/a

<sup>a</sup> Measurements are from specimens preserved in denatured (94%) ethanol and are not directly comparable to fresh measurements. Total beachseine catches are for index sites only and do not include supplemental catches (see Methods, section 3.4). In some cases, sub-samples were selected from the total sampled, proportional to numbers captured in individual sets or trawls. Percentages may not agree exactly with sample sizes for length/weight (n) since some fish observed for marks may not have been measurable.

Table 7. Numbers captured, mean lengths and weights, and percentages of enhanced and wild fish in samples of sockeye salmon juveniles from surveys of Tuya Lake during the summers and falls of 1993 and 1994. There was no juvenile sampling (beachseining or trawling) conducted on Trip 1 in either year. There are no wild sockeye in Tuya Lake<sup>a</sup>.

	<u>Trawl</u>		<u>Beachseine</u>	
	Enhanced	Wild	Enhanced	Wild
<b>1993 Surveys</b>				
<u>Trip 2, July 28</u>	No trawls conducted		0 sockeye captured	
<u>Trip 3, Sept. 2</u>	Total Catch: 6 Total Sampled: 6		0 sockeye captured	
Age 0+ (BY 1992)				
Length	57.8			
Weight	1.80			
n	5	n/a		
%	100	n/a		
Age 1+ (BY 1991)				
n	0	n/a		
<b>1994 Surveys</b>				
<u>Trip 2, July 28</u>	No trawls conducted		Total Index Catch:	1
			Total Sampled:	1
Age 0+ (BY 1993)				
Length			38.0	
Weight			0.37	
n			1	n/a
%			100	n/a
Age 1+ (BY 1992)				
n			0	n/a
<u>Trip 3, Sept. 5</u>	Total Catch: 131 Total Sampled: 75		0 sockeye captured	
Age 0+ (BY 1993)				
Length	60.5			
Weight	2.02			
n	75	n/a		
%	100	n/a		
Age 1+ (BY 1992)				
n	0	n/a		

<sup>a</sup> Measurements are from specimens preserved in denatured ethanol and are not directly comparable to fresh measurements. Total sampled refers to no. fish sampled for thermal marks. Total beachseine catches are for index sites only and do not include supplemental catches (see Methods, section 3.4). In some cases, sub-samples were selected from the total sampled, proportional to numbers captured in individual sets or trawls. Percentages may not agree exactly with sample sizes for length/weight (n) since some fish observed for marks may not have been measurable.

Table 8. Numbers captured, mean lengths and weights, and percentages of enhanced and wild fish in samples of sockeye salmon juveniles from surveys of Tatsamenie Lake during the summer and fall of 1992.<sup>a</sup>

	<u>Trawl</u>		<u>Beachseine</u>	
	Enhanced	Wild	Enhanced	Wild
<u>Trip 1, June 21</u>				
	No trawls conducted		Total Index Catch:	917
			Total Sampled:	310
Age 0+ (BY 1991)				
Length				33.4
Weight				0.24
n			0	44
%			0	100
Age 1+ (BY 1990)				
n			0	0
<u>Trip 2, August 1-2</u>				
	Total Catch:	4	Total Index Catch:	428
	Total Sampled:	4	Total Sampled:	351
Age 0+ (BY 1991)				
Length		45.0	33.4	35.9
Weight		1.28	0.21	0.31
n	0	4	9	114
%	0	100	7.3	92.7
Age 1+ (BY 1990)				
n	0	0	0	0
<u>Trip 3, August 21</u>				
	No trawls conducted		Total Index Catch:	225
			Total Sampled:	>100
Age 0+ (BY 1991)				
Length			48.5	50.2
Weight			0.96	1.12
n			2	89
%			2.2	96.7
Age 1+ (BY 1990)				
Length				88.0
Weight				6.31
n			0	1
%			0	100
<u>Trip 4, September 27</u>				
	Total Catch:	225	Total Index Catch:	22
	Total Sampled:	53	Total Sampled:	36
Age 0+ (BY 1991)				
Length	48.3	50.9	30.0	35.3
Weight	0.77	1.03	0.16	0.31
n	4	49	1	32
%	7.6	92.5	3.0	97.0
Age 1+ (BY 1990)				
n	0	0	0	0

<sup>a</sup> Measurements are from specimens preserved in denatured (94%) ethanol and are not directly comparable to fresh measurements. Total beachseine catches are for index sites only and do not include supplemental catches (see Methods, section 3.4). Total sampled refers to no. of juveniles sampled for thermal marks. In some cases, subsamples were selected from the total sampled, proportional to numbers captured in individual sets or trawls. Percentages may not agree exactly with sample sizes for length/weight (n) since some fish observed for marks may not have been measurable.

**Table 9. Numbers captured, mean lengths and weights, and percentages of enhanced and wild fish in samples of sockeye salmon juveniles from surveys of Tatsamenie Lake during the summers and falls of 1993 and 1994. No juvenile sampling (beachseining or trawling) was conducted on Trip 1 in either year.<sup>a</sup>**

	<u>Trawl</u>		<u>Beachseine</u>	
	Enhanced	Wild	Enhanced	Wild
<b>1993 Surveys</b>				
<u>Trip 2, August 1</u>	No trawls conducted		Total Index Catch:	143
			Total Sampled:	273
Age 0+ (BY 1992)				
Length			34.3	37.5
Weight			0.31	0.40
n			4	94
%			4.1	96.0
Age 1+ (BY 1991)				
n			0	0
<u>Trip 3, Sept. 14-16</u>			Total Index Catch:	11
	Total Catch:	164	Total Sampled:	11
	Total Sampled:	125		
Age 0+ (BY 1992)				
Length	43.9	47.8	41.0	33.5
Weight	0.75	0.92	0.41	0.23
n	15	103	1	10
%	12.4	85.1	9.1	90.9
Age 1+ (BY 1991)				
Length			98.7	
Weight			10.77	
n	0	3	0	0
%	0	2.5	0	0
<b>1994 Surveys</b>				
<u>Trip 2, July 26</u>	No trawls conducted		Total Index Catch:	1100
			Total Sampled:	278
Age 0+ (BY 1993)				
Length			31.5	44.3
Weight			0.18	0.75
n			2	119
%			1.7	98.4
Age 1+ (BY 1992)				
n			0	0
<u>Trip 3, Sept. 15-17</u>			Total Index Catch:	17
	Total Catch:	56	Total Sampled:	17
	Total Sampled:	56		
Age 0+ (BY 1993)				
Length	55.0	62.7	55.0	38.4
Weight	1.62	2.62	1.23	0.46
n	1	55	1	16
%	1.8	98.2	5.9	94.1
Age 1+ (BY 1992)				
n	0	0	0	0

<sup>a</sup> Measurements are from specimens preserved in denatured (94 or 90%, 1993 and 1994, respectively) ethanol and are not directly comparable to fresh measurements. Total beachseine catches are for index sites only and do not include supplemental catches (see section 3.4). Total sampled refers to no. of juveniles sampled for thermal marks. In some cases, sub-samples were selected from the total sampled, proportional to numbers captured in individual sets or trawls. Percentages may not agree exactly with sample sizes for length/weight (n) since some fish observed for marks may not have been measurable.

Table 10. Numbers captured, mean lengths and weights, and percentages of enhanced and wild fish in samples of sockeye salmon juveniles from surveys of Trapper Lake during the summer and fall of 1992.<sup>a</sup>

	<u>Trawl</u>		<u>Beachseine</u>	
	Enhanced	Wild	Enhanced	Wild
<u>Trip 1, June 20</u>	No trawls conducted		Total Index Catch:	19
			Total Sampled:	296
Age 0+ (BY 1991)				
Length			29.2	
Weight			0.13	
n			75	0
%			100	0
Age 1+ (BY 1990)				
n			0	0
<u>Trip 2, August 4</u>	No trawls conducted (equipment failure)		Total Index Catch:	582
			Total Sampled:	327
Age 0+ (BY 1991)				
Length			39.6	
Weight			0.44	
n			89	0
%			100	0
Age 1+ (BY 1990)				
n			0	0
<u>Trip 3, August 23</u>	Total Catch: no trawls		Total Index Catch:	314
			Total Sampled:	257
Age 0+ (BY 1991)				
Length			44.4	
Weight			0.68	
n			100	0
%			100	0
Age 1+ (BY 1990)				
n			0	0
<u>Trip 4, Sept. 21-23</u>	Total Catch:	49	Total Index Catch:	489
	Total Sampled:	49	Total Sampled:	241
Age 0+ (BY 1991)				
Length	52.4	41.0	53.6	
Weight	1.03	0.51	1.13	
n	14	14	100	0
%	28.6	28.6	100	0
Age 1+ (BY 1990)				
Length	90.3	80.2		
Weight	7.31	5.08		
n	8	13	0	0
%	16.3	26.5	0	0

<sup>a</sup> Measurements are from specimens preserved in denatured (94%) ethanol and are not directly comparable to fresh measurements. Total beachseine catches are for index sites only and do not include supplemental catches (see Methods, section 3.4). Total sampled refers to no. of juveniles sampled for thermal marks. In some cases, sub-samples were selected from the total sampled, proportional to numbers captured in individual sets or trawls. Percentages may not agree exactly with sample sizes for length/weight (n) since some fish observed for marks may not have been measurable.



Table 11. Numbers captured, mean lengths and weights, and percentages of enhanced and wild fish in samples of sockeye salmon juveniles from surveys of Trapper Lake during the summers and falls of 1993 and 1994. There was no juvenile sampling (beachseining or trawling) conducted on Trip 1 in either year.<sup>a</sup>

	<u>Trawl</u>		<u>Beachseine</u>	
	Enhanced	Wild	Enhanced	Wild
<b>1993 Surveys</b>				
<u>Trip 2, July 30</u>	No trawls conducted		Total Index Catch:	29
			Total Sampled:	119
Age 0+ (BY 1992)				
Length			35.3	
Weight			0.32	
n			100	0
%			100	0
Age 1+ (BY 1991)				
n			0	0
<u>Trip 3, Sept. 10-11</u>	Total Catch:	41	Total Index Catch:	214
	Total Sampled:	41	Total Sampled:	238
Age 0+ (BY 1992)				
Length	52.8	59.8	49.9	32.0
Weight	1.07	1.52	0.98	0.25
n	31	5	99	1
%	75.6	12.2	99.0	1.0
Age 1+ (BY 1991)				
Length	93.8	97.0		
Weight	7.61	7.77		
n	4	1	0	0
%	9.8	2.4	0	0
<b>1994 Surveys</b>				
<u>Trip 2, July 24</u>	No trawls conducted		Total Index Catch:	453
			Total Sampled:	178
Age 0+ (BY 1993)				
Length			33.6	29.3
Weight			0.28	0.16
n			69	3
%			95.8	4.2
Age 1+ (BY 1992)				
Length				
Weight				
n			0	0
%			0	0
<u>Trip 3, Sept. 12-13</u>	Total Catch:	3	Total Index Catch:	0
	Total Sampled:	3	Total Sampled:	0
Age 0+ (BY 1993)				
Length				36.3
Weight				0.37
n	0	3		
%	0	100		
Age 1+ (BY 1992)				
n	0	0		

<sup>a</sup> Measurements are from specimens preserved in denatured (94 or 90%, 1993 and 1994, respectively) ethanol and are not directly comparable to fresh measurements. Total beachseine catches are for index sites only and do not include supplemental catches (see section 3.4). Total sampled refers to no. of juveniles sampled for thermal marks. In some cases, sub-samples were selected from the total sampled, proportional to numbers captured in individual sets or trawls. Percentages may not agree exactly with sample sizes for length/weight (n) since some fish observed for marks may not have been measurable.

Table 12. Numbers captured, mean lengths and weights, and percentages of enhanced and wild fish in a sample of sockeye salmon juveniles from the single survey of Little Trapper Lake in the summer of 1992.<sup>a</sup>

	<u>Trawl</u>		<u>Beachseine</u>	
	Enhanced	Wild	Enhanced	Wild
<u>July 14</u>	No trawls conducted		Total Index Catch: unknown	
			Total Sampled:	100
Age 0+ (BY 1991)				
Length			33.7	35.4
Weight			0.28	0.36
n			18	82
%			18.0	82.0
Age 1+ (BY 1990)				
n			0	0

<sup>a</sup> Measurements are from specimens preserved in denatured (94%) ethanol and are not directly comparable to fresh measurements. Total beachseine catch is for index sites only and does not include supplemental catches (see Methods, section 3.4). A sub-sample was selected from total beachseine samples proportional to relative abundance at the capture sites. Total sampled refers to no. of juveniles sampled for thermal marks.

Table 13. Numbers captured, mean lengths and weights, and percentages of enhanced and wild fish in samples of sockeye salmon juveniles from surveys of Little Trapper Lake during the summers and falls of 1993 and 1994. No juvenile sampling (beachseining or trawling) was conducted on Trip 1 in either year.<sup>a</sup>

	<u>Trawl</u>		<u>Beachseine</u>	
	Enhanced	Wild	Enhanced	Wild
<b>1993 Surveys</b>				
<u>Trip 2, July 28</u>	No trawls conducted		Total Index Catch: > 3300 Total Sampled: 409	
Age 0+ (BY 1992)				
Length				40.5
Weight				0.50
n			0	115
%			0	99.1
Age 1+ (BY 1991)				
Length				65.0
Weight				2.62
n			0	1
%			0	0.9
<u>Trip 3, Sept. 7-8</u>				
	Total Catch:	149	Total Index Catch:	67
	Total Sampled:	149	Total Sampled:	67
Age 0+ (BY 1992)				
Length	47.0	46.2		51.3
Weight	0.57	0.64		1.01
n	1	147	0	62
%	0.7	98.7	0	92.5
Age 1+ (BY 1991)				
Length		66.0		71.8
Weight		2.78		2.94
n	0	1	0	5
%	0	0.7	0	7.5
<b>1994 Surveys</b>				
<u>Trip 2, July 23</u>	No trawls conducted		Total Index Catch: > 3800 Total Sampled: 392	
Age 0+ (BY 1993)				
Length			33.0	40.7
Weight			0.22	0.53
n			1	149
%			0.7	99.3
Age 1+ (BY 1992)				
n			0	0
<u>Trip 3, Sept. 9-10</u>				
	Total Catch:	599	Total Index Catch:	32
	Total Sampled:	599	Total Sampled:	32
Age 0+ (BY 1993)				
Length		56.7	50.0	52.3
Weight		1.58	1.04	1.23
n		147	1	31
%		98.0	3.1	96.9
Age 1+ (BY 1992)				
Length		78.7		
Weight		4.18		
n		3	0	
%		2.0	0	

<sup>a</sup> Measurements are from specimens preserved in denatured (94 or 90%, 1993 and 1994, respectively) ethanol and are not directly comparable to fresh measurements. Total beachseine catches are for index sites only and do not include supplemental catches (see Methods, section 3.4). Total sampled refers to no. of juveniles sampled for thermal marks. In some cases, subsamples were selected from the total sampled, proportional to numbers captured in individual sets or trawls. Percentages may not agree exactly with sample sizes for length/weight (n) since some fish observed for marks may not have been measurable.

Table 14. Hydroacoustic estimates of enhanced and wild juvenile sockeye in transboundary lakes, 1992 through 1994. Total estimates are apportioned to various categories of juveniles based on trawl capture data from Tables 1 through 13. Confidence limits of 95% are given for total estimates.

Date of survey	Estimated numbers of juvenile sockeye				
	total (+/- C.L.)	age 1+		age 1+	
		enhanced	wild	enhanced	wild
Tahltan Lake					
1992					
July 29	no estimate due to technical problems				
Oct. 03	no estimate due to equipment failure				
1993					
Sept. 18	817,429 +/-158,828	294,274	417,706	0	105,448
1994					
Sept. 18	436,634 +/-150,718	25,761	410,873	0	0
Tuya Lake					
1992					
July 25	147,322 +/-128,268	147,322	n/a	n/a	n/a
Sept. 17	596,537 <sup>a</sup> +/-196,156	596,537	n/a	n/a	n/a
1993					
Aug. 30	437,304 +/-228,578	437,304	n/a	0	n/a
1994					
Sept. 02	1,935,265 +/-1,080,984	1,935,265	n/a	0	n/a
Tatsamenie Lake					
1992					
Aug. 02	1,795,965 +/-772,015	0	1,795,965 <sup>b</sup>	0	0
Sept.28	no estimate due to equipment failure				

Table 14 cont'd.

1993					
Sept. 14	1,146,054 +/-409,859	142,111	975,292	0	28,651
1994					
Sept. 13	1,053,185 +/-358,658	18,957	1,034,228	0	0
Trapper Lake 1992					
Aug. 03	196,037 +/-55,203	type estimates not available as no trawls were made due to winch failure			
Sept. 30	no estimate due to equipment failure				
1993					
Sept. 10	125,459 +/-64,774	94,847	15,306	12,295	3,011
1994					
Sept. 11	64,554 +/-25,446	64,554 <sup>c</sup>	0	0	0
Little Trapper Lake 1992					
not surveyed in 1992					
1993					
Sept. 07	296,890 <sup>d</sup> +/-116,354	1,993	292,905	0	1,993
1994					
Sept. 08	554,748 <sup>d</sup> +/-311,232	0	543,653	0	11,095
Nakina Lake 1993 and 1994 no juvenile sockeye detected					

<sup>a</sup> reliability of estimate uncertain due to possible sounder malfunction

<sup>b</sup> based on exceptionally small trawl sample (4 fish)

<sup>c</sup> based on exceptionally small sample (3 fish)

<sup>d</sup> probable underestimate due to very high density

Table 15. Estimated survivals of outplanted sockeye fry based on fall hydroacoustic/trawl surveys. Reliability of these estimates is discussed in the text.

Brood-year (BY)	Year of out-planting (BY+1)	Number out-planted	Survival to fall, BY+1 (age 0+)		Survival to fall, BY+2 (age 1+) <sup>a</sup>	
			Estimated fall fry	%	Estimated fall fry	%
Tahltan Lake						
1989	1990	1,042,000	no est.	n/a	6,224	0.1
1990	1991	3,585,000	479,286	13.4	no est.	n/a
1991	1992	1,415,000	no est.	n/a	0	0.0
1992	1993	1,947,000	294,274	15.1	0	0.0
1993	1994	904,000	25,761	2.8	n/a	n/a
Average				10.4		.03
Tuya Lake						
1991	1992	1,632,000	596,537	36.6	0	0.0
1992	1993	1,990,000	437,304	22.0	0	0.0
1993	1994	4,691,000	1,935,265	41.3	n/a	n/a
Average				33.3		0.0
Tatsamenie Lake						
1990	1991	673,000	201,563	29.9	no est.	n/a
1991	1992	1,232,000	no est.	n/a	0	0.0
1992	1993	909,000	142,111	15.6	0	0.0
1993	1994	521,000	18,957	3.6	n/a	n/a
Average				16.4		0.0
Trapper Lake						
1990	1991	934,000	231,689	24.8	no est.	n/a
1991	1992	1,811,000	no est.	n/a	12,295	0.1
1992	1993	1,113,000	94,847	8.5	0	0.0
1993	1994	916,000	0 <sup>b</sup>	0.0	n/a	n/a
Average				11.1 <sup>c</sup>		0.1

<sup>a</sup> not a true survival as it does not account for smolts which migrated at age 1+; also, this age class is likely underrepresented because of the increased net avoidance associated with larger size.

<sup>b</sup> estimate extremely poor because of exceptionally small trawl sample (3 fish).

<sup>c</sup> 16.6% omitting BY 1993 (probably more realistic).

Table 16. Estimations of total emigration, percent by age class, mean lengths and weights of Tahltan Lake smolts; 1991 through 1995.<sup>a</sup>

		BY	Percent	Estimated number	length (mm)	weight (g)
1991						
Wild	1	1989	74.36	1,105,882	90.6	5.82
	2	1988	7.48	111,243	112	11.80
	3	1987	0.02	3,272	153	27.3
Enhanced	1	1989	17.94	266,868	88.6	5.40
	2	1988	n/a	(outplants began in 1990, BY 1989)		
1992						
Wild	1	1990	43.81	681,310	84.8	4.77
	2	1989	4.26	66,238	110	10.20
	3	1988	0.02	3,154	177	45.80
Enhanced	1	1990	49.70	772,782	84.3	4.63
	2	1989	2.03	31,542	115	12.00
	3	1988	n/a			
1993						
Wild	1	1991	86.01	2,799,607	80.1	3.94
	2	1990	1.72	55,955	105.3	10.03
Enhanced	1	1991	11.36	369,892	79.6	3.85
	2	1990	0.91	29,591	116.5	12.85
1994						
Wild	1	1992	59.30	542,633	84.3	5.00
	2	1991	8.54	78,176	101.8	8.41
Enhanced	1	1992	32.16	294,310	83.4	4.74
	2	1991	0	-	-	-
1995						
Wild	1	1993	90.44	743,674	83.4	4.71
	2	1992	2.84	23,353	116.7	13.45
Enhanced	1	1993	5.43	44,650	81.7	4.37
	2	1992	1.29	10,607	113.0	11.98

<sup>a</sup> Measurements are from fresh (unpreserved) fish.

Table 17. Estimated percentages by age class, total emigration, and mean lengths and weights for smolts observed at Tuya Lake in 1993, 1994, and 1995. <sup>a</sup>

Origin	Age	BY	Per- cent	Estimated number	length (mm)	weight (g)
<b>1993</b>						
Wild	There are no wild sockeye in Tuya Lake					
Enhanced	1	1991	100	no estimate	99.7	8.76
	2	1990	n/a	(the first outplant was in 1992, BY 1991)		
<b>1994</b>						
Wild	There are no wild sockeye in Tuya Lake					
Enhanced	1	1992	96.00	no estimate	99.0	8.99
	2	1991	4.00	no estimate	135.3	22.34
<b>1995</b>						
Wild	There are no wild sockeye in Tuya Lake					
Enhanced	1	1993	97.07	no estimate	95.58	9.64
	2	1992	2.93	no estimate	137.0	27.35

<sup>a</sup> measurements are from fresh (unpreserved) fish.



Table 18. Estimated percentage by age class, total emigration, numbers, and mean lengths and weights for smolts observed at Tatsamenie Lake; 1992 through 1995. <sup>a</sup>

Origin	Age	BY	Per- cent	Estimated number	length (mm)	weight (g)
1992						
Wild	1	1990	61.51	no estimate	81.0	4.87
	2	1989	32.64	no estimate	117.5	14.10
Enhanced	1	1990	5.86	no estimate	81.6	4.99
	2	1989	n/a	(there were no outplants until 1991, BY 1990)		
	3		1993			
Wild	1	1991	84.21	no estimate	76.3	4.56
	2	1990	9.47	no estimate	102.8	9.52
Enhanced	1	1991	6.32	no estimate	65.2	2.88
	2	1990	0	-	-	-
1994						
Wild	1	1992	84.05	no estimate	75.9	3.55
	2	1991	11.04	no estimate	114.7	13.34
Enhanced	1	1992	3.07	no estimate	73.0	3.40
	2	1991	1.84	no estimate	111.4	11.52
1995						
Wild	1	1993	84.77	no estimate	81.9	5.06
	2	1992	12.69	no estimate	119.3	16.12
Enhanced	1	1993	2.03	no estimate	79.8	4.53
	2	1992	0.51	no estimate	117.0	15.2

<sup>a</sup> measurements are from fresh (unpreserved) fish.

Table 19. Estimated percentage by age class, total emigration, and mean lengths and weights for smolts observed at Trapper Lake; 1992 through 1995. <sup>a</sup>

Origin	Age	BY	No. in Sample	Per- cent	Total emigration	Mean length (mm)	Mean weight (g)
1992							
There were no smolts captured during trapping conducted in 1992							
1993							
Wild	no wild smolts observed						
Enhanced	1	1991	1	100 <sup>b</sup>	no estimate	67.0	3.40
	2	1990	0	0	no estimate	-	-
	3	1989	0	n/a	(there were no outplants until 1991, BY 1990)		
1994							
Wild	no wild smolts observed						
Enhanced	1	1992	10	26.32	no estimate	71.3	3.60
	2	1991	27	71.05	no estimate	107.0	12.44
	3	1990	1	2.63	no estimate	142.0	26.90
1995							
Wild	no wild smolts observed						
Enhanced	1	1993	10	6.06	no estimate	84.7	5.96
	2	1992	147	89.09	no estimate	111.0	13.69
	3	1991	7	4.24	no estimate	134.6	23.91
	4	1990	1	0.61	no estimate	167.0	44.7

<sup>a</sup> measurements are from fresh (unpreserved) fish.

<sup>b</sup> only 1 fish captured

Table 20. Estimated percentages of total emigration, numbers, and mean lengths and weights for smolts observed at Little Trapper Lake; 1992 through 1995. <sup>a</sup>

Origin	Age	BY	Per- cent	Estimated number	Mean length (mm)	Mean weight (g)
1992						
Wild	1	1990	70.75	no estimate	69.8	2.90
	2	1989	22.13	no estimate	95.3	7.75
Enhanced	1	1990	7.11	no estimate	69.9	2.93
	2	1989	n/a	(there were no outplants until 1991, BY 1990)		
1993						
Wild	1	1991	71.0	no estimate	59.0	2.09
	2	1990	25.0	no estimate	82.3	4.98
Enhanced	1	1991	1.0	no estimate	54.0	1.3
	2	1990	3.0	no estimate	86.0	5.37
1994						
Wild	1	1992	88.81	no estimate	59.9	1.73
	2	1991	8.39	no estimate	81.3	4.03
Enhanced	1	1992	2.10	no estimate	54.7	1.43
	2	1991	0.70	no estimate	70.0	2.5
1995						
Wild	1	1993	64.08	no estimate	66.5	2.78
	2	1992	33.06	no estimate	80.9	4.80
Enhanced	1	1993	0.41	no estimate	69.0	3.20
	2	1992	2.45	no estimate	110.7	13.42

<sup>a</sup> measurements are from fresh (unpreserved) fish.

Table 21. Survival of sockeye fry outplanted to Tahltan Lake, brood-years 1989 to 1993; from outplanted fry to smolt.

Fry planted (year)	Abundance				Survival from planted fry				
	Juveniles <sup>a</sup>		Smolts		Juveniles <sup>a</sup>		Smolts		
	fall, age 0+ (year)	fall, <sup>b</sup> age 1+ (year)	age 1+ smolts (year)	age 2+ smolts (year)	to fall age 0+	to fall <sup>b</sup> age 1+	to age 1+	to age 2+	total (age 1+2)
<b>Brood-year 1989</b>									
1,042,000 (1990)	no est. (1990)	6,224 (1991)	266,868 (1991)	31,542 (1992)	n/a	0.1	25.6%	3.03%	28.6%
<b>Brood-year 1990</b>									
3,585,000 (1991)	479,286 (1991)	no est. (1992)	772,782 (1992)	29,591 (1993)	13.4%	n/a	21.6%	0.82%	22.4%
<b>Brood-year 1991</b>									
1,415,000 (1992)	no est. (1992)	0 (1993)	369,892 (1993)	0 (1994)	n/a	0.0%	26.2%	0.00%	26.2%
<b>Brood-year 1992</b>									
1,947,000 (1993)	294,274 (1993)	0 (1994)	294,310 (1994)	10,607 (1995)	15.1%	0.0%	15.1%	0.54%	15.7%
<b>Brood-year 1993</b>									
904,000 (1994)	25,761 (1994)	no est. <sup>c</sup> (1995)	44,650 (1995)	10,607 (1996)	2.8%	n/a	4.9%	n/a	n/a
<b>Average survivals</b>					10.4%	0.03%	18.7%	1.1%	23.2% <sup>d</sup>

<sup>a</sup> see comments on accuracy of hydroacoustic estimates in text.

<sup>b</sup> this age class likely under-represented in samples because of greater net avoidance associated with larger size.

<sup>c</sup> this data collected after period covered by this report, analysis not yet done.

<sup>d</sup> average for brood years 1989-1992.

Table 22. Summary of sockeye salmon smolt size in Tahltan Lake relative to spring juvenile abundance in first year of lake rearing. Years when lake enrichment (fertilization) took place are indicated.

Brood-year (BY) t	Estimated total juvenile abundance (1000's) in spring of year t+1 <sup>c</sup>				Mean weight (g) of smolts originating from BY t				Lake enrichment status	
					wild		enhanced			
	age 0+ (BY t)	age 1+ (BY t-1)	total	Adult Weir Counts	age 1+	age 2+	age 1+	age 2+	year t+1	year t+2
1982	1195	19	1214	28,257	4.81	9.31			no	no
1983	1786	154	1940	21,256	3.75	8.45			no	no
1984	1350	35	1385	32,777	4.71	10.77			no	yes
1985	2831	184	3015	67,326	6.34	12.11			yes	yes
1986	3791	165	3956	20,280	5.75	15.85			yes	no
1987	2191	81	2272	6,958	6.02	8.97			no	no
1988	2243	133	2376	2,536	5.93	11.68			no	no
1989	5048	161	5209	8,316	5.82	10.17	5.40	12.0	no	no
1990	6256	142	6398	14,927	4.77	10.03	4.63	12.85	no	no
1991	12398	213	12611	50,135	3.94	8.41	3.85	- <sup>a</sup>	no	no
1992	4027	113	4140	59,907	5.00	13.45	4.74	11.98	no	no
1993	3755	49	3804	53,362	4.71	7.2 <sup>b</sup>	4.37	8.7 <sup>b</sup>	no	no

<sup>a</sup> none observed in sample

<sup>b</sup> this age class emigrated in 1996

<sup>c</sup> estimates of spring juvenile abundance were calculated by extrapolating backwards using actual smolt counts beginning in 1984 and fry mortality rates that were presented in a previous report (TTC, 1994; Appendix 3).

Table 23. Percentages of enhanced fry from Trapper Lake outplants in samples of age 0+ fry collected the same year in Little Trapper Lake. Standardized percentages are observed percentages adjusted for differences in the numbers outplanted and in the numbers of wild spawners in Little Trapper Lake (see Results Section 3.7.4 for details).

Year of outplant (brood year)	Little Trapper sample details	Observed Percent enhanced	Standardized Percent enhanced
1991 (1990)	July 10 beachseine	12.0	12.0
1992 (1991)	July 14 beachseine	18.0	27.4
1993 (1992)	July 28 beachseine	0	0
"	Sept. 7 beachseine	0	0
"	Sept. 7 trawl	0.7	0.9
1994 (1993)	July 23 beachseine	0.7	1.5
"	Sept. 9 beachseine	3.1 <sup>a</sup>	6.8
"	Sept. 9 trawl	0	0

<sup>a</sup> reliability of estimate low due to small sample size (n =32)

Table 24. Zooplankton species composition (% of total biomass) of Trapper and Little Trapper Lakes, 1991 through 1994.

Lake, year	Season	Bosminids	Daphnids	Cyclopoids	Nauplii and rotifers
Trapper, 1991	summer	0	0	100	<0.1
	fall	1.5	0	98.5	<0.1
Trapper, 1992	summer	0.2	0	99.8	<0.1
	fall	0.1	0	99.9	<0.1
Trapper, 1993	summer	0.4	0	99.6	<0.1
	fall	0.7	0	99.3	<0.1
Trapper, 1994	summer	0	0.8	98.4	0.8
	fall	1.2	2.4	92.2	4.2
Little Trapper, 1991	summer	2.1	0	83.0	14.9
	fall	69.2	0.1	17.4	13.3
Little Trapper, 1993	summer	10.4	0.2	81.0	8.4
	fall	86.0	0.3	3.3	10.4
Little Trapper, 1994	summer	12.2	2.0	83.9	1.9
	fall	33.2	5.1	20.9	40.8

Table 25. Revised estimates of Euphotic Volume (EV), adult production capacities, and spring fry capacities for all Transboundary lakes studied. Based on all available Secchi depth data.

Lake (number years observed)	Average Secchi depth	Lake <sup>a</sup> type	Euphotic <sup>b</sup> depth estimate (m)	Surface area (hectares)	EV <sup>c</sup> units	Previous <sup>d</sup> EV unit estimate	Adult <sup>e</sup> production estimate (K's)	previous adult product. estimate	estimated <sup>f</sup> spring fry capacity (K's)
Tahltan (10)	11.23	C	19.21	492	94.53	81	201	176	10,040
Tuya (9)	5.29	C/S	9.07	3,127	283.50	407	543	764	27,142
Tatsamenie (10)	5.23	C/G	10.03	1,679	168.41	202	335	394	16,726
Little Tatsamenie (3)	4.8	C/G	9.39	76	7.14	n/a	43	n/a	2,131
Trapper (8)	1.7	G	6.79	557	37.81	35	98	93	4,907
Little Trapper (7)	2.34	G	8.90	199	17.71	26	62		
Nakina (2)	5.6	C/S	9.41	491	46.21	n/a	113	n/a	5,667
Chutine (2)	1.05	G	4.64	615	28.56	12	81	51	4,070
Christina (2)	0.55	G	2.99	141	4.22	8	37	44	1,867
Kennicott (2)	1.65	C/S	5.01	128	6.41	5	41	39	2,066
King Salmon (3)	10.08	C	17.79	227	40.37	28	103	80	5,139
Kuthai (1)	9.9	C	17.56	157	27.57	39	80	100	3,980
Klukshu (3)	2.83	C/G	6.45	135	8.71	12	45	51	2,273

<sup>a</sup> C = clear, C/S = clear/stained, G = glacial, C/G = clear/glacial

<sup>b</sup> derived from Secchi depth; euphotic depth estimates were calculated from revised average Secchi depths compiled from additional sample years (see section 3.62).

<sup>c</sup> EV = euphotic depth X surface area. 1 EV unit = 1 million cubic meters.

<sup>d</sup> as reported in PSC 1988.

<sup>e</sup> estimated from euphotic volume by formula (PSC 1988): number adults (1'000's) = 29.7 + (1.81 X EV) *Note:* the Enhancement Sub Committee recommends assuming a more conservative estimate of one-half this number until proven.

<sup>f</sup> wild plus enhanced, using a biostandard fry to adult survival of 2%. *Note:* in accordance with the more conservative adult production estimates, the Enhancement Sub-Committee recommends a safe maximum of one-half this number, until corroboration by further research.



Table 26. Transboundary Lakes sockeye brood stock disease histories, BY's 1988 - 1995. Results are discussed in Appendix 2.

<b>Tahltan</b>						
BROOD YEAR	BKD		IHNVA			
	Sample Size	Percent Positive	IHNV Positive		Positives greater or equal to 10 <sup>4</sup> pfu	
			Sample Size	Percent	Number	Percent
1988	19/60	31.7%	54/60	90.0%	28/54	51.9%
1989	7/151	4.6%	3/159	1.9%	1/3	33.3%
1990	9/150	6.0%	5/150	3.3%	0/5	0.0%
1991	11/148	7.4%	144/152	94.7%	65/144	45.1%
1992	9/154	5.8%	141/154	91.6%	82/141	58.2%
1993	11/150	7.3%	107/149	71.8%	45/107	42.1%
1994	4/150	2.7%	75/150	50.0%	21/75	28.0%
1995	7/150	4.7%	93/150	62.0%	45/93	48.4%

<b>Tatsamenle</b>						
BROOD YEAR	BKD		IHNVA			
	Sample Size	Percent Positive	IHNV Positive		Positives greater or equal to 10 <sup>4</sup> pfu	
			Sample Size	Percent	Number	Percent
1988	3/67	4.5%	25/65	38.5%	4/25	16.0%
1989				no egg take		
1990	12/150	8.0%	96/150	64.0%	50/96	52.1%
1991	9/150	6.0%	5/150	3.3%	0/5	0.0%
1992	5/151	3.3%	95/150	63.3%	49/95	51.6%
1993	24/111	21.6%	94/149	63.1%	57/94	60.6%
1994	10/150	6.7%	1/103	1.0%	0/1	0.0%
1995	15/150	10.0%	1/149	0.7%	1/1	100.0%

<b>Little Trapper</b>						
BROOD YEAR	BKD		IHNVA			
	Sample Size	Percent Positive	IHNV Positive		Positives greater or equal to 10 <sup>4</sup> pfu	
			Sample Size	Percent	Number	Percent
1988	2/60	3.3%	52/60	86.7%	23/52	44.2%
1989				no egg take		
1990	20/150	13.3%	146/152	96.1%	113/146	77.4%
1991	9/150	6.0%	20/150	13.3%	5/20	25.0%
1992	1/153	0.7%	146/150	97.3%	126/146	86.3%
1993	10/150	6.7%	90/150	60.0%	47/90	52.2%
1994	10/150	6.7%	50/148	33.8%	16/50	32.0%
1995				no egg take		

<sup>a</sup> For IHNVA, a titer  $\geq 10^4$  plague forming units (pfu), is the point at which the probability of vertical (parent to offspring) transmission of IHNVA is felt to greatly increase.

## **APPENDICES**

Appendix 1. Summary of thermal marks applied at Snettisham Hatchery to transboundary river sockeye salmon, Broodyears 1989 to 1995.

Stock	Release Site	Brood year	Mark <sup>a</sup>
Tahltan	Tahltan Lake	89	4
		90	3
		91	4
		92	7
		93	6+5
		94	6
		95	6
Tahltan	Tuya Lake	91	6
		92	5
		93	4+5
		94	4
		95	4+4
Little Trapper	Trapper Lake	90	5
		91	6
		92	7+3
		93	4+5
		94	7
Little Tatsamenie	Tatsamenie Lake	90	3
		91	4
		92	4+3
		93	5+5
		94	5
		95	5

<sup>a</sup> Each mark is comprised of a single band containing the listed number of rings. Where 2 bands of rings are denoted (i.e. 6+5), the 1<sup>st</sup> band is applied before the sockeye embryo hatches, and the 2<sup>nd</sup> band is applied after hatching.

## Appendix 2. Brood stock disease screening results for Tahltan, Little Trapper, and Tatsamenie lakes. Data summary is located in Table 26.

note: For IHNV, a titer  $\geq 10^4$  plaque forming units (pfu) is the point at which the likelihood of vertical (parent to offspring) transmission of IHNV is felt to greatly increase.

### **Tahltan Lake**

#### 1990 Brood year

Disease testing of brood stock showed 9/150 fish positive for BKD (6.0%). Five out of 150 (3.3%) tested positive for IHNV; however, none of these had titers  $>10^4$  pfu. The incidences of both diseases were very comparable to those seen in 1989 (TTC 1991) and considerably lower than those seen in natural spawners in the preliminary survey year in 1988 (TTC, 1989). This was likely attributable to the 1990 samples having been captured sooner after entering the spawning grounds, thereby reducing stress and the likelihood of horizontal (fish to fish) transmission. Risk of vertical transmission was considered to be very low.

#### 1991 Brood year

Disease testing of brood stock showed 11/148 fish positive for BKD (7.4%). Of 152 fish tested, 144 (94.7%) tested positive for IHNV; 65 of these had titers  $>10^4$  pfu (42.8% of the total sample). The high incidence and high titers of IHNV were comparable to those seen in 1988. It was felt the high incidence of IHNV was due to the cyclical nature of the virus and/or a result of factors favoring horizontal transmission. The latter appears quite probable since the high escapement in 1991 resulted in large numbers of fish congregating near and competing for the limited spawning grounds, where brood stock is captured and held. It is unlikely the higher incidence was due to differences in methods of capture and/or holding of brood stock since these were very similar to those of previous years.

#### 1992 Brood year

Disease testing of brood stock showed 9/154 fish positive for BKD (5.8%). Of 154 fish tested, 141 (91.6%) tested positive for IHNV; 82 of these had titers  $\geq 10^4$  pfu (58.2% of the positive fish). The risk of vertical transmission of IHNV this year may again be high.

#### 1993 Brood year

Disease testing of brood stock showed 11/150 fish positive for BKD (7.3%). Of 149 fish tested, 107 (71.8%) tested positive for IHNV; 45 of these had titers  $\geq 10^4$  pfu (42.1% of the positive fish). The risk of vertical transmission of IHNV this year could be considered moderate.

#### 1994 Brood year

Disease testing of brood stock showed 4/150 fish positive for BKD (2.7%). Of 150 fish tested, 75 (50.0%) tested positive for IHNV; 21 of these had titers  $\geq 10^4$  pfu (28.0% of the positive fish). The risk of vertical transmission of IHNV this year could be considered moderate.

### **Little Tatsamenie Lake**

#### 1990 Brood year

Disease testing of brood stock showed 12/150 fish positive for BKD (8.0%). Incidence of IHNV was 96/150 (64.0%), 50 of these having titers  $>10^4$  pfu (33.3% of the total sample). The incidence of both diseases was higher than those seen in the 1988 preliminary survey (0% BKD; 38.5% IHNV with 16% tier  $>10^4$ ). Tatsamenie brood stock is quite green when captured and the higher disease incidences may have been attributable to the requirement to hold brood stock fish for several weeks to ripen.

#### 1991 Brood year

Disease testing of brood stock showed 9/150 fish positive for BKD (6.0%). Incidence of IHNV was only 5/150 (3.3%), with none of these having titers  $\geq 10^4$  pfu. Incidence of IHNV was considerably lower than in 1990, possibly a result of lower holding densities and reduced stress. Likelihood of vertical transmission was considered to be very low.

#### 1992 Brood year

Disease testing of brood stock showed 5/151 fish positive for BKD (3.3%). Of 150 fish tested, 95 (63.3%) tested positive for IHNV; 49 of these had titers  $\geq 10^4$  pfu (51.6% of the positive fish). The risk of vertical transmission of IHNV this year was considered moderate.

#### 1993 Brood year

Disease testing of brood stock showed 24/111 fish positive for BKD (21.6%). Of 149 fish tested, 94 (63.3%) tested positive for IHNV; 57 of these had titers  $\geq 10^4$  pfu (60.6% of the positive fish). The risk of vertical transmission of IHNV this year was considered moderate.

#### 1994 Brood year

Disease testing of brood stock showed 10/150 fish positive for BKD (6.7%). Of 103 fish tested, 1 (1.0%) tested positive for IHNV; the titer was below  $10^4$  pfu. The risk of vertical transmission of IHNV this year could be considered low.

### **Little Trapper Lake**

#### 1990 Brood year

Disease testing of brood stock showed 20/150 fish positive for BKD (13.3%). Incidence of IHNV was very high, 146/152 (96.1%); 113 of these had titers  $\geq 10^4$  pfu (73.0% of the total sample). BKD level was much higher than the 3.3% seen in the initial disease survey in 1988. Incidence of IHNV was somewhat higher than the 1988 incidence of 86.7% IHNV with 44.2% having  $\geq 10^4$  pfu. It was felt the higher disease incidences were likely due to horizontal transmission resulting from holding large numbers of broodstock under stressful conditions for long periods. The possibility of vertical transmission of IHNV was considered to be high.

#### 1991 Brood year

Disease testing of brood stock showed 9/150 fish positive for BKD (6.0%). Incidence of IHNV was much lower than in 1990, 20/150 (13.3%) 5 of these had titers  $\geq 10^4$  pfu (3.3% of the total sample). The risk of vertical transmission of IHNV was considered to be minimal. The lower incidence of IHNV could have been attributable in part to the reduced need for sorting of fish due to the availability of more ripe fish from the larger escapement. However, capture and holding techniques employed in 1990 and 1991 were similar and it is also possible the lower incidence may have been attributable simply to an inherent annual variability in virus levels. If so, the similar reduced incidence of IHNV observed in the Little Tatsamenie brood stock in 1991 suggests annual fluctuations might be widespread rather than stock specific.

#### 1992 Brood year

Disease testing of brood stock showed 1/153 fish positive for BKD (0.7%). Of 150 fish tested for viruses, 146 (97.3%) tested positive for IHNV; 126 of these had titers  $\geq 10^4$  pfu (86.3% of the positive fish). The increase in incidence of IHNV virus again suggests annual variability in virus levels. The risk of vertical transmission of IHNV this year was considered high.

#### 1993 Brood year

Disease testing of brood stock showed 10/150 fish positive for BKD (6.7%). Of 150 fish tested, 90 (60.0%) tested positive for IHNV; 47 of these had titers  $\geq 10^4$  pfu (52.2% of the positive fish). The risk of vertical transmission of IHNV this year was considered high.

#### 1994 Brood year

Disease testing of brood stock showed 10/150 fish positive for BKD (6.7%). Of 148 fish tested, 50 (33.8%) tested positive for IHNV; 16 of these had titers  $\geq 10^4$  pfu (32.0% of the positive fish). The risk of vertical transmission of IHNV this year was considered moderate.

Appendix 3. Summary of fry stocking dates for brood years 1989 through 1994 at Tahltan, Tuya, Trapper, and Tatsamenie lakes.

Brood Year	Release Site	Stocking Dates
1989	Tahltan	June 6,13,14,20,25
1990	Tahltan	June 2,3,4,5,7,12,13,18,19,20,21
1991	Tahltan	June 9,10
1992	Tahltan	June 23,26; July 2
1993	Tahltan	June 24,28
1994	Tahltan	June 26; July 3
1991	Tuya	June 17,20,21
1992	Tuya	June 16,25; July 7
1993	Tuya	June 24,28,30; July 1,12,13
1994	Tuya	June 21, 25; July 3
1990	Trapper	June 5,8,20,22
1991	Trapper	June 4,5,9,10,11
1992	Trapper	June 25; July 2
1993	Trapper	June 16,24
1994	Trapper	June 21,28; July 3
1990	Tatsamenie	June 22
1991	Tatsamenie	June 22,24,26
1992	Tatsamenie	July 9,14
1993	Tatsamenie	July 14
1994	Tatsamenie	July 18, 21

Appendix 4. Zooplankton biomass, density, and mean size for six transboundary lakes, 1987-1995.

**Glossary of Codes for  
Zooplankton Data**

Code	Name
20	Epischura nevadensis
60	Harpacticoid
100	Bosmina longispina
141	Chydorid
180	Ceriodaphnia quadrangula
450	Ostracod
900	Chironomid Larva
970	Mite
BOS	Bosmina
CAL	Calanoid
CYC	Cyclopoid
DIA	Diaphanosoma
DPH	Daphnia
DPT	Diptera
HOL	Holopedium
LGB	Large Beast
NP	Nauplii
ROT	Rotifer
TOT	Total
LTPR	Little Trapper Lake
TPR	Trapper Lake
TLTN	Tahltan Lake
TATS	Tatsamenie Lake
TUYA	Tuya Lake
LTATS	Little Tatsamenie Lake



## Appendix 4 cont'd.

BIOMASS, DENSITY AND MEAN SIZE FOR ZOOPLANKTON IN 6 TRANSBOUNDARY LAKES, 1987-1995																
A GLOSSARY OF SHORTENED TERMS IS PROVIDED IN THE ABOVE CODES.																
Property	Lake	Date	Site	Time	DIA	BOS	DPH	HOL	CYC	CAL	DPT	NP	ROT	LGB	TOT	Comments
Biomass (mg/m <sup>3</sup> )	LTATS	6/8/90	1	13:20	0.0067	0.6087	0.0428		20.6358	0.0605		0.664	0.2551	50.8278	22.2736	
Density (#/m <sup>3</sup> )	LTATS	6/8/90	1	13:20	2.6667	33.3333	2.2222		1088.8900	4.4444		2022.22	311.11	34.2222	3499.11	DIA=141, CAL=060 LGB=900
Mean size (mm)	LTATS	6/8/90	1	13:20	0.3468	0.4135	0.7076		0.6635	0.5898		0.1501	0.1254	0.6198	0.3159	
Biomass (mg/m <sup>3</sup> )	LTATS	6/8/90	1	19:00	0.003	0.0731	13.8898		1.7442	23.0149	5.2085	0.0103	11.0427	76.975	54.985	
Density (#/m <sup>3</sup> )	LTATS	7/14/90	1	19:00	1.7778	3.5556	32		55.1111	33.7778	179.56	44.4444	13466.6632	5.3333	13821.9717	DIA=141, CAL=020, LGB=900
Mean size (mm)	LTATS	7/14/90	1	19:00	0.3197	0.4246	1.5999		0.7980	2.4823	0.7831	0.135	0.1433	1.7089	0.164	
Biomass (mg/m <sup>3</sup> )	LTATS	9/6/90	1	9:30		0.2323	0.2954		5.6250		0.0609	0.0816	1.4965	0.317	7.7917	
Density (#/m <sup>3</sup> )	LTATS	9/6/90	1	9:30		9	5		325.0000		0.5	350	1825	1	2515.5	LGB=OSTRACOD
Mean size (mm)	LTATS	9/6/90	1	9:30		0.4766	0.9299		0.6370		1.3377	0.129	0.1057	0.488	0.1809	
Biomass (mg/m <sup>3</sup> )	LTATS	10/2/90	1	12:00		0.1622	0.1556		24.0322			0.2034	3.3073	5.5648	27.8607	
Density (#/m <sup>3</sup> )	LTATS	10/2/90	1	12:00		4.5	4.5		1683.3300			1133.33	4033.33	0.5	6859.5	LGB=900
Mean size (mm)	LTATS	10/2/90	1	12:00		0.561	0.8307		0.5945			0.1202	0.1004	1.6237	0.2258	
Biomass (mg/m <sup>3</sup> )	LTPR	9/2/87				3.4334	0.0956		6.6842			0.3676	25.5184		36.0993	
Density (#/m <sup>3</sup> )	LTPR	9/2/87				320	1.0667		253.8700			800	31119.3129		32494.5106	
Mean size (mm)	LTPR	9/2/87				0.3159	1.1793		0.7477			0.171	4.49303		0.1857	
Biomass (mg/m <sup>3</sup> )	LTPR	8/20/88	South side		0.0137	259.52			51.9163				11.1083		322.56	
Density (#/m <sup>3</sup> )	LTPR	8/20/88	South side		312	4.34189			1813.3300				13546.5904		37336.1902	DIA=141
Mean size (mm)	LTPR	8/20/88	South side		0.4236	0.3362			0.7790				0.1798		0.301	
Biomass (mg/m <sup>3</sup> )	LTPR	6/8/89	1			1.1923	0.081		35.4935			10.0394	2.9739	128.94	49.78	
Density (#/m <sup>3</sup> )	LTPR	6/8/89	1			108.8	3.2		3768.8900			12870.9321	3626.67	8.5333	20386.844	LGB=900
Mean size (mm)	LTPR	6/8/89	1			0.3217	0.7681		0.4756			0.2007	0.0964	1.6177	0.2343	
Biomass (mg/m <sup>3</sup> )	LTPR	7/14/89	1	14:00	0.0027	14.2918	0.4532		10.5062		0.2417	0.0765	19.3126	0.889	44.8848	
Biomass (mg/m <sup>3</sup> )	LTPR	7/14/89	2	14:00	0.002	2.8681	1.2019		23.8975	0.2242	0.1383	0.4313	8.4318		37.195	
Density (#/m <sup>3</sup> )	LTPR	7/14/89	1	14:00	0.2667	1621.33	13.0667		1450.6700		4.2667	256	23551.5774	0.2667	26897.3813	DIA=chydoridae, LGB=araneida
Density (#/m <sup>3</sup> )	LTPR	7/14/89	2	14:00	2.1333	230.4	34.1333		2005.3300	4.2667	2.1333	512	10282.5303		13072.8416	DIA=141
Mean size (mm)	LTPR	7/14/89	1	14:00	0.5806	0.2897	0.8246		0.4574		1.0067	0.1471	0.0841	1.0864	0.1178	
Mean size (mm)	LTPR	7/14/89	2	14:00	0.2636	0.3389	0.7866		0.5413	0.9795	1.062	0.2098	0.1088		0.1854	
Biomass (mg/m <sup>3</sup> )	LTPR	8/30/89	1	16:00		17.1439	0.0532		5.2196		0.0449	0.0706	11.4144	0.0382	33.9465	
Biomass (mg/m <sup>3</sup> )	LTPR	8/30/89	2	16:30		4.791	0.0221		8.3167			0.1176	2.46	0.1132	15.7074	
Density (#/m <sup>3</sup> )	LTPR	8/30/89	1	16:00		2933.33	0.5333		640.0000		1.0667	266.67	13919.704	0.5333	17761.9237	LGB=450
Density (#/m <sup>3</sup> )	LTPR	8/30/89	2	16:30		546.67	0.5333		506.6700			226.67	3000	0.2667	4280.8	LGB=450
Mean size (mm)	LTPR	8/30/89	1	16:00		0.2422	1.2412		0.4864		0.9006	0.1389	0.0881	0.302	0.1287	
Mean size (mm)	LTPR	8/30/89	2	16:30		0.2871	0.8907		0.6134			0.1776	0.1308	0.5465	0.2105	
Biomass (mg/m <sup>3</sup> )	LTPR	10/2/89	1	16:30		1.2859	0.2506		1.2970		0.1131	0.0153	0.6997	4.8288	3.6616	
Biomass (mg/m <sup>3</sup> )	LTPR	10/2/89	2	16:15	0.0021	5.2504	0.0398		5.7597		0.1522	0.1108	3.7173	0.2904	15.0323	
Density (#/m <sup>3</sup> )	LTPR	10/2/89	1	16:30		140.95	1.3333		83.8095		3.4667	68.5714	853.33	0.2667	1151.73	LGB=900
Density (#/m <sup>3</sup> )	LTPR	10/2/89	2	16:15	0.2667	480	0.2667		266.6700		2.6667	231.11	4533.33	0.5333	5514.84	LGB=900
Mean size (mm)	LTPR	10/2/89	1	16:30		0.2992	1.3976		0.5983		0.8208	0.1308	0.0919	1.9079	0.1605	
Mean size (mm)	LTPR	10/2/89	2	16:15	0.5313	0.3268	1.4196		0.6890		1.0023	0.1745	0.1448	0.5927	0.1888	
Biomass (mg/m <sup>3</sup> )	LTPR	6/10/90	1	9:00	0.0088	0.6477			7.1704			0.7713	0.0875	22.1156	8.6857	
Biomass (mg/m <sup>3</sup> )	LTPR	6/10/90	2	9:30		0.0391	0.152		6.3789			0.4287	0.123	41.3774	7.1217	
Density (#/m <sup>3</sup> )	LTPR	6/10/90	1	9:00	0.2667	73.3333			693.3300			1220	106.67	1.6	2095.2	DIA=araneida (spider), LGB=900
Density (#/m <sup>3</sup> )	LTPR	6/10/90	2	9:30		0.8	2.1333		330.0000			710	150	0.5333	1193.47	LGB=900
Mean size (mm)	LTPR	6/10/90	1	9:00	0.8602	0.2967			0.4948			0.1905	0.1097	1.6379	0.292	
Mean size (mm)	LTPR	6/10/90	2	9:30		0.6508	1.0647		0.6124			0.1876	0.1063	3.0567	0.298	
Biomass (mg/m <sup>3</sup> )	LTPR	7/17/90	1	14:30		3.0171			72.4953			0.1825	0.1166		75.8115	
Biomass (mg/m <sup>3</sup> )	LTPR	7/17/90	2	14:00		3.5781			72.0216			1.0917	0.5029	13.8463	22.19	
Density (#/m <sup>3</sup> )	LTPR	7/17/90	1	14:30		337.78			4960.0000			248.89	142.22		5688.89	

## Appendix 4 cont'd.

Property	Lake	Date	Site	Time	DIA	BOS	DPH	HOL	CYC	CAL	DPT	NP	ROT	LGB	TOT	Comments
Density (#/m <sup>3</sup> )	LTPR	7/17/90	2	14:00		293.33			5813.3300			906.67	613.33	0.5333	7627.2	
Mean size (mm)	LTPR	7/17/90	1	14:30		0.2923			0.5822			0.2027	0.101		0.5364	
Mean size (mm)	LTPR	7/17/90	2	14:00		0.3373			0.5408			0.2232	0.1082	2.1534	0.46	
Biomass (mg/m3)	LTPR	9/4/90	1	14:50	0.0022	8.9589	0.0571	0.0009	3.8287			0.0567	1.0204	0.2678	13.925	
Biomass (mg/m3)	LTPR	9/4/90	2	13:50	0.0014	8.658	0.12		3.8113			0.068	1.2318	0.7512	13.8905	
Density (#/m <sup>3</sup> )	LTPR	9/4/90	1	14:50	0.5333	951.11	1.6	0.2667	204.4400			222.22	1244.44	0.5333	2625.16	
Density (#/m <sup>3</sup> )	LTPR	9/4/90	2	13:50	0.8	942.22	3.2		186.6700			160	1502.22	0.5333	2795.64	DIA=141, LGB=900
Mean size (mm)	LTPR	9/4/90	1	14:50	0.4321	0.3042	0.8772	0.4103	0.6028			0.1341	0.1008	0.5409	0.2171	
Mean size (mm)	LTPR	9/4/90	2	13:50	0.319	0.302	0.8827		0.6727			0.1615	0.1021	0.8078	0.2121	
Biomass (mg/m3)	LTPR	10/2/90	1			2.37	0.0394		0.6671			0.0696	0.6524	2.0479	3.7985	
Biomass (mg/m3)	LTPR	10/2/90	2	13:30		1.7829	0.2636		1.8044			0.0254	0.2962	4.7691	4.1725	
Density (#/m <sup>3</sup> )	LTPR	10/2/90	1			248.89	1.0667		44.4444			240	795.56	0.8	1330.76	LGB=900
Density (#/m <sup>3</sup> )	LTPR	10/2/90	2	13:30		172.12	8.2667		92.1212			101.82	361.21	0.5333	736.07	LGB=900
Mean size (mm)	LTPR	10/2/90	1			0.3069	0.8858		0.6055			0.1422	0.1016	0.8191	0.1652	
Mean size (mm)	LTPR	10/2/90	2	13:30		0.3165	0.8281		0.6608			0.1341	0.0933	1.3627	0.2313	
Biomass (mg/m3)	LTPR	6/19/91	1	8:00		0.5257			61.1518				10.7584	0.8379	72.4358	
Biomass (mg/m3)	LTPR	6/19/91	2	8:00		0.1077			30.0741		0.0211	0.217	5.7145	6.2896	36.1345	
Density (#/m <sup>3</sup> )	LTPR	6/19/91	1	8:00		53.3333			4480.0000				13119.8841	1.0667	17654.2796	LGB=900
Density (#/m <sup>3</sup> )	LTPR	6/19/91	2	8:00		35.5556			3448.8900		0.5333	320	6968.89	1.0667	10774.8194	LGB=900
Mean size (mm)	LTPR	6/19/91	1	8:00		0.3132			0.5601				0.0994	0.671	0.217	
Mean size (mm)	LTPR	6/19/91	2	8:00		0.1823			0.4930		0.8868	0.1891	0.1378	1.3137	0.2533	
Biomass (mg/m3)	LTPR	7/22/91	1	9:45		1.9603			31.5551			0.0144	2.0603		35.5902	
Biomass (mg/m3)	LTPR	7/22/91	2	9:00		0.6276			24.5511			0.0439	7.4638		32.6863	
Density (#/m <sup>3</sup> )	LTPR	7/22/91	1	9:45		237.04			2275.5600			23.7037	2512.59		5048	
Density (#/m <sup>3</sup> )	LTPR	7/22/91	2	9:00		71.1111			1635.5600			106.67	9102.22		10915.4087	
Mean size (mm)	LTPR	7/22/91	1	9:45		0.283			0.5778			0.1921	0.1074		0.328	
Mean size (mm)	LTPR	7/22/91	2	9:00		0.2956			0.5879			0.1622	0.129		0.1992	
Biomass (mg/m3)	LTPR	8/28/91	1	19:00		69.2361	0.003	0.003	53.5657			0.1774	10.8634	0.1682	134.01	
Biomass (mg/m3)	LTPR	8/28/91	2	19:30		16.4119			1.4105			0.0086	4.3873		22.2184	
Density (#/m <sup>3</sup> )	LTPR	8/28/91	1	19:00		11455.9207	0.32	0.32	2432.0000			512	13247.9903	0.32	27648.3997	DPH=141, LGB=180, HOL=180
Density (#/m <sup>3</sup> )	LTPR	8/28/91	2	19:30		3148.8			81.2800			51.2	5350.4		8631.68	
Mean size (mm)	LTPR	8/28/91	1	19:00		0.2454	0.5693	0.2773	0.6991			0.1538	0.1099	0.5869	0.2187	
Mean size (mm)	LTPR	8/28/91	2	19:30		0.2274			0.6389			0.1194	0.0958		0.149	
Biomass (mg/m3)	LTPR	10/6/91	1	12:30		4.5028			0.5384			0.0267	0.4155		5.4833	
Biomass (mg/m3)	LTPR	10/6/91	2			3.2505	0.0039		0.6025			0.0405	0.6305	2.358	4.5278	
Density (#/m <sup>3</sup> )	LTPR	10/6/91	1	12:30		613.33			46.6667			120	506.67		1286.67	
Density (#/m <sup>3</sup> )	LTPR	10/6/91	2			426.67	0.5333		45.3333			133.33	786.89	0.5333	1375.29	LGB=900, DPH=180
Mean size (mm)	LTPR	10/6/91	1	12:30		0.2705			0.5540			0.1273	0.0728		0.1896	
Mean size (mm)	LTPR	10/6/91	2			0.2754	0.5195		0.5746			0.1431	0.1031	1.1936	0.1765	
Biomass (mg/m3)	LTPR	6/19/93	1	14:00	0.0006	0.7894	0.0226		3.8629		0.0436	0.2703	0.6706	23.3964	5.66	
Biomass (mg/m3)	LTPR	6/19/93	2	14:30	0.0022	0.2403	0.0393		17.7434		0.0757	0.4073	0.8965	32.6699	19.4046	
Density (#/m <sup>3</sup> )	LTPR	6/19/93	1	14:00	0.2667	44.4444	0.8		248.8900		0.5333	453.33	817.78	0.8	1566.84	LGB=900, DIA=141
Density (#/m <sup>3</sup> )	LTPR	6/19/93	2	14:30	0.2667	26.6667	1.6		1253.3300		0.5333	533.33	1093.33	1.8667	2910.93	LGB=900, DIA=141
Mean size (mm)	LTPR	6/19/93	1	14:00	0.353	0.4019	0.7848		0.5663		1.155	0.1852	0.1173	1.8016	0.2179	
Mean size (mm)	LTPR	6/19/93	2	14:30	0.5432	0.3005	0.7534		0.5445		1.4034	0.2042	0.1187	1.6578	0.321	
Biomass (mg/m3)	LTPR	7/29/93	1			4.2258	0.043		13.0216	0.963	0.1636		0.0984	0.6735	18.5155	Sample full of rotifers
Biomass (mg/m3)	LTPR	7/29/93	2			1.3023	0.0025		31.2311			0.1032	0.328	8.9571	32.9671	
Density (#/m <sup>3</sup> )	LTPR	7/29/93	1			680	1.3333		600.0000	1.3333	3.4667		120	0.2667	1406.4	LGB=900, CAL=020,
Density (#/m <sup>3</sup> )	LTPR	7/29/93	2			186.67	0.2667		2213.3300			240	400	0.8	3041.07	LGB=900
Mean size (mm)	LTPR	7/29/93	1			0.2497	0.8389		0.6888	2.5533	0.9366		0.1327	0.9904	0.4316	
Mean size (mm)	LTPR	7/29/93	2			0.2626	0.5672		0.5805			0.1658	0.1029	1.5839	0.4657	
Biomass (mg/m3)	LTPR	9/8/93	1			58.814	0.2392		1.2530		0.117	0.0494	4.3733	10.2885	64.846	

## Appendix 4 cont'd.

Property	Lake	Date	Site	Time	DIA	BOS	DPH	HOL	CYC	CAL	DPT	NP	ROT	LGB	TOT	Comments
Biomass (mg/m3)	LTPR	9/8/93	2			49.3471	0.0586		2.8258		0.1721	0.4225	7.872	19.5341	60.6981	
Density (#/m <sup>3</sup> )	LTPR	9/8/93	1			8747.38	21.3333		91.7333		4.9778	213.33	5333.33	2.8444	14414.8458	LGB=900
Density (#/m <sup>3</sup> )	LTPR	9/8/93	2			7253.33	4.2667		168.5300		8.5333	853.33	9600	4.2667	17892.0458	LGB=900
Mean size (mm)	LTPR	9/8/93	1			0.2596	0.5863		0.5577		0.7307	0.1348	0.1144	0.9909	0.2067	
Mean size (mm)	LTPR	9/8/93	2			0.2606	0.6297		0.6297		0.6867	0.1752	0.1435	1.1652	0.1975	
Biomass (mg/m3)	LTPR	6/19/94	1	7:00		0.2755	0.0111		35.9837			0.3642	5.7728	285.3	42.41	
Biomass (mg/m3)	LTPR	6/19/94	2	8:00		0.8742	0.0481		31.3093			0.2088	3.7611	57.8744	36.2015	
Density (#/m <sup>3</sup> )	LTPR	6/19/94	1	7:00		17.0667	2.1333		1920.0000			213.33	7040	3.2	9195.73	LGB=900
Density (#/m <sup>3</sup> )	LTPR	6/19/94	2	8:00		53.3333	2.1333		2453.3300			213.33	4586.67	4.2667	7313.07	LGB=900
Mean size (mm)	LTPR	6/19/94	1	7:00		0.3896	0.4651		0.6388			0.2589	0.1357	2.8712	0.2451	
Mean size (mm)	LTPR	6/19/94	2	8:00		0.3954	0.7382		0.5455			0.2269	0.1248	1.6682	0.272	
Biomass (mg/m3)	LTPR	7/23/94	1	14:45		4.3284	0.6663		44.2791			0.0119	0.8528		50.1385	
Biomass (mg/m3)	LTPR	7/23/94	2	16:00		35.4347	5.0869		178.8700			0.1802	6.1227		225.69	
Density (#/m <sup>3</sup> )	LTPR	7/23/94	1	14:45		213.33	13.8667		1813.3300			26.6667	1040		3107.2	
Density (#/m <sup>3</sup> )	LTPR	7/23/94	2	16:00		2880	145.07		5866.6700			213.33	7466.67		16571.4305	
Mean size (mm)	LTPR	7/23/94	1	14:45		0.4303	0.9403		71.9300			0.1716	0.2159		0.5273	
Mean size (mm)	LTPR	7/23/94	2	16:00		0.3315	0.8428		0.7732			0.2129	0.1861		0.4253	
Biomass (mg/m3)	LTPR	9/9/94	1	14:00		91.6536	2.1069		7.1230		5.8486	0.1324	12.1579		119.02	
Biomass (mg/m3)	LTPR	9/9/94	2	14:20	0.0256	12.4204	1.9183	0.0577	7.8278			0.0771	0.7081		23.0351	
Density (#/m <sup>3</sup> )	LTPR	9/9/94	1	14:00		8853.33	179.2		0.7256		166.4	213.33	14826.5464		24532.9628	
Density (#/m <sup>3</sup> )	LTPR	9/9/94	2	14:20	4.2667	1015.87	162.13	4.2667	223.4900			101.59	863.49		2375.11	
Mean size (mm)	LTPR	9/9/94	1	14:00		0.3162	0.5971		0.7256		0.8102	0.1921	0.1474		0.2234	
Mean size (mm)	LTPR	9/9/94	2	14:20	0.4884	0.34	0.5887	0.6394	0.8174			0.2072	0.1406		0.3245	
Biomass (mg/m3)	LTPR	7/24/95	1	9:50		0.0122	0.0559		29.1352			0.3469	0.3717		29.922	
Biomass (mg/m3)	LTPR	7/24/95	2			0.0164	0.0309		1.6497			0.0191	0.0276		1.7438	
Density (#/m <sup>3</sup> )	LTPR	7/24/95	1	9:50		1.0667	4.2667		1520.0000			280	453.33		2258.67	
Density (#/m <sup>3</sup> )	LTPR	7/24/95	2			1.6	2.6667		88.0000			25.6	33.6		151.47	
Mean size (mm)	LTPR	7/24/95	1	9:50		0.3354	0.6166		0.6552			0.2466	0.1602		0.505	
Mean size (mm)	LTPR	7/24/95	2			0.3135	0.5911		0.6491			0.2019	0.2142		0.4725	
Biomass (mg/m3)	LTPR	9/14/95	1	14:37		10.1035	2.0261		18.5735			0.9644	1.5416		33.2091	
Biomass (mg/m3)	LTPR	9/14/95	2			2.7816	0.7681		0.5510			0.4401	3.3784		7.9191	
Density (#/m <sup>3</sup> )	LTPR	9/14/95	1	14:37		880	90		880.0000			1100	1880		4830	haul depth 15m
Density (#/m <sup>3</sup> )	LTPR	9/14/95	2			240	61.6		32.8000			640	4120		5094.4	haul depth 15m
Mean size (mm)	LTPR	9/14/95	1	14:37		0.3294	0.7315		0.6706			0.2151	0.155		0.3051	
Mean size (mm)	LTPR	9/14/95	2			0.3318	0.6033		0.6226			0.1959	0.1357		0.1613	
Biomass (mg/m3)	TATS	8/31/87	Trans 3			52.638	101.47		352.2400			11.0202	3.6526		521.02	
Biomass (mg/m3)	TATS	8/31/87	Trans 6													
Density (#/m <sup>3</sup> )	TATS	8/31/87	Trans 3			1152	1938.77		6502.4000			14438.0985	4454.4		28485.9036	
Density (#/m <sup>3</sup> )	TATS	8/31/87	Trans 6													
Mean size (mm)	TATS	8/31/87	Trans 3			0.6229	0.9719		0.9108			0.2039	0.171		0.4293	
Mean size (mm)	TATS	8/31/87	Trans 6													
Biomass (mg/m3)	TATS	7/22/88	1	9:30		104	43.4572		311.4000			2.9555	4.9661	207.37	466.75	
Biomass (mg/m3)	TATS	7/22/88	2	10:30		94.5558	12.7863		151.7400			1.0868	1.968	87.9957	262.1343	
Density (#/m <sup>3</sup> )	TATS	7/22/88	1	9:30		3136	1408		11903.9200			2560	6016	1.28	25024.7645	LGB=900
Density (#/m <sup>3</sup> )	TATS	7/22/88	2	10:30		2848	448		6464.0000			896	2400	0.64	13056.597	LGB=900
Mean size (mm)	TATS	7/22/88	1	9:30		0.5357	0.7926		0.7213			0.2415	0.1759	3.7255	0.522	
Mean size (mm)	TATS	7/22/88	2	10:30		0.537	0.6784		0.6962			0.2454	0.1742	3.7446	0.5341	
Biomass (mg/m3)	TATS	8/22/88	1	12:20		60.432	13.2027		98.2797			2.2928	1.277	62.3783	175.4817	
Biomass (mg/m3)	TATS	8/22/88	2	11:30		52.4971	22.5871		95.0346			2.6754	0.9971		173.79	
Density (#/m <sup>3</sup> )	TATS	8/22/88	1	12:20		1557.33	725.33		3648.0000			1834	1557.33	0.32	9322.99	LGB=900
Density (#/m <sup>3</sup> )	TATS	8/22/88	2	11:30		1408	746.67		3733.3300			2026.67	1216		9130.67	
Mean size (mm)	TATS	8/22/88	1	12:20		0.5739	0.6756		0.7407			0.2486	0.1759	4.2167	0.5167	

## Appendix 4 cont'd.

Property	Lake	Date	Site	Time	DIA	BOS	DPH	HOL	CYC	CAL	DPT	NP	ROT	LGB	TOT	Comments
Mean size (mm)	TATS	8/22/88	2	11:30		0.5654	0.7733		0.7175			0.2536	0.1782		0.5238	
Biomass (mg/m3)	TATS	9/24/88	1	19:00		40.346	64.7678	0.0055	210.6300	0.8921	1.8927	2.1042	1.0496	44.5739	321.6861	
Density (#/m <sup>3</sup> )	TATS	9/24/88	1	19:00		1152	1600	0.32	7264.0000	32.32	32	1440	1280	0.32	12800.8851	LGB=900
Mean size (mm)	TATS	9/24/88	1	19:00		0.5508	0.8965	0.6904	0.7507	0.6601	1.027	0.2632	0.1803	3.7698	0.6396	
Biomass (mg/m3)	TATS	6/8/89	1	11:00		2.4167	9.2954		249.0200			1.8949	2.2042		264.83	
Biomass (mg/m3)	TATS	6/8/89	2	11:30		11.9213	21.4037		413.3300			2.7401	2.4491	203.53	451.84	
Density (#/m <sup>3</sup> )	TATS	6/8/89	1	11:00		192	192		12735.9105			5632	2688		21439.764	
Density (#/m <sup>3</sup> )	TATS	6/8/89	2	11:30		597.33	597.33		16981.2635			7168	2986.67	2.56	28332.8329	LGB=900
Mean size (mm)	TATS	6/8/89	1	11:00		0.3363	0.8886		0.6414			0.1496	0.0902		0.4426	
Mean size (mm)	TATS	6/8/89	2	11:30		0.4167	0.7872		0.7081			0.1587	0.1203	3.1223	0.5029	
Biomass (mg/m3)	TATS	7/13/89	1	11:40		232.63	84.9644		254.0300			4.4563	17.4234		593.5	
Biomass (mg/m3)	TATS	7/13/89	2	11:20		7.9011	17.6661		85.9659			3.0146	6.1716		120.72	
Density (#/m <sup>3</sup> )	TATS	7/13/89	1	11:40		7168	2944		8192.0000			11903.92	21247.6058		51455.2864	
Density (#/m <sup>3</sup> )	TATS	7/13/89	2	11:20		307.2	512		2662.4000			5580.8	7526.4		16588.6101	
Mean size (mm)	TATS	7/13/89	1	11:40		0.523	0.7474		0.4574			0.1555	0.0896		0.3091	
Mean size (mm)	TATS	7/13/89	2	11:20		0.4812	0.732		0.7610			0.18	0.1172		0.2674	
Biomass (mg/m3)	TATS	8/30/89	1	11:50		33.9275	94.9818		174.3500			3.2493	6.4375		312.94	
Density (#/m <sup>3</sup> )	TATS	8/30/89	2	11:20		127.65	112.63		86.0279	0.525		4.113	8.4668		339.41	
Density (#/m <sup>3</sup> )	TATS	8/30/89	1	11:50		1024	2389.33		5034.6700			9898.67	7850.67		14068.5714	
Density (#/m <sup>3</sup> )	TATS	8/30/89	2	11:20		3413.33	3242.67		2304.0000	1.28		11775.7886	10325.2363		31062.0418	CAL=020
Mean size (mm)	TATS	8/30/89	1	11:50		0.5381	0.8792		0.7936			0.1469	0.0965		0.3382	
Mean size (mm)	TATS	8/30/89	2	11:20		0.5632	0.8454		0.7949	2.0847		0.1528	0.1247		0.3086	
Biomass (mg/m3)	TATS	10/4/89	1	15:00		5.4015	28.2782		44.1322			0.9815	2.54		81.3334	
Biomass (mg/m3)	TATS	10/4/89	2	14:45		38.8386	198.55		107.0000			2.0393	3.6946		350.12	
Density (#/m <sup>3</sup> )	TATS	10/4/89	1	15:00		147.2	486.4		1408.0000			2432	3097.6		7571.2	
Density (#/m <sup>3</sup> )	TATS	10/4/89	2	14:45		921.6	3132.2		2560.0000			4403.2	4505.6		15513.5075	
Mean size (mm)	TATS	10/4/89	1	15:00		0.5641	1.0229		0.7471			0.1586	0.095		0.3054	
Mean size (mm)	TATS	10/4/89	2	14:45		0.5994	1.0567		0.8326			0.1697	0.1276		0.471	
Biomass (mg/m3)	TATS	6/8/90	1	13:50		1.5433	4.7243		92.2893			2.2629	1.207		102.03	
Biomass (mg/m3)	TATS	6/8/90	2	13:30		5.5715	4.1399		30.8883			1.934	1.9243	5.2663	44.4581	
Density (#/m <sup>3</sup> )	TATS	6/8/90	1	13:50		51.2	212.48		3200.0000			7072	1472		12007.4282	
Density (#/m <sup>3</sup> )	TATS	6/8/90	2	13:30		192	116.48		1173.3300			3477.33	2346.67	2.56	7308.37	LGB= 900>1.5mm & ostracod< 0.6mm
Mean size (mm)	TATS	6/8/90	1	13:50		0.5012	0.6611		0.7602			0.1476	0.0924		0.3147	
Mean size (mm)	TATS	6/8/90	2	13:30		0.493	0.7331		0.7202			0.1804	0.0987	0.8301	0.2581	
Biomass (mg/m3)	TATS	7/15/90	1	10:15		143.63	37.4739		84.8700			2.5302	13.183		281.68	
Biomass (mg/m3)	TATS	7/15/90	2	10:00		59.3212	11.1126		48.3389			2.5228	7.3997		128.7	
Density (#/m <sup>3</sup> )	TATS	7/15/90	1	10:15		5222.4	1241.03		6348.8000			6144	16076.4443		35032.4088	
Density (#/m <sup>3</sup> )	TATS	7/15/90	2	10:00		1856	448		3008.0000			5312	9024		19647.6223	
Mean size (mm)	TATS	7/15/90	1	10:15		0.4874	0.7717		52.9900			0.1589	0.101		0.2702	
Mean size (mm)	TATS	7/15/90	2	10:00		0.5209	0.7126		0.5811			0.1691	0.0998		0.246	
Biomass (mg/m3)	TATS	9/8/90	2	14:17		13.9349	64.7186		64.7186			3.6857	1.5114	0.0723	138.99	
Density (#/m <sup>3</sup> )	TATS	9/8/90	2	14:17		409.6	1382.4		2355.2000			10854.2545	1843.2	0.64	16845.3485	LGB=UNK INSECT (HEAD WIDTH)
Mean size (mm)	TATS	9/8/90	2	14:17		0.5383	0.701		0.7010			0.1504	0.097	0.3516	0.2889	
Biomass (mg/m3)	TATS	10/2/90	1	12:40		28.8685	125.09		126.0900			0.6529	2.3791		283.08	
Density (#/m <sup>3</sup> )	TATS	10/2/90	1	12:40		896	3200		4949.3300			1877.33	2901.33		13823.8814	
Mean size (mm)	TATS	10/2/90	1	12:40		0.5311	0.8907		0.6916			0.1517	0.1095		0.5318	
Biomass (mg/m3)	TATS	6/22/91	1			0.8155	3.1401		293.4100			1.0572	0.035	95.5878	298.4622	
Density (#/m <sup>3</sup> )	TATS	6/22/91	1			58.3333	82.56		8661.3300			4266.67	42.6667	1.28	13139.8377	LGB=900
Mean size (mm)	TATS	6/22/91	1			0.3084	0.7565		0.8092			0.1331	0.0874	3.0591	0.584	
Biomass (mg/m3)	TATS	7/15/91	1			45.0595	33.7417		270.5100		207.6	0.943	4.3783		562.24	
Density (#/m <sup>3</sup> )	TATS	7/15/91	1			2267.43	768		7972.5700		3218.29	2779.43	5339.43		22344.9815	
Mean size (mm)	TATS	7/15/91	1			0.4221	0.9127		0.8021		1.0515	0.1518	0.1015		0.555	

## Appendix 4 cont'd.

Property	Lake	Date	Site	Time	DIA	BOS	DPH	HOL	CYC	CAL	DPT	NP	ROT	LGB	TOT	Comments
Biomass (mg/m3)	TATS	8/17/91	1	17:00		499.51	12.9444		138.3700			1.5172	5.6678		658.01	
Density (#/m <sup>3</sup> )	TATS	8/17/91	1	17:00		15999.6322	576		6784.0000			8448	6912		38719.5231	
Mean size (mm)	TATS	8/17/91	1	17:00		0.5197	0.7088		0.6350			0.1185	0.097		0.3797	
Biomass (mg/m3)	TATS	9/15/91	1			13.9574	12.8683		250.3500			1.4212	2.2042		280.8	
Density (#/m <sup>3</sup> )	TATS	9/15/91	1			448	393.61		6144.0000			6784	2688		16457.3536	
Mean size (mm)	TATS	9/15/91	1			0.5241	0.8015		0.8273			0.1273	0.0777		0.4075	
Biomass (mg/m3)	TATS	6/22/92	1			69.7674	77.7684		132.9600			4.9503	1.0196		286.47	
Biomass (mg/m3)	TATS	6/22/92	2			20.4519	1.424		44.5886			1.2995	0.3849	58.2157	68.1443	
Density (#/m <sup>3</sup> )	TATS	6/22/92	1			2852.57	1536		6509.7100			10971.3482	1243.43		23112.6637	
Density (#/m <sup>3</sup> )	TATS	6/22/92	2			896	83.2		1962.6700			2005.33	469.33	1.28	5417.81	LGB=900
Mean size (mm)	TATS	6/22/92	1			0.455	0.8493		0.6574			0.1667	0.0882		0.3816	
Mean size (mm)	TATS	6/22/92	2			0.4493	0.6079		0.6846			0.1885	0.1017	2.5959	0.4108	
Biomass (mg/m3)	TATS	8/2/92	1			39.5791	35.163		225.8900			2.694	0.5598		303.89	
Biomass (mg/m3)	TATS	8/2/92	2			194.51	92.4346		163.8300			4.8911	1.9942	664.28	457.66	
Density (#/m <sup>3</sup> )	TATS	8/2/92	1			1792	2474.67		6656.0000			3584	682.67		15189.0286	
Density (#/m <sup>3</sup> )	TATS	8/2/92	2			7552	2816		5632.0000			9984	2432	3.36	28419.079	LGB=900
Mean size (mm)	TATS	8/2/92	1			0.4429	0.6098		0.7878			0.1964	0.1052		0.5479	
Mean size (mm)	TATS	8/2/92	2			0.4738	0.7831		0.7279			0.1709	0.1094	4.0191	0.4176	
Biomass (mg/m3)	TATS	8/22/92	1			44.1607	56.1898		116.8200			1.7573	2.0467	269.91	220.97	
Biomass (mg/m3)	TATS	8/22/92	2			129.24	129.9		112.5600			3.1742	3.1068	468.23	377.98	
Density (#/m <sup>3</sup> )	TATS	8/22/92	1			1280	1920		3328.0000			4544	2496	1.28	13569.0674	LGB=900
Density (#/m <sup>3</sup> )	TATS	8/22/92	2			3379.2	3891.2		5017.6000			8601.6	3788.8	2.56	24680.8436	
Mean size (mm)	TATS	8/22/92	1			0.549	0.8076		0.7977			0.1578	0.0926	4.3286	0.432	
Mean size (mm)	TATS	8/22/92	2			0.5745	0.8334		0.6616			0.1563	0.0912	4.1281	0.4135	
Biomass (mg/m3)	TATS	9/28/92	1			143.48	142.17		274.8400			2.8973	3.0438		566.42	
Biomass (mg/m3)	TATS	9/28/92	2			51.8297	45.2997		95.7601			1.1245	1.4095		195.42	
Density (#/m <sup>3</sup> )	TATS	9/28/92	1			3712	2688		6144.0000			8192	3712		24447.8122	
Density (#/m <sup>3</sup> )	TATS	9/28/92	2			1316.57	877.71		2596.5700			2157.71	1718.86		8667.43	
Mean size (mm)	TATS	9/28/92	1			0.5702	0.9795		0.8732			0.1512	0.0909		0.4782	
Mean size (mm)	TATS	9/28/92	2			0.5771	0.9738		0.8015			0.1753	0.0997		0.4898	
Biomass (mg/m3)	TATS	6/19/93	1	20:30		91.2747	2.3042		205.7800			4.0126	10.496	88.1341	313.8659	
Density (#/m <sup>3</sup> )	TATS	6/19/93	1	20:30		4224	76.8		11263.9315			6400	12799.7062	1.28	34765.6217	LGB=900
Mean size (mm)	TATS	6/19/93	1	20:30		0.4308	0.7757		0.6165			0.1893	0.0929	2.9807	0.323	
Biomass (mg/m3)	TATS	8/2/93	1			130.72	99.8252		165.4800			1.4945	5.5629	119.83	403.08	
Biomass (mg/m3)	TATS	8/2/93	2			87.283	51.6054		74.0545			0.9447	6.2276		220.12	
Density (#/m <sup>3</sup> )	TATS	8/2/93	1			4736	2432		7296.0000			5120	6784	1.28	26368.7778	LGB=900
Density (#/m <sup>3</sup> )	TATS	8/2/93	2			3498.67	2730.67		4266.6700			3328	7594.67		21418.5467	
Mean size (mm)	TATS	8/2/93	1			0.493	0.843		0.6814			0.1426	0.0892	3.3021	0.4056	
Mean size (mm)	TATS	8/2/93	2			0.4714	0.6672		0.6143			0.1402	0.0883		0.3375	
Biomass (mg/m3)	TATS	9/15/93	1			7.0765	42.3251		133.1000			1.7884	0.5878		184.88	
Biomass (mg/m3)	TATS	9/15/93	2			32.4053	141.81		105.8800			1.7959	2.4491		284.35	
Density (#/m <sup>3</sup> )	TATS	9/15/93	1			256	1484.8		3840.0000			4505.6	716.8		10803.1399	
Density (#/m <sup>3</sup> )	TATS	9/15/93	2			1024	4693.33		3498.6700			7680	2986.67		19882.4546	
Mean size (mm)	TATS	9/15/93	1			0.4944	0.7911		0.7819			0.1596	0.0903		0.4709	
Mean size (mm)	TATS	9/15/93	2			0.5291	0.7985		0.7459			0.1305	0.0856		0.4103	
Biomass (mg/m3)	TATS	6/17/94	1			1.3517	0.0646		7.5935			0.2403	0.2617	124.76	9.51	
Biomass (mg/m3)	TATS	6/17/94	2			115.97	4.1209		122.7900			1.2067	0.2099	11.9359	256.23	
Density (#/m <sup>3</sup> )	TATS	6/17/94	1			52.5253	1.3333		210.1000			222.22	319.19	3.5556	808.93	LGB=900
Density (#/m <sup>3</sup> )	TATS	6/17/94	2			4032	51.2		5184.0000			1216	256	1.28	10740.3887	LGB=900
Mean size (mm)	TATS	6/17/94	1			0.4772	0.9581		0.7903			0.2307	0.1537	2.1007	0.3711	
Mean size (mm)	TATS	6/17/94	2			0.4917	1.0915		0.6935			0.2269	0.115	1.5307	0.5531	
Biomass (mg/m3)	TATS	6/18/94	1				0.0571		448.3500		0.1219	1.3786	2.3091		452.22	

## Appendix 4 cont'd.

Property	Lake	Date	Site	Time	DIA	BOS	DPH	HOL	CYC	CAL	DPT	NP	ROT	LGB	TOT	Comments
Density (#/m <sup>3</sup> )	TATS	6/18/94	1				1.28		24319.8001		1.28	1280	2816		28418.4247	
Mean size (mm)	TATS	6/18/94	1				0.9502		0.6303		1.2227	0.2323	0.1371		0.5636	
Biomass (mg/m3)	TATS	7/26/94	1	16:20		165.49	22.0104		240.9900			3.1095	16.3738		447.97	
Biomass (mg/m3)	TATS	7/26/94	2	18:00		238.36	8.434		261.2000			3.2125	18.8928		530.12	
Density (#/m <sup>3</sup> )	TATS	7/26/94	1	16:20		3840	451.28		66.5600			5504	19967.79		36419.1663	
Density (#/m <sup>3</sup> )	TATS	7/26/94	2	18:00		5760	225.64		6912.0000			5376	23039.8687		41313.3108	
Mean size (mm)	TATS	7/26/94	1	16:20		0.6048	0.8935		0.7920			0.1795	0.1183		0.3116	
Mean size (mm)	TATS	7/26/94	2	18:00		0.5929	0.832		0.8100			0.1865	0.1255		0.317	
Biomass (mg/m3)	TATS	9/14/94	1			7.0053	20.1878		171.4000			12.0058	1.5219		212.12	
Biomass (mg/m3)	TATS	9/14/94	2			47.1271	96.596		143.0800			8.3754	1.4694		296.65	
Density (#/m <sup>3</sup> )	TATS	9/14/94	1			128	432		3712.0000			16575.6283	1856		22703.8757	
Density (#/m <sup>3</sup> )=10	TATS	9/14/94	2			938.67	2304		3925.3300			11263.9315	1792		20223.6714	
Mean size (mm)	TATS	9/14/94	1			0.6836	0.9267		0.8854			0.2005	0.1168		0.3222	
Mean size (mm)	TATS	9/14/94	2			0.6519	0.8892		0.7761			0.202	0.113		0.4047	
Biomass (mg/m3)	TATS	7/18/95	1	13:00		94.4762	46.0219		335.2900			2.2723	9.6563		487.71	
Biomass (mg/m3)	TATS	7/18/95	2			72.993	26.7999		0.1037			1.0364	1.312	1144.59	178.24	
Density (#/m <sup>3</sup> )	TATS	7/28/95	1	13:00		2304	2432		7424.0000			4992	11775.7886		28927.4399	
Density (#/m <sup>3</sup> )	TATS	7/28/95	2			1920	1216		2304.0000			2624	1600	1.28	9665.28	LGB=900
Mean size (mm)	TATS	7/28/95	1	13:00		0.5775	0.6822		0.8621			0.1652	0.129		0.4056	
Mean size (mm)	TATS	7/28/95	2			0.5727	0.696		0.7662			0.1594	0.1405	6.4081	0.4514	
Biomass (mg/m3)	TATS	9/19/95	1			26.8365	55.1778		167.7400			2.926	1.207		253.89	
Biomass (mg/m3)	TATS	9/19/95	2			24.7829	110.41		54.4639			1.6699	1.0496		192.37	
Density (#/m <sup>3</sup> )	TATS	9/19/95	1			640	768		2560.0000			5568	1472		11007.7866	
Density (#/m <sup>3</sup> )	TATS	9/19/95	2			576	1664		1792.0000			2944	1280		8256	
Mean size (mm)	TATS	9/19/95	1			0.5983	1.092		1.0000			0.1759	0.128		0.4496	
Mean size (mm)	TATS	9/19/95	2			0.6073	1.0625		0.7390			0.1823	0.1297		0.502	
Biomass (mg/m3)	TLTN	6/18/85		10:20	1.6206	17.0669	7.6542		313.7900		169.04	17.9679	5.1168		532.26	
Density (#/m <sup>3</sup> )	TLTN	6/18/85		10:20	160	480	96		7968.0000		3872	19839.9238	6240		38655.3847	
Mean size (mm)	TLTN	6/18/85		10:20	0.5809	0.5602	1.1456		0.8237		0.9103	0.216	0.1073		0.4014	
Biomass (mg/m3)	TLTN	7/16/85		10:40	1.1442	26.643	48.6846		250.8500		178.58	13.305	32.144		551.35	
Density (#/m <sup>3</sup> )	TLTN	7/16/85		10:40	160	480	880		5040.0000		2240	13919.704	39199.4524		61919.8649	
Mean size (mm)	TLTN	7/16/85		10:40	0.5175	0.684	0.8993		0.9039		1.1392	0.2208	0.1085		0.2525	
Biomass (mg/m3)	TLTN	8/13/85		14:15	1.1442	13.7906	35.5531		63.5492		14.304	1.5427	49.5936		179.48	
Density (#/m <sup>3</sup> )	TLTN	8/13/85		14:15	160	320	1178.67		2218.6700		181.33	1920	60479.7518		66458.4182	
Mean size (mm)	TLTN	8/13/85		14:15	0.5175	0.6135	0.8213		0.7179		1.1316	0.2013	0.0871		0.1309	
Biomass (mg/m3)	TLTN	9/10/85		12:30		28.0633	271.1		275.5700		258.88	29.3848	61.0867		924.09	
Density (#/m <sup>3</sup> )	TLTN	9/10/85		12:30		512	3456		6976.0000		3008	33302.7425	74495.4932		121727.864	
Mean size (mm)	TLTN	9/10/85		12:30		0.6877	1.1251		0.7974		1.1643	0.2116	0.075		0.2131	
Biomass (mg/m3)	TLTN	8/26/87				155.9	606.71		647.6400		645.25	33.9519	57.5315		2146.98	
Density (#/m <sup>3</sup> )	TLTN	8/26/87				5120	11788.268		14843.6259		10018.6683	63998.5302	70160.0678		175930.039	
Mean size (mm)	TLTN	8/26/87				0.5162	0.9414		0.8477		1.0452	0.1766	0.1215		0.3219	
Biomass (mg/m3)	TLTN	8/28/88	1			28.8155	204.86		115.3900		222.66	6.447	1.7318	3.2136	574.9164	
Biomass (mg/m3)	TLTN	8/28/88	2			32.3784	151.25		95.2246		136.6	9.7348	1.2595	6.4995	425.4505	
Density (#/m <sup>3</sup> )	TLTN	8/28/88	1			704	5120		5632.0000		4736	6912	2112	1.28	25216.8015	LGB=970
Density (#/m <sup>3</sup> )	TLTN	8/28/88	2			1152	4096		5312.0000		3200	7680	1536	1.92	22977.8823	LGB=970
Mean size (mm)	TLTN	8/28/88	1			0.5473	0.8798		0.6192		0.9314	0.2204	0.2653	0.8902	0.5898	
Mean size (mm)	TLTN	8/28/88	2			0.5036	0.8599		0.5942		0.8898	0.2386	0.2943	0.9758	0.5393	
Biomass (mg/m3)	TLTN	6/8/89	1	14:10		0.1935	8.5337		89.2521		54.039	4.7418	0.6822	50.1733	157.4467	
Biomass (mg/m3)	TLTN	6/8/89	2	13:30		0.7249	66.4683		637.4500		471.35	15.1796	8.3968		1199.57	
Density (#/m <sup>3</sup> )	TLTN	6/8/89	1	14:10		8.64	192		3712.0000		2176	12863.8213	832	0.32	19784.7242	LGB=900
Density (#/m <sup>3</sup> )	TLTN	6/8/89	2	13:30		24	1706.67		20053.0298		11733.2953	27733.201	10239.7652		71489.128	
Mean size (mm)	TLTN	6/8/89	1	14:10		0.4445	0.935		0.6859		0.7326	0.1546	0.1023	3.9215	0.3234	

## Appendix 4 cont'd.

Property	Lake	Date	Site	Time	DIA	BOS	DPH	HOL	CYC	CAL	DPT	NP	ROT	LGB	TOT	Comments
Mean size (mm)	TLTN	6/8/89	2	13:30		0.513	0.8082		0.7498		0.8749	0.1788	0.1143		0.4591	
Biomass (mg/m3)	TLTN	7/13/89	1	12:40		4.8205	165.44		242.3800		328.41	3.7205	6.9274		751.7	
Biomass (mg/m3)	TLTN	7/13/89	2	13:00		24.6277	29.41		250.2600		250.07	7.7937	15.674		846.83	
Density (#/m <sup>3</sup> )	TLTN	7/13/89	1	12:40		184.32	4480		8192.0000		7552	11263.9315	8448		40119.9146	
Density (#/m <sup>3</sup> )	TLTN	7/13/89	2	13:00		877.53	9386.67		7509.3300		3413.33	17919.6697	19114.3705		58221.0455	
Mean size (mm)	TLTN	7/13/89	1	12:40		0.4803	0.8229		0.7574		0.9015	0.1488	0.0921		0.4796	
Mean size (mm)	TLTN	7/13/89	2	13:00		0.4969	0.7823		0.7879		1.0965	0.1633	0.1231		0.3902	
Biomass (mg/m3)	TLTN	8/30/89	1	14:30		7.2334	265.67		178.5400		100.86	9.7762	5.5979		567.68	
Biomass (mg/m3)	TLTN	8/30/89	2	14:50		85.5732	293.38		104.2100		73.0852	8.3548	6.4142	2.6516	271.0184	
Density (#/m <sup>3</sup> )	TLTN	8/30/89	1	14:30		261.12	6485.33		6314.6700		2560	26112.593	6826.67		48559.0297	
Density (#/m <sup>3</sup> )	TLTN	8/30/89	2	14:50		2560	6400		3555.5600		1280	22897.6019	7822.22	2.1333	44517.4213	****NOTE:time is 15:50 on the field r
Mean size (mm)	TLTN	8/30/89	1	14:30		0.4962	0.884		0.6982		0.8793	0.1557	0.0992		0.3556	
Mean size (mm)	TLTN	8/30/89	2	14:50		0.5349	0.9091		0.7093		0.9999	0.1539	0.1383	0.7294	0.3503	
Biomass (mg/m3)	TLTN	10/4/89	1	16:30		72.6202	284.71		118.8600		47.8606	7.9167	4.6182	3.3452	536.5948	
Biomass (mg/m3)	TLTN	10/4/89	2	16:45		75.9906	658.94		186.9500		38.5027	2.5952	2.599	2.3754	967.95	
Density (#/m <sup>3</sup> )	TLTN	10/4/89	1	16:30		2560	5120		11775.7886		1024	37375.7572	5632	1.28	63489.2212	LGB=ARANEIDA
Density (#/m <sup>3</sup> )	TLTN	10/4/89	2	16:45		2438.1	10239.7652		11946.4811		609.52	8045.71	3169.52	1.0667	36450.2071	LGB=ARANEIDA
Mean size (mm)	TLTN	10/4/89	1	16:30		0.5043	1.008		0.4678		0.9281	0.1264	0.1016	0.9858	0.2868	
Mean size (mm)	TLTN	10/4/89	2	16:45		0.5231	1.0635		0.5576		1.0504	0.1472	0.1213	0.9497	0.5771	
Biomass (mg/m3)	TLTN	6/10/90				2.2171	6.3491		395.2700		154.59	20.1748	0.2099		578.81	
Density (#/m <sup>3</sup> )	TLTN	6/10/90				69.12	166.4		13311.8986		3754.67	22100.9021	256		39658.8393	
Mean size (mm)	TLTN	6/10/90				0.5264	0.8651		0.7759		0.8934	0.2217	0.1017		0.4737	
Biomass (mg/m3)	TLTN	7/17/90				32.2025	171.99		171.5700		137.82	16.7763	12.0704	2.6491	542.4209	
Density (#/m <sup>3</sup> )	TLTN	7/17/90				1152	6656		5248.0000		2432	16511.632	14719.7353	0.96	46720.7709	LGB=ACARINA
Mean size (mm)	TLTN	7/17/90				0.5003	0.7671		0.7906		1.0063	0.2304	0.1056	0.884	0.3775	
Biomass (mg/m3)	TLTN	8/25/90	1			47.9986	306.29		247.5800		78.5976	40.2323	4.6671	4.6671	747.9929	
Density (#/m <sup>3</sup> )	TLTN	8/25/90	1			1792	9984		8704.0000		1536	41215.4456	33279.7458	0.64	96511.7077	LGB=ACARINA
Mean size (mm)	TLTN	8/25/90	1			0.4915	0.8095		0.7244		0.9724	0.2265	1.4098	1.4098	0.3137	
Biomass (mg/m3)	TLTN	10/1/90	1			41.9183	81.4373		200.2000		34.1286	6.7595	3.4987	6.1019	367.9381	
Density (#/m <sup>3</sup> )	TLTN	10/1/90	1			1621.33	1962.67		14933.1009		682.67	7594.67	4266.67	0.64	31061.3266	LGB=ACARINA
Mean size (mm)	TLTN	10/1/90	1			0.4828	0.9077		0.5534		0.9516	0.2482	0.1227	1.5154	0.4398	
Biomass (mg/m3)	TLTN	6/24/91	1	10:00		20.7607	17.5667		251.6400		88.4477	16.0968	9.7963	14.8541	419.16	
Biomass (mg/m3)	TLTN	6/24/91	2	12:15		28.4574	6.3748		458.8600		253.22	9.7316	11.4756		768.12	
Density (#/m <sup>3</sup> )	TLTN	6/24/91	1	10:00		711.11	477.87		9102.2200		1280	13498.9504	11946.4811	4.2667	49406.0348	LGB=ARANEIDA
Density (#/m <sup>3</sup> )	TLTN	6/24/91	2	12:15		1194.67	187.23		4.2189		3754.67	25599.4126	13994.5842		61285.8198	
Mean size (mm)	TLTN	6/24/91	1	10:00		0.4959	0.8265		0.6965		1.038	0.19	0.123	1.1022	0.2997	
Mean size (mm)	TLTN	6/24/91	2	12:15		0.4616	0.8132		0.7145		1.0495	0.1577	0.1163		0.3612	
Biomass (mg/m3)	TLTN	7/12/91	1			67.5008	140.11		181.6500		134.41	9.8672	4.4608		538	
Biomass (mg/m3)	TLTN	7/12/91	2			5.4126	7.9296		54.3531		60.1331	2.0788	1.5114		131.42	
Density (#/m <sup>3</sup> )	TLTN	7/12/91	1			2453.33	3733.33		5013.3300		2026.67	18666.3756	5440		37332.7515	
Density (#/m <sup>3</sup> )	TLTN	7/12/91	2			256	160		1996.8000		819.2	3609.6	1843.2		8684.8	
Mean size (mm)	TLTN	7/12/91	1			0.4912	0.8135		0.7761		1.0373	0.178	0.1206		0.3807	
Mean size (mm)	TLTN	7/12/91	2			0.4334	0.9306		0.7147		1.0789	0.1831	0.1261		0.3989	
Biomass (mg/m3)	TLTN	8/18/91	1	20:00		38.7578	65.5066		82.1760		19.9369	1.424	12.1287		219.93	
Biomass (mg/m3)	TLTN	8/18/91	2			30.9726	540.88		241.3400		68.199	16.651	17.6333		915.68	
Biomass (mg/m3)	TLTN	8/18/91	2			41.2969	540.88		241.3400		90.932	16.651	17.6333		915.68	
Density (#/m <sup>3</sup> )	TLTN	8/18/91	1	20:00		1493.33	2062.22		3413.3300		392.73	2488.89	14791.0839		24641.0948	
Density (#/m <sup>3</sup> )	TLTN	8/18/91	2			864	9386.67		7680.0000		944	30549.2111	21503.5419		70926.7402	
Density (#/m <sup>3</sup> )	TLTN	8/18/91	2			1152	9386.67		7680.0000		1258.67	30549.2111	21503.5419		70926.7402	
Mean size (mm)	TLTN	8/18/91	1	20:00		0.4788	0.7943		0.6563		0.9251	0.1727	0.2242		0.3532	
Mean size (mm)	TLTN	8/18/91	2			0.5563	0.9974		0.7383		1.0791	0.1743	0.133		0.3474	
Mean size (mm)	TLTN	8/18/91	2			0.5563	0.9974		0.7283		1.0791	0.1743	0.133		0.3474	



## Appendix 4 cont'd.

Property	Lake	Date	Site	Time	DIA	BOS	DPH	HOL	CYC	CAL	DPT	NP	ROT	LGB	TOT	Comments
Biomass (mg/m3)	TLTN	9/11/91	1			44.0711	130		269.1500		94.221	16.3773	2.3091		556.12	
Biomass (mg/m3)	TLTN	9/11/91	2		0.0122	33.7819	106.67		105.8100		22.1165	1.5882	1.1895		271.17	
Density (#/m <sup>3</sup> )	TLTN	9/11/91	1			1280	2048		9856.0000		1267.2	33279.7458	2816		50546.3732	
Density (#/m <sup>3</sup> )	TLTN	9/11/91	2		2.56	1152	2436		5504.0000		268.8	4565.33	1450.67		15375.1726	
Mean size (mm)	TLTN	9/11/91	1			0.5468	9856		0.6654		1.1022	0.1701	0.131		0.3325	
Mean size (mm)	TLTN	9/11/91	2		0.4517	0.5106	0.9071		0.6114		1.1476	0.1498	0.3388		0.4972	
Biomass (mg/m3)	TLTN	6/23/92	1			184.13	53.5402		370.6900		661.6	9.5722	4.8981		1284.43	
Biomass (mg/m3)	TLTN	6/23/92	2			21.0119	20.4616		63.3538		142.98	1.2248	1.8893		250.92	
Density (#/m <sup>3</sup> )	TLTN	6/23/92	1			7253.33	2773.33		9386.6700		7253.33	23892.9624	5973.33		1064.7523	
Density (#/m <sup>3</sup> )	TLTN	6/23/92	2			621.71	621.71		1901.7100		1718.86	2889.14	2304		10057.0359	
Mean size (mm)	TLTN	6/23/92	1			0.4708	0.6951		0.8454		1.1815	0.1586	0.0968		0.4637	
Mean size (mm)	TLTN	6/23/92	2			0.5343	0.8006		0.7993		1.1516	0.1647	0.1021		0.5012	
Biomass (mg/m3)	TLTN	7/29/92	1			100.26	366.8		72.9004		14.0238	3.1382	0.6717		557.79	
Biomass (mg/m3)	TLTN	7/29/92	2			102.19	324.5		140.3800		222.7	3.8561	4.8981		798.53	
Density (#/m <sup>3</sup> )	TLTN	7/29/92	1			3379.2	8192		2764.8000		230.03	5120	819.2		20505.0107	
Density (#/m <sup>3</sup> )	TLTN	7/29/92	2			3413.33	8533.33		4949.3300		4266.67	8362.67	5973.33		35498.4998	
Mean size (mm)	TLTN	7/29/92	1			0.5042	0.9115		0.7220		1.0083	0.1877	0.1053		0.607	
Mean size (mm)	TLTN	7/29/92	2			0.509	0.8277		0.7127		0.9217	0.1659	0.0969		0.5134	
Biomass (mg/m3)	TLTN	8/20/92	2			169.85	737.76		151.3100		180.42	13.6541	5.6678		1258.66	
Density (#/m <sup>3</sup> )	TLTN	8/20/92	2			5376	15615.6476		5120.0000		2560	36607.494	6912		72190.4917	
Mean size (mm)	TLTN	8/20/92	2			0.5234	0.9274		0.7330		1.0803	0.1522	0.099		0.4165	
Biomass (mg/m3)	TLTN	8/21/92	1			47.3896	399.24		126.0200		91.3971	1.1639	1.244		666.46	
Density (#/m <sup>3</sup> )	TLTN	8/21/92	1			2180.74	9671.11		3223.7000		1706.67	6352.59	1517.04		24651.3098	
Mean size (mm)	TLTN	8/21/92	1			0.4329	0.8865		0.7994		0.9521	0.1206	0.1207		0.5943	
Biomass (mg/m3)	TLTN	10/3/92	1			16.7349	84.6621		83.5834		9.6899	1.4887	0.933		197.09	
Biomass (mg/m3)	TLTN	10/3/92	2			38.6586	134.2		56.6878		84.7129	1.1469	1.1196		316.53	
Density (#/m <sup>3</sup> )	TLTN	10/3/92	1			568.89	2133.33		8626.6700		247.07	5973.33	1137.78		16886.9027	
Density (#/m <sup>3</sup> )	TLTN	10/3/92	2			1706.67	3072		5034.6700		1706.67	4522.67	1365.33		17407.6441	
Mean size (mm)	TLTN	10/3/92	1			0.512	0.8567		0.5341		0.8342	0.1361	0.1046		0.4088	
Mean size (mm)	TLTN	10/3/92	2			0.4526	0.9239		0.5161		0.9286	0.1352	0.1225		0.4925	
Biomass (mg/m3)	TLTN	6/17/93	1	12:00		38.5713	67.7575		128.2200		109.85	1.0364	1.3995		346.83	
Biomass (mg/m3)	TLTN	6/17/93	2	13:00		17.7111	99.799		370.6200		165.41	5.2103	5.6678	98.9948	664.4152	
Density (#/m <sup>3</sup> )	TLTN	6/17/93	1	12:00		2005.33	2090.67		4864.0000		1834.67	1706.67	1706.67		14207.9035	
Density (#/m <sup>3</sup> )	TLTN	6/17/93	2	13:00		1152	2816		16895.8482		3072	11903.92	6912	1.28	42752.3508	LGB=900
Mean size (mm)	TLTN	6/17/93	1	12:00		0.4105	0.7933		0.7203		1	0.1876	0.1154		0.8568	
Mean size (mm)	TLTN	6/17/93	2	13:00		0.3762	0.8193		0.6379		0.9526	0.1654	0.1094	3.0127	0.4485	
Biomass (mg/m3)	TLTN	8/3/93	1	19:30		165.64	473.21		335.1200		205.76	3.9082	13.4349		1197.07	
Biomass (mg/m3)	TLTN	8/3/93	2			68.442	124.8		94.0042		97.298	4.8551	3.0905		392.49	
Density (#/m <sup>3</sup> )	TLTN	8/3/93	1	19:30		5632	9216		11946.4811		3925.33	5802.67	16383.625		52906.6179	
Density (#/m <sup>3</sup> )	TLTN	8/3/93	2			2702.22	3840		2773.3300		2560	9600	3768.89		25244.1063	
Mean size (mm)	TLTN	8/3/93	1	19:30		0.5119	0.9647		0.7253		0.9304	0.1897	0.1493		0.5224	
Mean size (mm)	TLTN	8/3/93	2			0.4739	0.8319		0.7833		0.8062	0.1703	0.2383		0.4454	
Biomass (mg/m3)	TLTN	9/19/93	1			6.1164	324.37		255.4700		8.6381	8.0413	3.7786		606.41	
Biomass (mg/m3)	TLTN	9/19/93	2			12.9729	136.66		59.7758		47.295	2.8419	2.1342		261.68	
Density (#/m <sup>3</sup> )	TLTN	9/19/93	1			256	8192		11007.7866		130.56	18431.8955	4608		42626.5319	
Density (#/m <sup>3</sup> )	TLTN	9/19/93	2			682.67	3669.33		2858.6700		810.67	4864	2602.67		15487.8096	
Mean size (mm)	TLTN	9/19/93	1			0.47	0.8865		0.6359		1.0629	0.1674	0.1472		0.429	
Mean size (mm)	TLTN	9/19/93	2			0.416	2858.67		0.6278		1.0041	0.1824	0.1871		0.4811	
Biomass (mg/m3)	TLTN	6/17/94	1			38.2352	71.5169		251.3400		154.96	0.9236	1.6181		518.59	
Biomass (mg/m3)	TLTN	6/17/94	2	13:00		38.131	147.75		742.8600		653.82	2.2319	3.4637	568.29	1588.27	
Density (#/m <sup>3</sup> )	TLTN	6/17/94	1			1120	1120		4480.0000		1706.67	1600	1973.33		11999.9656	
Density (#/m <sup>3</sup> )	TLTN	6/17/94	2	13:00		1280	2304		13183.7816		6784	4480	4224	2.56	32258.1903	LGB=900



## Appendix 4 cont'd.

Property	Lake	Date	Site	Time	DIA	BOS	DPH	HOL	CYC	CAL	DPT	NP	ROT	LGB	TOT	Comments
Mean size (mm)	TLTN	6/17/94	1			0.5346	0.9962		0.9331		1.1755	0.1839	0.1178		0.7023	
Mean size (mm)	TLTN	6/17/94	2	13:00		0.5038	0.9584		0.9421		1.2133	0.1761	0.1209	4.4034	0.7693	
Biomass (mg/m3)	TLTN	7/27/94	1	17:00		175.24	572.29		73.3258		174.7	4.3329	8.0469		1007.94	
Biomass (mg/m3)	TLTN	7/27/94	2	15:30		196.73	1706.23		509.1400		1579.07	21.1005	4024.7706		4037.04	
Density (#/m <sup>3</sup> )	TLTN	7/27/94	1	17:00		4693.33	9671.11		1991.1100		1280	9102.22	9813.33		36551.062	
Density (#/m <sup>3</sup> )	TLTN	7/27/94	2	15:30		4608	18943.9265		6656.0000		13311.8986	33791.6968	30207.8628		107517.709	
Mean size (mm)	TLTN	7/27/94	1	17:00		0.5688	0.9893		0.8012		1.3775	0.1689	0.102		0.4961	
Mean size (mm)	TLTN	7/27/94	2	15:30		0.6069	1.1439		1.0686		1.3055	0.1863	0.0967		0.5411	
Biomass (mg/m3)	TLTN	9/18/94	1	11:20		13.3137	229.51		113.9100		63.6442	0.7457	1.6794		422.81	
Biomass (mg/m3)	TLTN	9/18/94	2	13:15		28.489	821.23		303.5800		461.84	3.4159	1.2595		1619.76	
Density (#/m <sup>3</sup> )	TLTN	9/18/94	1	11:20		614.4	3020.8		6195.2000		665.6	1587.2	2048		14130.9058	
Density (#/m <sup>3</sup> )	TLTN	9/18/94	2	13:15		1024	10751.7709		11434.5743		4437.33	5632	1536		34815.2886	
Mean size (mm)	TLTN	9/18/94	1	11:20		0.4442	1.0949		0.5841		1.1982	0.1665	0.1962		0.613	
Mean size (mm)	TLTN	9/18/94	2	13:15		0.4869	1.0807		0.6473		1.2577	0.1823	0.2445		0.7612	
Biomass (mg/m3)	TLTN	7/30/95	1	11:00		195.15	974.86		256.6300		79.1832	12.5031	8.1636		1535.49	
Biomass (mg/m3)	TLTN	7/30/95	2	13:30		198.36	1065.98		335.6200		255.28	43.2965	7.5571		1906.1	
Density (#/m <sup>3</sup> )	TLTN	7/30/95	1	11:00		5973.33	19910.8591		7395.5600		940.17	13937.6643	9955.56		58112.559	
Density (#/m <sup>3</sup> )	TLTN	7/30/95	2	13:30		5376	21247.6058		7680.0000		3200	30207.8628	9216		76927.2132	
Mean size (mm)	TLTN	7/30/95	1	11:00		5361	0.9457		0.7771		1.1456	0.2154	0.3042		0.6003	
Mean size (mm)	TLTN	7/30/95	2	13:30		0.568	0.9565		0.8556		1.1374	0.2585	0.1908		0.561	
Biomass (mg/m3)	TPR	9/3/87							185.2400			0.7945	19.0502		205.09	
Density (#/m <sup>3</sup> )	TPR	9/3/87							8829.4400			1920	23231.647		33981.3008	
Mean size (mm)	TPR	9/3/87							0.6393			0.1625	0.1637		0.2872	
Biomass (mg/m3)	TPR	7/21/88	1	15:00					176.3900		0.0351	0.0611	0.2362	124.2	176.73	
Biomass (mg/m3)	TPR	7/21/88	2	15:30		0.003			90.5404			0.0029	0.2624		90.8087	
Density (#/m <sup>3</sup> )	TPR	7/21/88	1	15:00					11071.8451		0.64	32	288	0.32	11392.7876	LGB=900
Density (#/m <sup>3</sup> )	TPR	7/21/88	2	15:30		0.32			4912.0000			1.6	320		5233.92	
Mean size (mm)	TPR	7/21/88	1	15:00					0.5997		0.9991	0.292	0.1836	5.3048	0.5885	
Mean size (mm)	TPR	7/21/88	2	15:30		0.3062			0.6313			0.286	0.1855		0.6039	
Biomass (mg/m3)	TPR	8/22/88	1	9:45		0.2092			217.7800			0.021	1.1808		219.18	
Biomass (mg/m3)	TPR	8/22/88	2	9:00		9.5018			46.9341				2.073	47.4311	58.5089	
Density (#/m <sup>3</sup> )	TPR	8/22/88	1	9:45		10.56			4.0663			32	1440		13130.4618	
Density (#/m <sup>3</sup> )	TPR	8/22/88	2	9:00		720			3024.0000				2528	0.32	6272.32	LGB=905????question marks on data
Mean size (mm)	TPR	8/22/88	1	9:45		0.4144			0.6545			0.1976	0.2045		0.6039	
Mean size (mm)	TPR	8/22/88	2	9:00		0.3546			0.6115				0.2769	3.8487	0.4473	
Biomass (mg/m3)	TPR	9/24/88	1	18:00		0.019	0.0576		62.5461	0.1594	0.0109	0.003	2.3354		65.1314	
Biomass (mg/m3)	TPR	9/24/88	2	17:30			0.0315		145.3100			0.0013	4.2246		149.57	
Density (#/m <sup>3</sup> )	TPR	9/24/88	1	18:00		0.8	2.72		2720.0000	0.32	0.16	3.04	2848		5575.04	CAL=020
Density (#/m <sup>3</sup> )	TPR	9/24/88	2	17:30			1.28		6272.0000			1.28	5152		11426.4152	
Mean size (mm)	TPR	9/24/88	1	18:00		0.4475	0.7166		0.7121	2.0746	1.083	0.228	0.1812		0.4407	
Mean size (mm)	TPR	9/24/88	2	17:30			0.7575		0.7154			0.2323	0.1769		0.4726	
Biomass (mg/m3)	TPR	6/8/89	1	10:30		0.0887	0.1305		76.6787			2.7923	2.0467	????	81.88	
Biomass (mg/m3)	TPR	6/8/89	2	10:00		0.2904	0.1931		47.1156			3.0734	1.9155	3.1747	52.5881	
Density (#/m <sup>3</sup> )	TPR	6/8/89	1	10:30		2.4	3.04		2272.0000			5632	2496	0.16	10405.4292	LGB=900
Density (#/m <sup>3</sup> )	TPR	6/8/89	2	10:00		8.64	4.16		1984.0000			8320	2336	0.16	12652.8978	LGB=900
Mean size (mm)	TPR	6/8/89	1	10:30		0.5627	0.9192		0.8202			0.1759	0.1145	2.8778	0.3022	
Mean size (mm)	TPR	6/8/89	2	10:00		0.5331	0.9366		0.7154			0.1547	0.0958	1.9688	0.2323	
Biomass (mg/m3)	TPR	7/13/89	1	10:50					221.2700			4.472	11.9654		239.9	
Biomass (mg/m3)	TPR	7/13/89	2	10:30					81.7489			11.5508	2.1692	69.8688	95.4712	
Density (#/m <sup>3</sup> )	TPR	7/13/89	1	10:50					10367.8809			12799.7062	14591.838		37759.8274	
Density (#/m <sup>3</sup> )	TPR	7/13/89	2	10:30					6741.3300			15445.0742	2645.33	0.64	24832.4746	LGB=900
Mean size (mm)	TPR	7/13/89	1	10:50					0.6363			0.1774	0.0893		0.2694	

## Appendix 4 cont'd.

Property	Lake	Date	Site	Time	DIA	BOS	DPH	HOL	CYC	CAL	DPT	NP	ROT	LGB	TOT	Comments
Mean size (mm)	TPR	7/13/89	2	10:30					0.5003			0.2026	0.1131	3.4757	0.274	
Biomass (mg/m3)	TPR	8/30/89	1	10:00		0.0457	0.0311		69.5030			0.4401	6.9498	122.3	77	
Biomass (mg/m3)	TPR	8/30/89	2	10:30	0.0014	0.1602	0.4866		152.1900		0.0409	0.7646	3.8205		157.47	
Density (#/m <sup>3</sup> )	TPR	8/30/89	1	10:00		2.56	1.28		7168.0000			2112	8512	0.32	17795.9018	LGB=900
Density (#/m <sup>3</sup> )	TPR	8/30/89	2	10:30	0.16	5.28	11.84		9984.0000		0.64	2713.6	4659.2		16978.9176	DIA=DPH
Mean size (mm)	TPR	8/30/89	1	10:00		0.3961	0.7574		0.5061			0.1252	0.0793	5.2775	0.2568	
Mean size (mm)	TPR	8/30/89	2	10:30	0.5582	0.5126	0.8853		0.6007		1.0181	0.1434	0.1067		0.397	
Biomass (mg/m3)	TPR	10/4/89	1	14:30		0.0068	58.371		58.3710			0.2202	1.866	42.0208	60.4592	
Biomass (mg/m3)	TPR	10/4/89	2	13:00		0.7731			59.0654		0.0512	0.8286	1.8106	67.086	62.524	
Density (#/m <sup>3</sup> )	TPR	10/4/89	1	14:30		0.64	5233.78		5233.7800			938.67	2275.56	0.32	8448.96	LGB=900
Density (#/m <sup>3</sup> )	TPR	10/4/89	2	13:00		64			3904.0000		0.64	2624	2208	0.64	8801.28	LGB=900
Mean size (mm)	TPR	10/4/89	1	14:30		0.3252	0.5424		0.5424			0.1299	0.0859	3.6964	0.3737	
Mean size (mm)	TPR	10/4/89	2	13:00		0.3348			0.6087		1.1461	0.1481	0.1138	3.3802	0.3455	
Biomass (mg/m3)	TPR	6/8/90	1	12:50					109.0200			0.6289	0.0175		109.67	
Biomass (mg/m3)	TPR	6/8/90	2			0.0052			18.6672		0.0125	0.2592	0.0656		19.0097	
Density (#/m <sup>3</sup> )	TPR	6/8/90	1	12:50					5162.6700			1493.33	21.3333		6677.33	
Density (#/m <sup>3</sup> )	TPR	6/8/90	2			0.32			933.3300		0.32	506.67	80		1520	
Mean size (mm)	TPR	6/8/90	1	12:50					0.6935			0.165	0.0788		0.5733	
Mean size (mm)	TPR	6/8/90	2			0.393			0.6752		0.882	0.1755	0.0928		0.4781	
Biomass (mg/m3)	TPR	7/17/90	1	12:50		0.0275			190.1800			3.2606	0.2099	67.6463	193.6837	
Biomass (mg/m3)	TPR	7/17/90	2	12:20		0.2527	0.0583		41.8332			2.6562	0.3149	0.4308	45.1152	
Density (#/m <sup>3</sup> )	TPR	7/17/90	1	12:50		0.64			14015.8680			4416	256	0.32	18688.739	LGB=900
Density (#/m <sup>3</sup> )	TPR	7/17/90	2	12:20		6.08	1.6		4821.3300			3605.33	384	0.32	8818.67	LGB=ARANEIDA (SPIDER)
Mean size (mm)	TPR	7/17/90	1	12:50		0.6145			0.5447			0.2034	0.0971	4.3322	0.458	
Mean size (mm)	TPR	7/17/90	2	12:20		0.5959	0.8755		0.4675			0.2028	0.1072	0.798	0.3438	
Biomass (mg/m3)	TPR	9/2/90	1			0.057	0.1083		29.2513			0.046	0.7347		30.1974	
Biomass (mg/m3)	TPR	9/2/90	2	11:00		0.0975	0.2701		79.3262		0.0168	0.0473	0.5904	20.5266	80.3434	
Density (#/m <sup>3</sup> )	TPR	9/2/90	1			0.96	2.4		1488.0000			104	896		2491.36	
Density (#/m <sup>3</sup> )	TPR	9/2/90	2	11:00		2.24	5.92		4016.0000		0.32	160	720	0.16	4904.64	LGB=900
Mean size (mm)	TPR	9/2/90	1			0.7079	0.9267		0.6720			0.1679	0.0933		0.4431	
Mean size (mm)	TPR	9/2/90	2	11:00		0.6145	0.9402		0.6692		0.9831	0.1424	0.0919	3.6678	0.5677	
Biomass (mg/m3)	TPR	9/6/90	1	11:50		0.0388	0.0777		110.4000			0.1211	2.1254		112.76	
Density (#/m <sup>3</sup> )	TPR	9/6/90	1	11:50		0.96	1.44		6016.0000			384	2592		8994.4	
Mean size (mm)	TPR	9/6/90	1	11:50		0.5828	0.9853		0.6534			0.1438	0.087		0.4685	
Biomass (mg/m3)	TPR	6/19/91	1	18:00		0.0158			121.3900			0.1281	0.1225		121.66	
Biomass (mg/m3)	TPR	6/19/91	2	17:00					128.0900			0.7024	0.1924		128.98	
Density (#/m <sup>3</sup> )	TPR	6/19/91	1	18:00		0.64			5034.6700			277.33	149.33		5461.97	
Density (#/m <sup>3</sup> )	TPR	6/19/91	2	17:00					5589.3300			1088	234.67		6912	
Mean size (mm)	TPR	6/19/91	1	18:00		0.477			0.7279			0.165	0.1127		0.6825	
Mean size (mm)	TPR	6/19/91	2	17:00					0.7137			0.1918	0.1041		0.6108	
Biomass (mg/m3)	TPR	7/17/91	1			1.3598			70.0496			1.1478	0.3779	257.34	72.94	
Biomass (mg/m3)	TPR	7/17/91	2			0.0142			34.8080			0.7423	0.4264		35.9909	
Density (#/m <sup>3</sup> )	TPR	7/17/91	1			33.7067			4556.8000			1996.8	460.8	0.4267	7048.53	LGB=900
Density (#/m <sup>3</sup> )	TPR	7/17/91	2			0.64			2216.0000			968	520		3704.64	
Mean size (mm)	TPR	7/17/91	1			0.5875			0.5666			0.1839	0.1063	6.1445	0.4286	
Mean size (mm)	TPR	7/17/91	2			0.4541			0.5627			0.204	0.111		0.4055	
Biomass (mg/m3)	TPR	8/15/91	1	13:50					93.9171			0.0234	0.2099		94.1504	
Biomass (mg/m3)	TPR	8/15/91	2						176.1500			0.0564	4.0934		180.3	
Density (#/m <sup>3</sup> )	TPR	8/15/91	1	13:50					6835.2000			76.8	256		7168	
Density (#/m <sup>3</sup> )	TPR	8/15/91	2						12607.8200			128	4992		17727.6023	
Mean size (mm)	TPR	8/15/91	1	13:50					0.5687			0.1419	0.1062		0.5476	
Mean size (mm)	TPR	8/15/91	2						0.5830			0.1544	0.1033		0.4448	

## Appendix 4 cont'd.

Property	Lake	Date	Site	Time	DIA	BOS	DPH	HOL	CYC	CAL	DPT	NP	ROT	LGB	TOT	Comments
Biomass (mg/m3)	TPR	9/18/91	1			2.9754	0.0662		150.5200			0.0215	9.8662		163.45	
Biomass (mg/m3)	TPR	9/18/91	2						93.0729			0.3569	3.4112		96.8411	
Density (#/m <sup>3</sup> )	TPR	9/18/91	1			69.76	1.92		8128.0000			64	12031.7833		20295.5114	
Density (#/m <sup>3</sup> )	TPR	9/18/91	2						4896.0000			1216	4160		10271.8815	
Mean size (mm)	TPR	9/18/91	1			0.6029	0.8646		0.6603			0.1544	0.1142		0.3348	
Mean size (mm)	TPR	9/18/91	2						0.6636			0.1454	0.1225		0.3831	
Biomass (mg/m3)	TPR	6/20/92	1						84.7574			0.5687	0.1889		85.515	
Biomass (mg/m3)	TPR	6/20/92	2						129.7300			1.7513	0.1837	43.1504	131.6596	
Density (#/m <sup>3</sup> )	TPR	6/20/92	1						3148.8000			2048	230.4		5427.2	
Density (#/m <sup>3</sup> )	TPR	6/20/92	2						5984.0000			3200	224	1.6	9408	LGB=900
Mean size (mm)	TPR	6/20/92	1						0.7412			0.1312	0.0673		0.4824	
Mean size (mm)	TPR	6/20/92	2						0.6893			0.175	0.0959	1.9577	0.5005	
Biomass (mg/m3)	TPR	8/3/92	1			0.3439	0.0505		109.8900			0.5041	0.2624		111.05	
Biomass (mg/m3)	TPR	8/3/92	2			0.0906	0.0545		146.0200			1.5778	0.2099	43.3182	147.9518	
Density (#/m <sup>3</sup> )	TPR	8/3/92	1			7.68	1.6		12799.7062			1536	320		14665.2679	
Density (#/m <sup>3</sup> )	TPR	8/3/92	2			1.92	0.96		14335.7362			3136	256	0.32	17730.8681	LGB=900
Mean size (mm)	TPR	8/3/92	1			0.6184	0.8182		0.4601			0.1453	0.0589		0.4185	
Mean size (mm)	TPR	8/3/92	2			0.6381	0.9966		0.4834			0.1711	0.1271	3.7341	0.4231	
Biomass (mg/m3)	TPR	8/23/92	1			0.0767	0.0657		152.0900			0.2389	0.8922		153.37	
Biomass (mg/m3)	TPR	8/23/92	2				0.1905		144.6100			0.2963	1.9732		147.07	
Density (#/m <sup>3</sup> )	TPR	8/23/92	1			2.24	1.28		13119.8841			1088	1088		15299.245	
Density (#/m <sup>3</sup> )	TPR	8/23/92	2				5.12		11468.5893			921.6	2406.4		14801.6455	
Mean size (mm)	TPR	8/23/92	1			0.5455	0.9477		0.5308			0.12	0.0671		0.4686	
Mean size (mm)	TPR	8/23/92	2				0.8835		0.5541			0.1469	0.1148		0.4575	
Biomass (mg/m3)	TPR	9/22/92	1				0.0057		101.2200			0.067	5.7728		107.07	
Biomass (mg/m3)	TPR	9/22/92	2			0.0197	0.0745		133.0000			0.0139	0.4921		134.96	
Density (#/m <sup>3</sup> )	TPR	9/22/92	1				0.32		9792.0000			384	7040		17216.3071	
Density (#/m <sup>3</sup> )	TPR	9/22/92	2			0.64	0.64		9344.0000			0.32	2048		13057.499	
Mean size (mm)	TPR	9/22/92	1				0.7017		0.5314			0.1187	0.0893		0.3414	
Mean size (mm)	TPR	9/22/92	2			0.5264	1.1482		0.5944			0.9164	0.1193		0.4569	
Biomass (mg/m3)	TPR	6/19/93	1	19:30		0.0207	0.038		242.3600			1.5612	0.105	168.88	244.09	
Biomass (mg/m3)	TPR	6/19/93	2	20:00			0.0235		82.0935			4.0832	0.1574	87.5894	86.3606	
Density (#/m <sup>3</sup> )	TPR	6/19/93	1	19:30		0.64	1.28		7040.0000			1920	128	1.92	9091.84	LGB=900
Density (#/m <sup>3</sup> )	TPR	6/19/93	2	20:00			0.64		3840.0000			6848	192	0.64	10881.0298	LGB=900
Mean size (mm)	TPR	6/19/93	1	19:30		0.5397	0.8293		0.7915			0.2127	0.0983	3.1616	0.66	
Mean size (mm)	TPR	6/19/93	2	20:00			0.891		0.6633			0.1868	0.1191	3.7477	0.354	
Biomass (mg/m3)	TPR	7/31/93	1	12:00			0.2234		121.2000			0.4921	1.0496	55.1322	122.9678	
Biomass (mg/m3)	TPR	7/31/93	2	11:00			0.0568		154.3400			4.662	0.6298		155.49	
Density (#/m <sup>3</sup> )	TPR	7/31/93	1	12:00			6.08		10751.7709			1280	1280	0.64	13318.6437	LGB=900
Density (#/m <sup>3</sup> )	TPR	7/31/93	2	11:00			0.64		9088.0000			896	768		10752.5136	
Mean size (mm)	TPR	7/31/93	1	12:00			0.8602		0.5156			0.1575	0.117	2.8009	0.4431	
Mean size (mm)	TPR	7/31/93	2	11:00			1.1944		0.5775			0.1673	0.1075		0.5098	
Biomass (mg/m3)	TPR	9/11/93	1				0.3803		141.8100			0.2482	4.8282	44.7892	177.2708	
Biomass (mg/m3)	TPR	9/11/93	2		0.0025		0.7597		68.4600			0.4859	5.7728		75.4808	
Density (#/m <sup>3</sup> )	TPR	9/11/93	1	11:00			10.6667		6400.0000			1152	5888	0.4267	13450.8584	LGB=900
Density (#/m <sup>3</sup> )	TPR	9/11/93	2		0.64		38.4		2560.0000			2432	7040		12070.9097	DIA=141
Mean size (mm)	TPR	9/11/93	1				0.8614		0.7533			0.1294	0.0992	3.4306	0.4137	
Mean size (mm)	TPR	9/11/93	2		0.4215		0.6968		0.7404			0.1263	0.1772		0.288	
Biomass (mg/m3)	TPR	7/24/94	1	14:00			1.6344		288.3500			0.2649	2.0992		292.34	
Biomass (mg/m3)	TPR	7/24/94	2	16:00			1.0838		122.4800			1.1066	0.2099		124.88	
Density (#/m <sup>3</sup> )	TPR	7/24/94	1	14:00			66.56		17151.8117			256	2560		20034.1075	
Density (#/m <sup>3</sup> )	TPR	7/24/94	2	16:00			34.56		12799.7062			1536	256		14626.486	

## Appendix 4 cont'd.

Property	Lake	Date	Site	Time	DIA	BOS	DPH	HOL	CYC	CAL	DPT	NP	ROT	LGB	TOT	Comments
Mean size (mm)	TPR	7/24/94	1	14:00			0.7237		0.6050			0.2333	0.2276		0.5524	
Mean size (mm)	TPR	7/24/94	2	16:00			0.8004		0.4918			0.203	0.1342		0.4559	
Biomass (mg/m3)	TPR	9/11/94	1			0.0389	0.4494		245.7800			2.5943	5.4579	115.86	254.32	
Biomass (mg/m3)	TPR	9/11/94	2			1.6673	3.2825		62.9013			1.3783	2.519		71.7484	
Density (#/m <sup>3</sup> )	TPR	9/11/94	1			1.92	16.64		11775.7886			3754.67	6656	0.32	22205.4715	LGB=900
Density (#/m <sup>3</sup> )	TPR	9/11/94	2			128	85.76		1834.6700			2048	3072		7168.43	
Mean size (mm)	TPR	9/11/94	1			0.4322	0.7798		0.6674			0.1968	0.1306	5.1833	0.427	
Mean size (mm)	TPR	9/11/94	2			0.3528	0.8238		0.8026			0.1969	0.1421		0.3387	
Biomass (mg/m3)	TPR	7/26/95	1				0.0479		112.5600			3.8156			116.43	
Biomass (mg/m3)	TPR	7/26/95	2				0.0487		80.0163			1.4993	0.0109		81.5753	
Biomass (mg/m3)	TPR	7/26/95	3				0.0647		281.2700			3.3683			284.71	
Density (#/m <sup>3</sup> )	TPR	7/26/95	4				0.0494		197.9100			8.204	0.0437		206.2	
Density (#/m <sup>3</sup> )	TPR	7/26/95	1				1.4667		5573.3300			2826.67			8401.47	
Density (#/m <sup>3</sup> )	TPR	7/26/95	2				1.3333		3906.6700			1160	13.3333		5081.33	
Density (#/m <sup>3</sup> )	TPR	7/26/95	3				1.6		8693.3300			1866.67			10561.3637	
Density (#/m <sup>3</sup> )	TPR	7/26/95	4				1.0667		8053.3300			4586.67	53.3333		12694.3363	
Mean size (mm)	TPR	7/26/95	1				0.8369		0.6275			0.2469			0.4995	
Mean size (mm)	TPR	7/26/95	2				0.8674		0.6438			0.2479	0.3141		0.5526	
Mean size (mm)	TPR	7/26/95	3				0.9192		0.7698			0.2825			0.6837	
Mean size (mm)	TPR	7/26/95	4				0.9475		0.6884			0.2808	0.1714		0.539	
Biomass (mg/m3)	TPR	9/16/95	1	13:20			1.2726		35.2551			0.1082	1.2923		37.9283	
Biomass (mg/m3)	TPR	9/16/95	2			0.3943	5.4854		148.1200			0.1675	0.656		154.82	
Density (#/m <sup>3</sup> )	TPR	9/16/95	1	13:20			61.6		1160.0000			184	1576		2981.6	
Density (#/m <sup>3</sup> )	TPR	9/16/95	2			32	131.84		3904.0000			224	800		5091.84	
Mean size (mm)	TPR	9/16/95	1	13:20			0.6965		0.7840			0.1828	0.114		0.391	
Mean size (mm)	TPR	9/16/95	2			0.3469	0.8976		0.8570			0.2064	0.1287		0.7118	
Biomass (mg/m3)	TUYA	9/9/87	1				17.9762		139.8600	110.54	176.21	6.4324	4.9856		456	
Biomass (mg/m3)	TUYA	9/9/87	2				18.3596		266.0700	903.12	522.86	3.1401	6.2976		1719.85	
Density (#/m <sup>3</sup> )	TUYA	9/9/87	1				88.5333		3254.4000	76.8	4470.4	14879.8996	6080		28849.6135	CAL=HETEROCOPE
Density (#/m <sup>3</sup> )	TUYA	9/9/87	2				40.96		5075.2000	691.2	11701.728	6432	7680		31600.9399	CAL=HETEROCOPE
Mean size (mm)	TUYA	9/9/87	1				1.5615		0.8979	3.2957	0.8543	0.1685	0.1321		0.362	
Mean size (mm)	TUYA	9/9/87	2				1.7366		0.9645	3.1497	0.8877	0.1743	0.1215		0.6193	
Biomass (mg/m3)	TUYA	7/21/88	1	8:30	18.5126				125.5300		122.03	0.6314	0.2493	2071.1	266.96	note: dia stuff crossed out on sheet????
Biomass (mg/m3)	TUYA	7/21/88	2	9:30			0.5673	0.0189	91.3080	31.6525	249.74	0.3514	1.6619		375.3	
Density (#/m <sup>3</sup> )	TUYA	7/21/88	1	8:30	16				4016.0000		4000	976	304	48	9360	LGB=100
Density (#/m <sup>3</sup> )	TUYA	7/21/88	2	9:30			2.4889	0.7111	3093.3300	38.7556	8373.33	480	2026.67		14015.2226	CAL=020
Mean size (mm)	TUYA	7/21/88	1	8:30	2.8011				0.7831		0.7718	0.1956	0.1593	2.4921	0.709	
Mean size (mm)	TUYA	7/21/88	2	9:30			1.5669	0.7999	0.7832	2.6535	0.7692	0.2051	0.1708		0.6718	
Biomass (mg/m3)	TUYA	8/24/88	1	12:30		0.085	1.6945		131.3400	45.6372	115.06	2.4642	0.656	2552.02	296.94	
Biomass (mg/m3)	TUYA	8/24/88	2	13:00		0.5778	1.5358		53.8672	107.95	212.86	3.7025	1.1079		381.61	
Density (#/m <sup>3</sup> )	TUYA	8/24/88	1	12:30		1.28	14.08		4160.0000	49.92	3456	3136	800	1.28	4.06515	LGB=900, CAL=020
Density (#/m <sup>3</sup> )	TUYA	8/24/88	2	13:00		9.6	7.4667		1493.3300	114.13	5226.67	4017.78	1351.11		12219.9661	CAL=020
Mean size (mm)	TUYA	8/24/88	1	12:30		0.751	1.1921		0.8063	2.792	0.8204	0.2101	0.1771	9.1531	0.6162	
Mean size (mm)	TUYA	8/24/88	2	13:00		0.7155	1.3705		0.8460	2.8291	0.8659	0.223	0.1748		0.5942	
Biomass (mg/m3)	TUYA	9/23/88	1	12:45		0.011	1.1294		78.6503	16.3885	13.008	3.6026	0.4854		113.57	NOTE: DAPH WRITTEN IN ABOVE
Biomass (mg/m3)	TUYA	9/23/88	2	12:00		0.177			92.8498	75.2602	17.2042	2.9231	1.7493	164.54	190.16	NOTE: BOS CROSSED OUT AND D.
Density (#/m <sup>3</sup> )	TUYA	9/23/88	1	12:45		0.32	12.48		1920.0000	17.6	272	3648	592		6462.4	CAL=020
Density (#/m <sup>3</sup> )	TUYA	9/23/88	2	12:00		2.1333			2506.6700	83.2	480	3013	2133.33	27.7333	8246.4	CAL=020
Mean size (mm)	TUYA	9/23/88	1	12:45		0.5562	1.1517		0.8885	2.812	0.9446	0.2281	0.1843		0.4593	
Mean size (mm)	TUYA	9/23/88	2	12:00		0.8318			0.8566	2.7814	0.8517	0.2273	0.1825	1.2355	0.4726	
Biomass (mg/m3)	TUYA	6/10/89	2	9:30			1.5995		239.9800		5.5256	4.7865	2.649	259.57	254.54	
Density (#/m <sup>3</sup> )	TUYA	6/10/89	2	9:30			14.9333		12373.1421		110.93	3596.19	3230.48	2.1333	19327.6922	LGB=FISH LARVA

## Appendix 4 cont'd.

Property	Lake	Date	Site	Time	DIA	BOS	DPH	HOL	CYC	CAL	DPT	NP	ROT	LGB	TOT	Comments
Mean size (mm)	TUYA	6/10/89	2	9:30			1.1715		0.6372		0.96576	0.2422	0.1362	3.6025	0.4826	
Biomass (mg/m3)	TUYA	6/20/89	1	12:00			1.2796		190.8600		9.9719	8.6807	1.4694	0.009	212.27	
Density (#/m <sup>3</sup> )	TUYA	6/20/89	1	12:00			7.2		10303.8612		1600	4288	1792	0.32	17991.1946	LGB=UNK INSECT HEAD WIDTH
Mean size (mm)	TUYA	6/20/89	1	12:00			1.4708		0.6436		0.4345	0.2649	0.0918	0.2194	0.4801	
Biomass (mg/m3)	TUYA	7/15/89	1	10:00			9.6238		158.7400	42.7638	215.13	1.0643	6.0177		433.34	
Density (#/m <sup>3</sup> )	TUYA	7/15/89	1	10:00			38.4		7850.6700	81.92	4352	4352	7338.67		24013.1979	CAL=020
Mean size (mm)	TUYA	7/15/89	1	10:00			1.6314		0.6844	2.2105	0.8986	0.1343	0.1047		0.4531	
Biomass (mg/m3)	TUYA	8/28/89	1	14:00			45.2537		274.6700	25.4263	13.2681	2.0596	0.6822		361.36	
Biomass (mg/m3)	TUYA	8/28/89	2	13:00			15.4819		229.0000	41.4282	11.69	2.079	2.3179		301.99	
Density (#/m <sup>3</sup> )	TUYA	8/28/89	1	14:00			204.8		9792.0000	33.28	448	8256	832		19565.9077	CAL=020
Density (#/m <sup>3</sup> )	TUYA	8/28/89	2	13:00			142.93		7040.0000	64	320	6080	2826.67		16473.277	CAL=020
Mean size (mm)	TUYA	8/28/89	1	14:00			1.404		0.7713	2.6109	0.7893	0.1355	0.0907		0.4842	
Mean size (mm)	TUYA	8/28/89	2	13:00			1.1057		0.8090	2.3555	0.8555	0.1535	0.1171		0.4578	
Biomass (mg/m3)	TUYA	10/1/89	1	12:00			35.1209		120.0600	16.5877	21.7467	0.7122	2.4891		196.71	
Density (#/m <sup>3</sup> )	TUYA	10/1/89	2	12:30			148.86		122.5000	54.1979	14.7679	1.4081	1.4245		343.2	
Density (#/m <sup>3</sup> )	TUYA	10/1/89	1	12:00			219.43		4352.0000	21.3333	621.71	2560	3035.43		10809.8583	CAL=020
Density (#/m <sup>3</sup> )	TUYA	10/1/89	2	12:30			518.1		3596.1900	58.1333	335.24	3382.86	1737.14		9627.66	CAL=020
Mean size (mm)	TUYA	10/1/89	1	12:00			1.3754		0.7656	2.6228	0.8338	0.1425	0.0953		0.4498	
Mean size (mm)	TUYA	10/1/89	2	12:30			1.6366		0.8306	2.8088	0.9153	0.1654	0.1113		0.5254	
Biomass (mg/m3)	TUYA	6/6/90	1			0.3035			146.3000		11.3904	7.6347	1.6094	569.88	167.24	
Biomass (mg/m3)	TUYA	6/6/90	2						146.7900		9.0824	6.3648	2.5803		164.82	
Density (#/m <sup>3</sup> )	TUYA	6/6/90	1			10.24			6144.0000		240.64	6144	1962.67	5.12	14506.4117	LGB=FISH LARV.
Density (#/m <sup>3</sup> )	TUYA	6/6/90	2						6346.6700		185.6	6613.33	3146.67		16292.21	
Mean size (mm)	TUYA	6/6/90	1			0.5098			0.6388		0.9397	0.233	0.1011	3.4865	0.4001	
Mean size (mm)	TUYA	6/6/90	2						0.6289		0.953	0.2151	0.1031		0.3631	
Biomass (mg/m3)	TUYA	7/16/90	1	10:30					69.5137	97.0425	116.3	0.5772	4.8631		288.3	
Biomass (mg/m3)	TUYA	7/16/90	2	9:50					39.1936	98.8975	88.8553	0.3949	3.4237		230.76	
Density (#/m <sup>3</sup> )	TUYA	7/16/90	1	10:30					2304.0000	121.6	2645.33	4053.33	5930.67		15054.627	CAL=020
Density (#/m <sup>3</sup> )	TUYA	7/16/90	2	9:50					1371.4300	157.87	1950.48	1645.71	4175.24		9300.72	CAL=020
Mean size (mm)	TUYA	7/16/90	1	10:30					0.7831	2.6235	0.8656	0.1102	0.0923		0.3592	
Mean size (mm)	TUYA	7/16/90	2	9:50					0.7446	2.3959	0.8616	0.1334	0.0971		0.3983	
Biomass (mg/m3)	TUYA	10/7/90	1	15:00		0.0169	0.0524		131.2300	44.2416	21.3962	1.5293	0.4023	0.0069	198.88	
Density (#/m <sup>3</sup> )	TUYA	10/7/90	2	16:00			0.1475	0.048	56.4030	23.5169	21.1138	1.9691	1.6619		104.86	
Density (#/m <sup>3</sup> )	TUYA	10/7/90	1	15:00		0.4267	1.28		2752.0000	43.093	384	3328	490.67	0.4267	6999.89	CAL=020, LGB=UNK INSECT (HEA
Density (#/m <sup>3</sup> )	TUYA	10/7/90	2	16:00			2.1333	0.8	1344.0000	25.8667	384	4373.33	2026.67		8156.8	CAL=020
Mean size (mm)	TUYA	10/7/90	1	15:00		0.5921	0.9207		0.9221	2.9063	1.0003	0.1688	0.0905	0.1836	0.5221	
Mean size (mm)	TUYA	10/7/90	2	16:00			1.0739	1.0216	0.8617	2.7754	0.9933	0.1657	0.0976		0.311	
Biomass (mg/m3)	TUYA	6/18/91	1	8:00			0.4345		274.2400		4.7187	9.7383	0.3499		289.48	
Density (#/m <sup>3</sup> )	TUYA	6/18/91	1	8:00			2.56		4480.0000		197.12	6826.67	426.67		11933.0099	
Mean size (mm)	TUYA	6/18/91	1	8:00			1.481		0.9468		0.6541	0.2344	0.0786		0.5035	
Biomass (mg/m3)	TUYA	7/23/91	1				5.6607	0.0538	79.7070	61.753	241.79	3.3904	8.0469		400.4	
Density (#/m <sup>3</sup> )	TUYA	7/23/91	1				22.4	1.0667	4266.6700	65.0667	8533.33	24746.2844	9813.33		47448.2282	CAL=020
Mean size (mm)	TUYA	7/23/91	1				1.6066	0.9897	0.6613	2.8138	0.7323	0.1095	0.0919		0.2719	
Biomass (mg/m3)	TUYA	9/4/91	1			0.743	5.6187	0.2728	103.8900	25.4612	8.0603	2.4873	8.3268		154.86	
Density (#/m <sup>3</sup> )	TUYA	9/4/91	1			35.84	74.24	5.12	2304.0000	23.04	250.88	8021.33	10154.534		20868.9212	CAL=020
Mean size (mm)	TUYA	9/4/91	1			0.4326	1.0256	0.9864	0.9171	2.9907	0.7963	0.1486	0.0898		0.2195	
Biomass (mg/m3)	TUYA	10/10/91	1	10:30		0.075	3.4558	0.0035	52.0147	13.4707	5.4525	1.6399	1.0496		77.1617	
Density (#/m <sup>3</sup> )	TUYA	10/10/91	1	10:30		7.3143	10.9714	1.8286	1408.0000	14.6286	138.97	6869.33	1280		9731.05	CAL=020, HOL=141
Mean size (mm)	TUYA	10/10/91	1	10:30		0.3131	1.7471	0.3338	0.8465	2.7965	0.8749	0.135	0.0754		0.2467	
Biomass (mg/m3)	TUYA	6/25/92	1			0.1538			281.1200		1.6441	2.7225	0.2099		285.85	
Biomass (mg/m3)	TUYA	6/25/92	2			7.3078	2.9341		455.9100		1.7735	9.6339	1.0496		478.61	
Density (#/m <sup>3</sup> )	TUYA	6/25/92	1			5.12			10495.9076		102.4	1792	256		12651.4412	

## Appendix 4 cont'd.

Property	Lake	Date	Site	Time	DIA	BOS	DPH	HOL	CYC	CAL	DPT	NP	ROT	LGB	TOT	Comments
Density (#/m <sup>3</sup> )	TUYA	6/25/92	2			426.67	51.2		19199.9457		89.6	4693.33	1280		25740.6791	
Mean size (mm)	TUYA	6/25/92	1			0.5093			0.7496		0.594	0.266	0.1822		0.6683	
Mean size (mm)	TUYA	6/25/92	2			0.4035	0.9743		0.7154		0.6159	0.2784	0.211		0.6056	
Biomass (mg/m <sup>3</sup> )	TUYA	7/26/92	1				0.314	0.1449	256.1000	6.8455	128.89	2.5836	0.6298		395.5	
Biomass (mg/m <sup>3</sup> )	TUYA	7/26/92	2						240.7200	0.6522	93.6973	4.214	1.7712	330.26	341.05	
Density (#/m <sup>3</sup> )	TUYA	7/26/92	1				2.24	7.36	14335.7362	19.84	3712	2560	768		21405.235	CAL=020
Density (#/m <sup>3</sup> )	TUYA	7/26/92	2						13919.7040	3.2	2560	10079.9876	2160	3.2	28726.3204	LGB=900, CAL=020
Mean size (mm)	TUYA	7/26/92	1				1.367	0.6775	0.6475	1.855	0.8152	0.2	0.1116		0.6051	
Mean size (mm)	TUYA	7/26/92	2						0.6357	1.6158	0.8286	0.1571	0.1045	3.4112	0.4454	
Biomass (mg/m <sup>3</sup> )	TUYA	8/24/92	1				0.5418	0.843	573.2000	14.3563	0.9481	7.1122	0.2099		597.21	
Density (#/m <sup>3</sup> )	TUYA	8/24/92	1				7.68	21.12	13823.8814	11.52	36.88	11263.9315	256		25410.8972	CAL=020
Mean size (mm)	TUYA	8/24/92	1				1.0046	0.8298	0.8923	3.1202	0.8144	0.1808	0.1281		0.5701	
Biomass (mg/m <sup>3</sup> )	TUYA	8/25/92	2				0.2312	1.3777	534.5200	6.6927	1.9574	11.5745	0.2332		556.58	
Density (#/m <sup>3</sup> )	TUYA	8/25/92	2				5.3333	35.2	15075.4401	5.3333	52.2667	23039.8687	284.44		38497.2759	CAL=020
Mean size (mm)	TUYA	8/25/92	2				0.9294	0.8562	0.8414	3.1388	0.8543	0.1576	0.1163		0.4271	
Biomass (mg/m <sup>3</sup> )	TUYA	9/18/92	1				1.3694	1.4442	853.8200	5.8206	2.4303	3.8191	0.4198		869.13	
Biomass (mg/m <sup>3</sup> )	TUYA	9/18/92	2				0.1142	1.7141	303.2500	1.7555	2.0271	19.0269			327.88	
Density (#/m <sup>3</sup> )	TUYA	9/18/92	1				6.4	24.32	23039.8687	5.12	51.2	12799.7062	512		36438.4588	CAL=020
Density (#/m <sup>3</sup> )	TUYA	9/18/92	2				2.1333	37.3333	8533.3300	3.2	42.6667	17066.3245			25685.0254	CAL=020
Mean size (mm)	TUYA	9/18/92	1				1.3907	1	0.8506	3.0307	0.93	0.1409	0.073		0.591	
Mean size (mm)	TUYA	9/18/92	2				0.9952	0.9068	0.8454	2.2636	0.9384	0.2295			0.4366	
Biomass (mg/m <sup>3</sup> )	TUYA	6/16/93	1	23:00				0.0484	466.4900		0.4119	6.286	2.7989	472.99	476.03	
Biomass (mg/m <sup>3</sup> )	TUYA	6/16/93	2				0.0264	0.146	121.2700		0.866	4.7838	4.9331	167.18	132.03	
Density (#/m <sup>3</sup> )	TUYA	6/16/93	1	23:00				30.9333	12799.7062		68.2667	613.33	3413.33	9.6	22935.0663	LGB=900
Density (#/m <sup>3</sup> )	TUYA	6/16/93	2				2.56	84.48	4992.0000		184.32	4352	6016	2.56	15633.6361	LGB=900
Mean size (mm)	TUYA	6/16/93	1	23:00				0.3088	0.7911		0.4242	0.204	0.0977	2.6363	0.5177	
Mean size (mm)	TUYA	6/16/93	2					0.5843	0.3213	0.6916	0.4036	0.2208	0.1101	2.9286	0.3317	
Biomass (mg/m <sup>3</sup> )	TUYA	8/4/93	1			0.0489	0.3768	1.5845	164.3000	25.0296	97.9433	1.8187	7.4172		298.52	
Biomass (mg/m <sup>3</sup> )	TUYA	8/4/93	2				0.1646	42.6239	61.8923	15.4306	59.8842	0.615	3.382		183.99	
Density (#/m <sup>3</sup> )	TUYA	8/4/93	1			1.0237	2.0473	51.1836	5973.3300	20.4734	4096	8874.67	9045.33		28064.0277	CAL=020
Density (#/m <sup>3</sup> )	TUYA	8/4/93	2				0.5333	2346.67	2204.4400	12.2667	2204.44	2631.11	4124.44		13523.8393	CAL=020
Mean size (mm)	TUYA	8/4/93	1			0.646	1.4325	0.788	0.7588	3.1067	0.6429	0.1265	0.0924		0.329	
Mean size (mm)	TUYA	8/4/93	2				1.8061	0.6564	0.7493	3.1397	0.642	0.1302	0.0965		0.3984	
Biomass (mg/m <sup>3</sup> )	TUYA	9/1/93	1		0.0241			4.0137	298.9100	5.6764	2.2239	1.4853	2.729		315.06	
Biomass (mg/m <sup>3</sup> )	TUYA	9/1/93	2					5.4953	65.7325	3.0071	2.8154	0.9077	1.7318		79.6899	
Density (#/m <sup>3</sup> )	TUYA	9/1/93	1		2.56			138.24	8704.0000	5.12	107.52	6784	3328		19069.0914	CAL=020, DIA=141
Density (#/m <sup>3</sup> )	TUYA	9/1/93	2					117.76	1984.0000	2.56	94.72	4864	2112		9175.04	CAL=020
Mean size (mm)	TUYA	9/1/93	1		0.5672			0.7874	0.8321	3.0014	0.6532	0.1312	0.0933		0.4531	
Mean size (mm)	TUYA	9/1/93	2					0.923	0.8195	3.0691	0.7395	0.1232	0.0862		0.2827	
Biomass (mg/m <sup>3</sup> )	TUYA	6/18/94	2	19:00	0.7091		0.0479	0.0298	824.3800		0.6934	3.1993	9.0965		838.15	
Density (#/m <sup>3</sup> )	TUYA	6/18/94	2	19:00	16		0.5333	5.8667	52905.3997		10.6667	2133.33	11093.2806		66165.2564	DIA=juv epi or heterocope
Mean size (mm)	TUYA	6/18/94	2	19:00	0.9415		1.199	0.4558	0.6065		1.0485	0.2607	0.1674		0.5219	
Biomass (mg/m <sup>3</sup> )	TUYA	7/28/94	1	15:30		14.3473	21.2283		881.7200		22.5413	2.2504	0.4198		942.51	
Biomass (mg/m <sup>3</sup> )	TUYA	7/28/94	2	18:00					2492.0700		52.9712	6.1127	1.3995		2552.55	
Density (#/m <sup>3</sup> )	TUYA	7/28/94	1	15:30		328.21	287.18		24063.5668		164.1	5632	512		30987.0334	
Density (#/m <sup>3</sup> )	TUYA	7/28/94	2	18:00					58878.9423		221.87	15359.957	1706.67		76167.5524	
Mean size (mm)	TUYA	7/28/94	1	15:30		0.6109	10843		0.8392		1.3749	0.1628	0.1222		0.7071	
Mean size (mm)	TUYA	7/28/94	2	18:00					0.8903		1.6657	0.1625	0.1299		0.7288	
Biomass (mg/m <sup>3</sup> )	TUYA	9/4/94	1	13:30		0.1787		29.6238	1091.5300		20.5623	10.6413	0.5598		1153.1	
Biomass (mg/m <sup>3</sup> )	TUYA	9/4/94	2					77.4775	2622.3400		22.2022	16.1234	6.2976		2744.45	
Density (#/m <sup>3</sup> )	TUYA	9/4/94	1	13:30		5.12		373.76	28330.2235		153.6	15359.957	682.67		44905.5479	
Density (#/m <sup>3</sup> )	TUYA	9/4/94	2					819.2	62293.1080		187.73	17066.3245	7680		88046.0749	

## Appendix 4 cont'd.

Lake	Date	Site	Time	DIA	BOS	DPH	HOL	CYC	CAL	DPT	NP	ROT	LGB	TOT	Comments
TUYA	9/4/94	1	13:30		0.5592		1.0224	0.8684		1.3309	0.1993	0.1387		0.6313	
TUYA	9/4/94	2					1.0881	0.8950		1.2609	0.221	0.1841		0.7049	
TUYA	8/1/95	1	14:00		2.7074	0.7502	181.43	4.7320		31.636	5.785	4.7232		231.77	
TUYA	8/1/95	2	18:45		18.9096	0.5474	278.65	4.5673		52.5841	8.0748	6.7058		369.95	
TUYA	8/1/95	1	14:00		213.33	27.7333	4010.67	83.2000		1194.67	4053.33	5760		15342.6366	
TUYA	8/1/95	2	18:45		711.11	32	6186.67	80.0000		1777.78	4622.22	8177.78		21587.3832	
TUYA	8/1/95	1	14:00		0.3491	0.7401	0.8701	0.9868		0.6882	0.2539	0.1236		0.406	
TUYA	8/1/95	2	18:45		0.4727	0.6543	0.8385	0.9696		0.716	0.2694	0.1193		0.4223	
TUYA	9/11/95	1			22.4274	218.48		1.6228		573.05	7.6924	0.4198		823.69	
TUYA	9/11/95	2		0.0936	40.1685	94.1665		114.6400		407.14	5.0428	0.8528		662.1	
TUYA	9/11/95	1			1024	12799.7062		43.7333		22783.4769	5888	512		43051.6697	
TUYA	9/11/95	2		0.8	1680	5680		2720.0000		9120	3760	1040		24000.484	
TUYA	9/11/95	1			0.4508	0.6511		0.8301		0.709	0.2466	0.1064		0.6153	
TUYA	9/11/95	2		1.3091	0.462	0.6582		0.8840		0.8229	0.2471	0.1131		0.6446	