CENTRAL REGION LIMNOLOGY
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TABLE OF CONTENTS

Section | **Page**

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (continued)

Figure **Page**

ABSTRACT

Edmundson, J. A., G. L. Todd. 2001. Central Region Limnology 2001 annual report of progress. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 2A01-16:48 pp.

The Alaska Department of Fish and Game (ADF&G), Central Region Limnology (CRL) program provides technical support for research activities in upper and lower Cook Inlet, Bristol Bay, and Prince William Sound areas including fish stock assessment, aquatic resource surveys, ecological studies, and salmon enhancement/restoration (e.g., nutrient enrichment and fry stocking programs). A key component of CRL is the integration of ecological data with fisheries information to assess carrying capacity of aquatic systems, evaluate salmon escapement goals, and to develop quantitative models that improve management of fish stocks. In addition, CRL laboratory provides technical support of various fisheries and limnological projects with other state, federal, and non-profit aquaculture associations. An overview of program organization and field and laboratory research highlights over the past fiscal year 2001 is presented. We also include an assessment of limnological and fisheries data relative to the current and proposed escapement goals for sockeye salmon for several systems in Upper Cook Inlet (UCI). This report is also designed to provide results of CRL's annual quality control and quality assurance program, statistical evaluations of analytical methodologies, and updated field and laboratory methods, in order to promote regional as well as statewide standardization and consistency in methods for assessing aquatic production.

INTRODUCTION

This status report is the second in a series summarizing the annual progress of research and activities of the Alaska Department of Fish and Game (ADF&G), Division of Commercial Fisheries, Central Region Limnology (CRL) program. The desired outcome of CRL is to advance fishery and aquatic science through developing research information (analytical results) and conducting fisheries research activities in upper and lower Cook Inlet, Prince William Sound, and Bristol Bay areas. Research activities include fisheries monitoring, stock assessments, aquatic resource surveys, biological investigations, and limnological evaluations. Reflecting on the objectives within CRL, the current mission statement is as follows:

The overall mission of the Division of Commercial Fisheries, Central Region Limnology is to (1) integrate ecological data to assess sustainability of commercial salmon production and (2) provide technical support of projects related to management and development of commercial fishery stocks and to promote aquatic resource conservation. The laboratory analyzes water and biological samples collected from lake and riverine systems on a contractual basis with state, federal, and private non-profit agencies for projects involving the evaluation of salmon escapement goals, assessment of aquatic productivity, and enhancement activities. Technical support for non-region projects are prioritized based on applicability to commercial fishery management needs, continuance of long-term data sets, administrative demands and funding.

In keeping with the above mission statement, CRL projects within Region II receive top priority. After fulfilling regional research and management needs, CRL also develops cooperative agreements for processing samples for non-region projects provided they meet specific criteria. First, CRL accepts projects in which the scientific information can be used to develop techniques and models to assess fisheries production. We encourage data sharing and cooperative endeavors that elucidate major factors, processes, and underlying mechanisms regulating aquatic production. To that end, water or biological samples to be analyzed by CRL must be collected using standardized procedures detailed in our field and laboratory manual (Koenings et al. 1987). Second, applied limnological and ecological concepts toward developing integrated salmon production models can require the collection of data over many years. For example, the dependence of juvenile salmon production on lake/riverine physical characteristics, forage availability, and density-dependent factors argues for including ecological data in stock-recruit modeling. Such an approach may lead to improvements in the ability to forecast fish stocks. As such, CRL continues to provide technical support for projects with significant and long-term data sets. On the other hand, CRL does not develop or accept new projects in areas where the information obtained is unrelated to the missions of ADF&G Division of Commercial Fisheries and CRL. Third, because of the cumulative time and cost for developing multiple cooperative agreements and budget tracking, CRL prefers that all administrative functions associated with initiating and implementing cooperative projects in other regions be handled by ADF&G personnel within their respective area/region. Fourth, cooperative agreements must meet a minimum funding level to cover all direct and indirect costs based on the current laboratory fee schedule.

Our objective in this report is to provide a summary of recent research accomplishments and overall program direction (status) of CRL. In addition, our annual report serves as a conveyance of addendum or errata associated with publications, refinement of methods or development of new technology or analyses. We also include results of our annual laboratory quality control and assurance program for fiscal year 2001 (01 July 2000 to 30 June 2001). This report is our second annual report of progress and we hope program reviewers will find it helpful in assessing fisheries research within Central Region.

PROGRAM ORGANIZATION and BUDGET

CRL is under the responsibility of the Upper and Lower Cook Inlet Regional Management Biologist. The existing research program has two permanent staff members including project leader and six long-term seasonal biologists and technicians (Figure 1). The project leader or principal investigator oversees all regional CRL staff and projects dealing with fisheries stock assessment, fish stocking, nutrient enrichment, and water-quality monitoring. CRL staff provides technical support for such projects and they participate in cooperative projects with state and federal agencies, non-profit aquaculture associations, universities, and public resource awareness groups. CRL operates a centralized laboratory in Soldotna where water chemistry, nutrients, plankton, and fish samples are sent from around Region II and elsewhere in the State to be processed and analyzed. For fiscal year (FY) 2001, CRL received $91,000 (27%) in general funds and $244,700 (73%) in total program receipts from other State and federal agencies, non-profit associations, and the *Exxon Valdez* Oil Spill (EVOS) trustee council (Table 1).

RESEARCH HIGHLIGHTS

Program highlights in the past year include fisheries research directed toward (1) determining the depensatory mechanism(s) that cause or maintain the cycles in sockeye production of the Kvichak (Lake Iliamna) system stock (Bristol Bay), (2) assessing the existing and proposed escapement goals for five sockeye salmon stocks (upper Cook Inlet), (3) developing regional nutrient criteria for water quality and fisheries (upper Cook Inlet), and (4) technical support (laboratory analysis of samples) of various fisheries and limnological projects throughout Region II, as well as in other areas of the State. The following is a brief overview of each of the projects and important findings.

Juvenile Sockeye Salmon Assessment and Limnological Studies of Lake Iliamna

The U. S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service funded this three-year (1999-2002) project in response to the recent (1997-1998) poor returns of sockeye salmon in western Alaska. This Western Alaska Disaster Grant (WADG) project is a joint venture with University of Alaska Fairbanks and University of Washington, Fisheries Research Institute (UW-FRI) to examine freshwater aspects of sockeye salmon production in the Kvichak River system. Currently, our research activities are largely involved in the data collection phase. CRL is conducting limnological surveys on a monthly basis at 5 sites representing Pedro Bay, Knutson Bay, Pile Bay (East and West), and off

CENTRAL REGION LIMNOLOGY

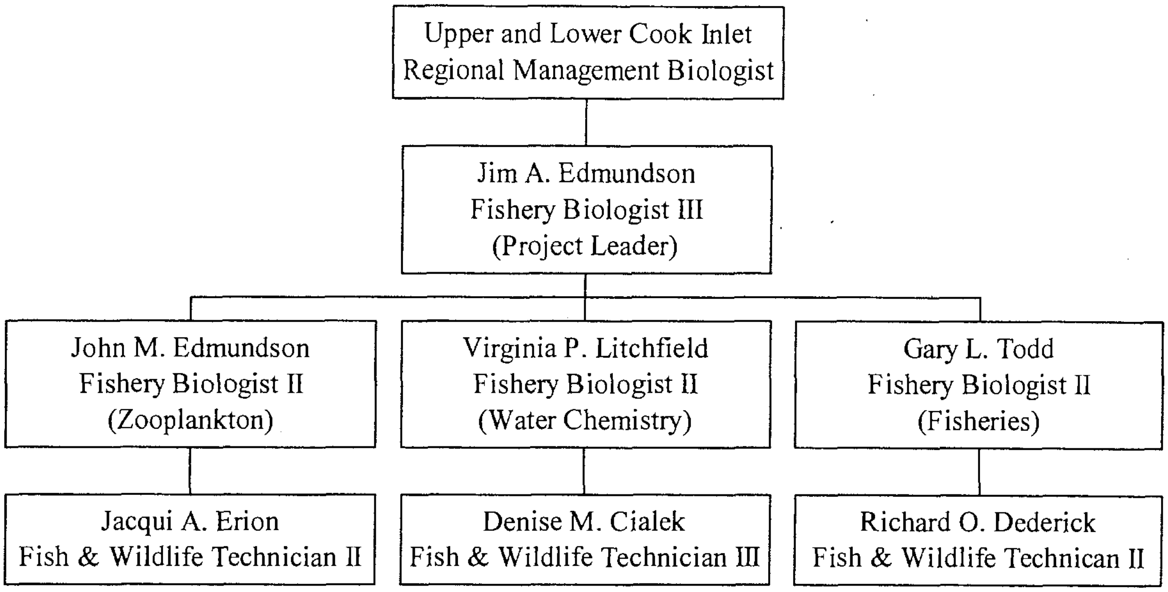

Figure 1. Organizational chart for Central Region Limnology, fiscal year 2001.

Table 1. Funding category, amount, and percentage of the total fiscal year 2001 budget including general funds and program receipts for Central Region Limnology.

Source	Amount (thousands)	Percentage (%)
General Fund Allocation	$91.0	27.1
State (pass through)	$57.1	17.0
Federal	$146.0	43.5
Private non-profit	$35.9	10.7
EVOS[a]	$5.7	1.7
TOTAL	$335.7	100.0

a/ *Exxon Valdez* oil spill

Woody (Flat) Island to obtain information on lake physical conditions, nutrient concentrations, and plankton abundance and biomass. We also developed a new automated method for processing zooplankton samples using an optical plankton counter. This method allows us to process more samples in a shorter time frame. The output gives size distribution of plankton that we hope will be useful to assess impacts of consumers (i.e., planktivorous sockeye fry) on their food resources. UW-FRI staff are currently analyzing fry samples collected in fall (August-September) 2000 and 2001. Dr. Bruce Finney from University of Alaska Fairbanks (UAF), in cooperation with ADF&G, analyzed 70 samples for $\delta^{15}N$ from the Knutson Bay sediment core from the period before commercial fishing. The samples were finely spaced, and based on sedimentation rates from the location of the Katmai 1912 ash layer, they were estimated to be approximately of 1-year duration. Interpretation of the data is still in progress to determine if cyclic changes in sockeye production occurred prior to commercial fishing. Additional sediment samples will be processed from the modern era for comparison. For the Two-Headed Island site core, UAF analyzed 170 samples for $\delta^{15}N$. These data will provide a longer-term view of sockeye abundance and are being finalized and interpretation is in progress. Dr. Ole Mathisen (UAF) is developing a stationary ECOPATH (Christen and Pauly 1992) model for Lake Iliamna. The preliminary results indicate that this model is similar to another model developed for Lake Becharof (Mathisen and Sands 1999) and that the sockeye salmon nursery lakes in the Bristol Bay area are similar in their trophic relationships. In both cases, results indicate Apex predators may be very important and are the most unknown quantities regulating the dynamic relationships of the Lake Iliamna ecosystem. Dr. Mathsien presented a portion of this research component at the 28th Congress of the International Association of Limnology, Melborne, Australia, 05-09 February 2001. The following paper was accepted for publication:

Mathisen, O. A., N. J. Sands, and N. Haubenstock. 2001. Trophic ranking of the biota in Iliamna Lake, Alaska. *Verhandlungen Internationale Vereinigung fur Theoretische und Angewandte Limnologie.* (In press).

Collectively, results of this cooperative project will be used to better understand sockeye production (e.g., carrying capacity) of the Kvichak River system and to aid fishery managers in setting escapement goals so the stock can be optimally managed.

Limnological Evaluation of Upper Cook Inlet Escapement Goals for Sockeye Salmon

We (CRL) reviewed the limnological and fisheries data relative to the current and proposed escapement goals for select systems in Upper Cook Inlet (UCI). Our analysis and discussion is intended to supplement the analyses and technical input provided by the UCI area staff in preparation for this winter's (2002) Board of Fisheries meeting. Specifically, our evaluation of Kenai River sockeye centered on analysis of 14 years of fry, zooplankton, and environmental data from Skilak/Kenai lakes in conjunction with stock-recruit information. For Crescent River sockeye, we compared zooplankton and turbidity data between the early 1980s and late 1990s for Crescent Lake. Results of a long-term sockeye enhancement program at Packers Lake provided us an opportunity to assess carrying capacity of the Packers Creek system through analysis of trophic interactions in response to fertilization and stocking. We compared historic and recent data on nutrients to assess the trophic state of Big Lake and examined fry stocking levels in relation to recruitment in Fish Creek. As to Kasilof River sockeye, we examined smolt and zooplankton information in conjunction with adult return data. Because we lack comprehensive limnological data from lakes within the Northern District, we have not addressed escapement goals for Susitna River or Yentna River sockeye salmon.

Kenai River

Over the past 30 years, escapements (and escapement goals) for the Kenai River sockeye, have increased markedly (Figure 2). Our research has demonstrated that large escapements produce larger fry populations. For example, for rearing years 1986-2000 a significant, positive relationship existed between spawner abundance and the number of sockeye salmon fry (estimated from hydroacoustic and tow-net surveys) rearing in the fall (Figure 3A-B). In this model, fall fry counts were based on combined estimates from Skilak and Kenai lakes. However, the linear relationship accounted for only 40% of the variation in total (age-0 + age-1) fry and 35% of the variation in age-0 fry abundance, suggesting that fall fry production is not principally a function of escapement. We also found that within the range of 5 to 35 million fall fry (age-0) a reasonably strong ($r^2 = 0.47$; P=0.010) inverse relationship existed between fry abundance and size (Figure 4) suggesting density dependent growth occurs in this system. Below about 15 million fry however, fry growth (and survival) seemed largely independent of fry density. Considering this level of fall fry production (i.e., <15 million), the corresponding average number of total spawners (Kenai in-river sonar counts excluding the sport fishery harvest) and total mainstem spawners (total spawners excluding Hidden Lake enhanced sockeye and Russian River weir counts) was 660,000 and 520,000, respectively. These spawner estimates are in good agreement with the current biological escapement goal (BEG).

We further examined the variation in fall fry abundance as a function of seasonal (spring, summer, and fall) zooplankton (*Cyclops* and *Diaptomus*) biomass in Skilak Lake and the number of Kenai River mainstem spawners (MS) through stepwise multiple regression. This is the approach previously used by Schmidt et al. (1997) for the 1986-1995 data sets. Taken together, MS and spring (May-June) copepod (*Cyclops* + *Diaptomus*) biomass (SpC) accounted for 59% of the variation in total fall fry and 60% of the variation in age-0 fry (Figure 5A-B). Besides being a significant variable, SpC greatly improved the ability to predict fall fry abundance. This model differed somewhat from that originally derived by Schmidt et al. (1997). In their multivariate (3 predictors) model, fall fry abundance was strongly related ($R^2 = 0.95$) to MS, spring *Cyclops* biomass, and summer *Cyclops* biomass. In our multiple regression analysis, *Cyclops* biomass was not a significant predictor of fall fry abundance; only the variable SpC was significant. However, examination of the seasonal changes in length frequency of *Cyclops* led Schmidt et al. (1997) to conclude that this species had a two-year life history. Furthermore, they suggested spring *Cyclops* biomass was a result of summer recruitment the previous year and grazing by planktivorous sockeye fry during the summer and fall. This was a hypothesized biological mechanism underlying the Kenai River brood-year interaction ($R = Se^{[\alpha-\beta S_i S_{i-1}]}$) spawner-recruit model (Carlson et al. 1999). Simply put, the previous year's fall fry affected spring *Cyclops* biomass. Our multivariate regression model to predict fall fry still supports the hypothesized interaction between adjacent year classes as the biological basis for the brood-year interaction term (i.e., $S_i S_{i-1}$). That is, *Cyclops* makes up the lion's share of the total copepod

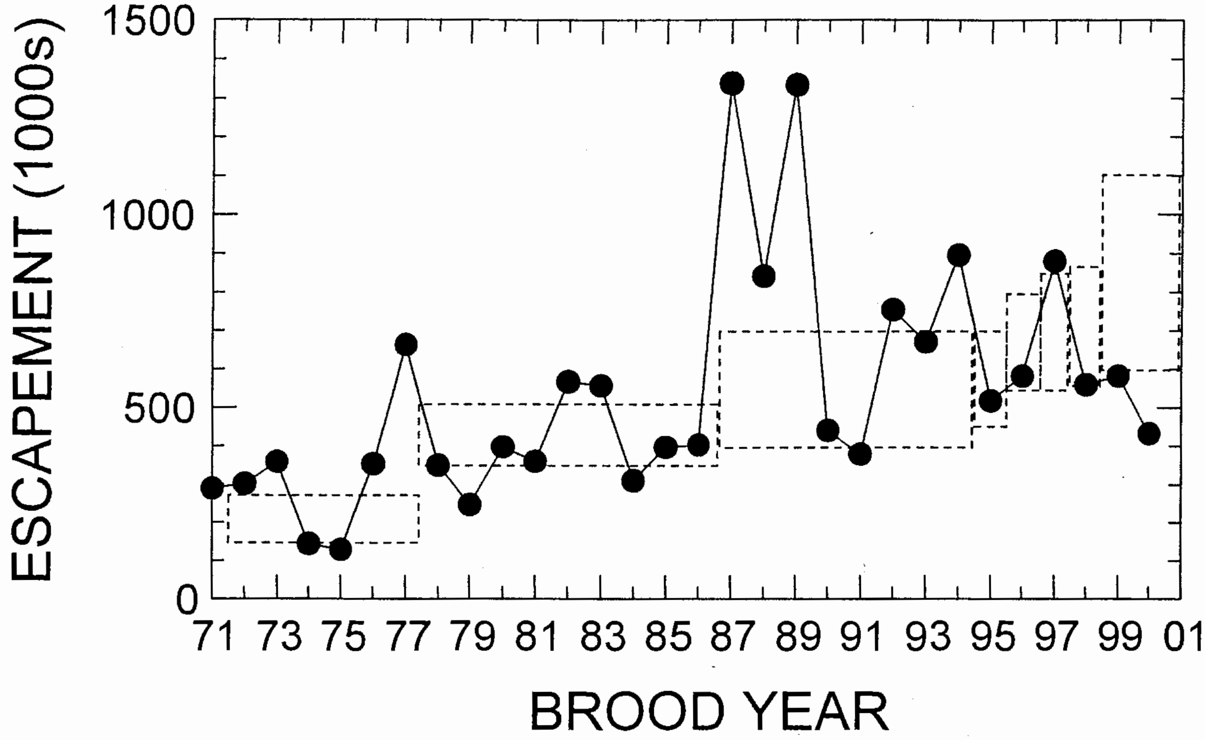

Figure 2. Sockeye escapement for the Kenai River, 1971-2000. Spawner estimates were based on sonar counts after removing escapement estimates of Russian River and Hidden Lake weir counts. Boxes indicate the optimum escapement goal range.

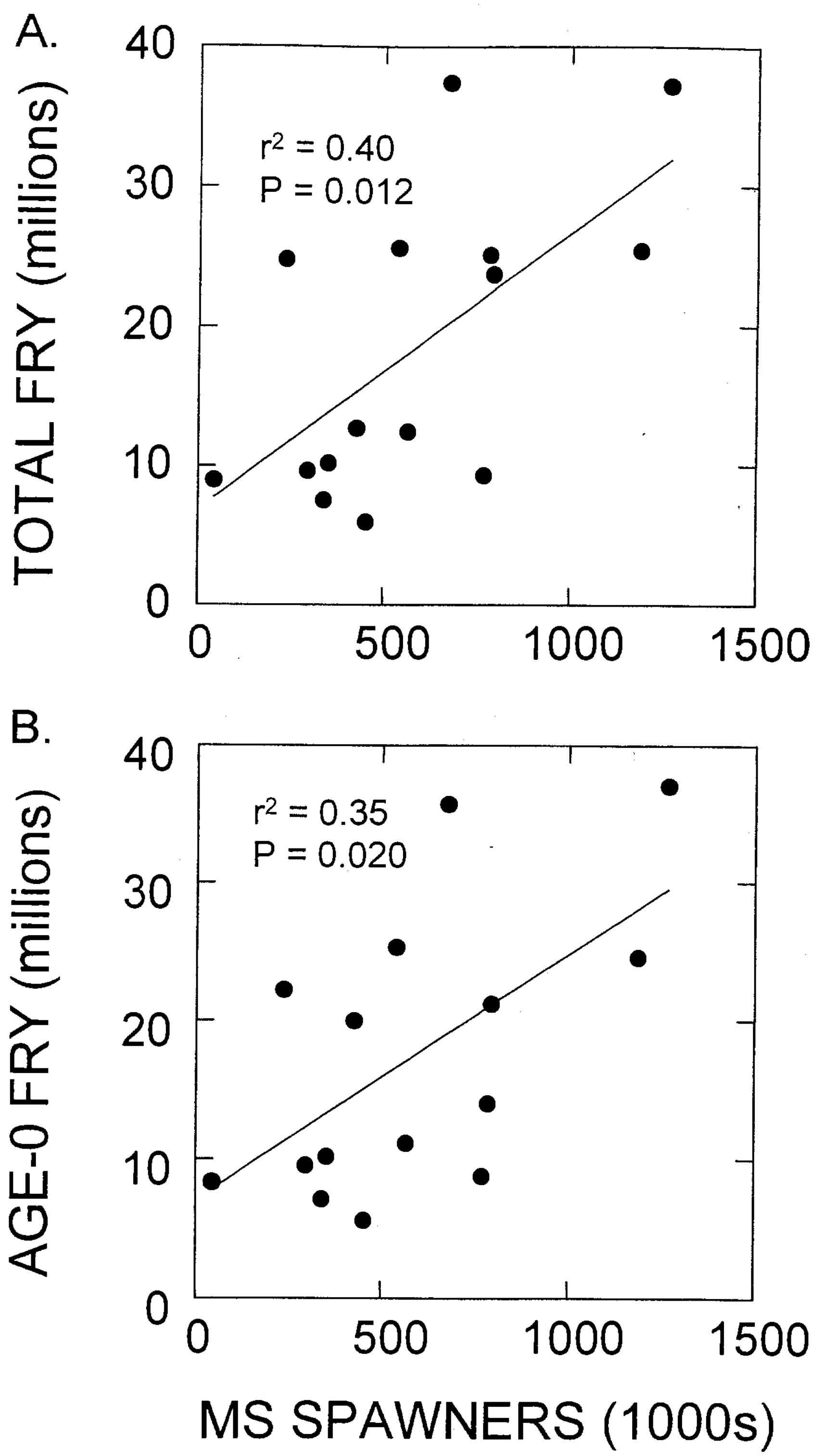

Figure 3. Relationship between the number of Kenai River mainstem (*MS*) sockeye spawners (excludes Russian River escapement and Hidden Lake enhanced sockeye) and (A) age-0 + age-1 fall fry and (B) age-0 fall fry for Skilak+Kenai lakes.

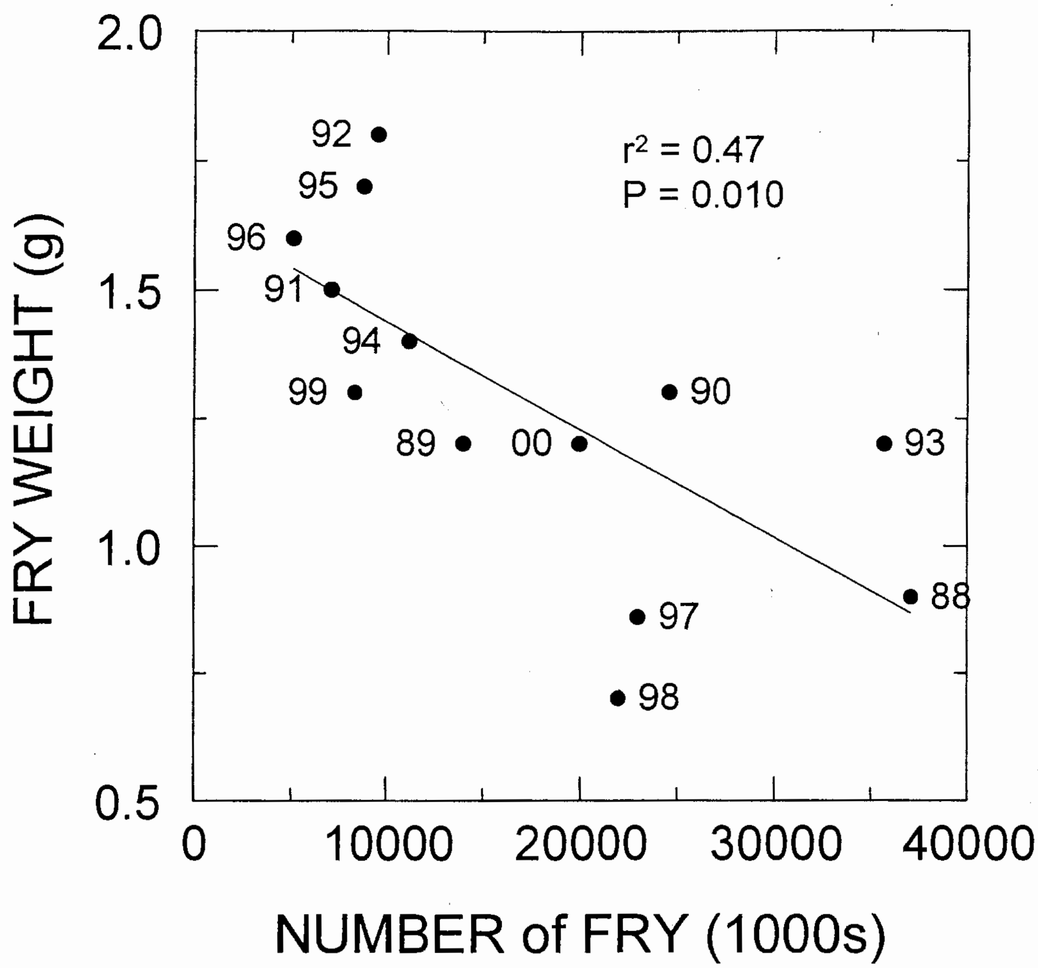

Figure 4. Relationship between age-0 sockeye fall (September) fry (Skilak + Kenai lakes) and mean weight for age-0 fry in Skilak Lake, 1988-2000. Data labels denote rearing year.

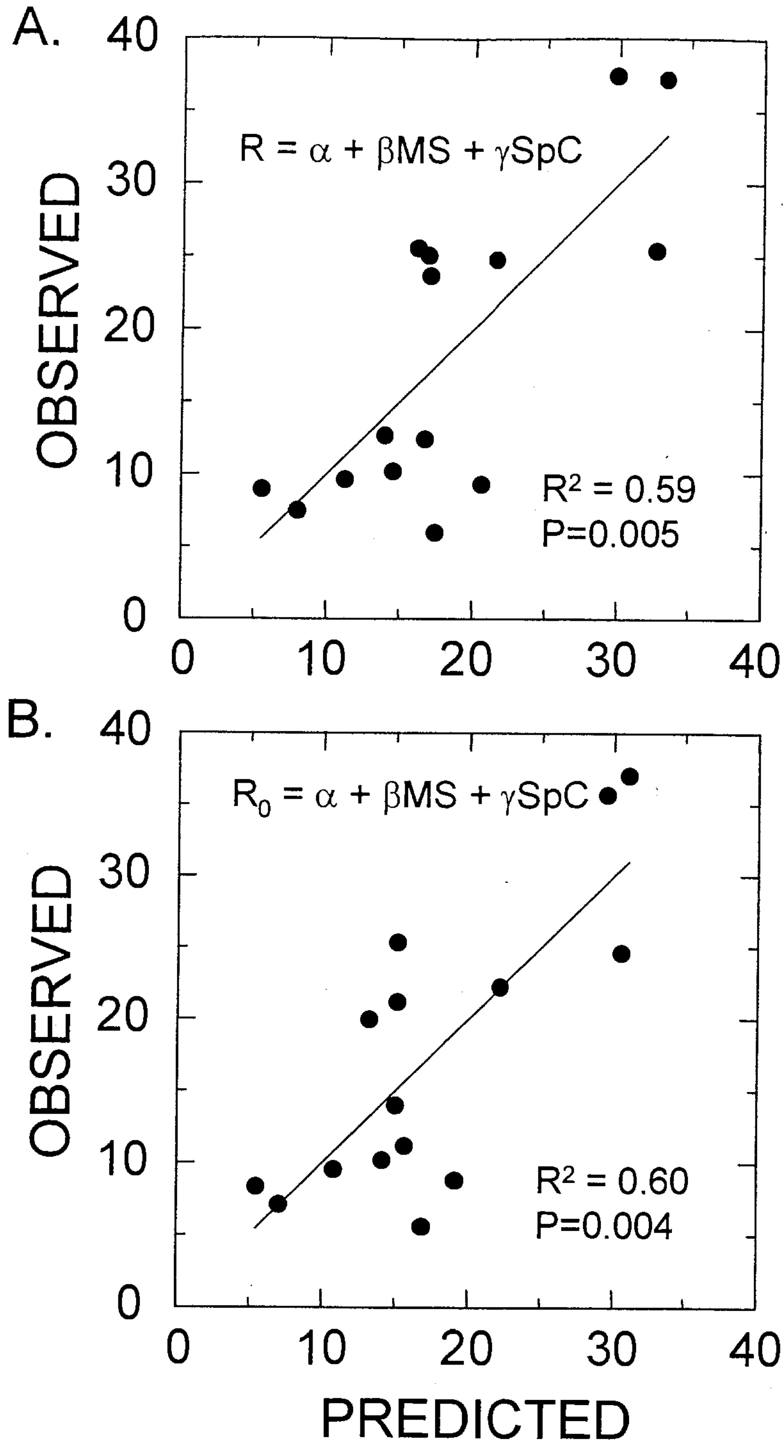

Figure 5. Plot of predicted versus observed values from multiple regression for predicting abundance of Skilak+Kenai fall fry, (A) total fall fry (R) and (B) age-0 fall fry (R_0) from mainstem spawners (*MS*) and spring (May-June) copepods (Cyclops + Diaptomus) biomass (*SpC*). R and R_0 are in millions.

biomass during the critical spring period when both age-0 and age-1 sockeye juveniles compete for the same food resource. Thus, in this system overgrazing by rearing sockeye juveniles negatively affects fry recruitment in subsequent years(s).

We understand that there may be some motivation to revise the existing escapement goal(s) upward during the 2002 Board of Fisheries meeting. This may not be an appropriate action, assuming it translates into higher fry recruitment in Skilak/Kenai lakes. Turbidity levels in Skilak Lake have increased substantially in recent years (Figure 6A-B). During 1986-1992, turbidity in the near-surface water (1 m) averaged 4.6 nephelometric turbidity units (NTU), whereas over the past 8 years (1993-2000) turbidity levels averaged 11.1 NTU. In comparison, turbidity levels in nearby Tustumena Lake vary between 40 and 50 NTU. The highest turbidity (50 NTU) in Skilak Lake coincided with the flood event in fall 1995. However, we do not believe that the current elevated turbidity levels resulted from a carry-over effect from the flood because the estimated hydraulic residence time in this lake is rather short (~8 months). Instead, the higher turbidity levels probably result from a change in the nature (size or concentration) of the particles in the glacier meltwater (Edmundson and Koenings 1985) or perhaps some regional climatic (warming) effect and its attendant silt loading. Nonetheless, a seemingly small 5-10 NTU increase in turbidity, such as that observed in Skilak Lake restricts light penetration even further (Lloyd et al. 1987; Koenings and Edmundson 1991) and lowers primary (phytoplankton) (Koenings et al. 1986; Edmundson and Carlson 1998) production. In addition, zooplankton biomass levels have decreased by approximately 30% between the 1986-1993 (mean 580 mg m^{-2}) and 1994-2000 (414 mg m^{-2}) periods (Figure 7). Thus, it appears the rearing capacity of Skilak Lake may be decreasing with higher turbidity.

Our research demonstrates that high escapements of sockeye salmon produce larger fry populations that overgraze the forage base (zooplankton), decrease juvenile sockeye growth, and increase overwinter mortality in this system. Even under optimal rearing conditions (lower fry densities and lower turbidity) juvenile sockeye rearing in Skilak/Kenai lakes are very near threshold condition (1-2 g; 10-15% fat content) to survive over the winter (Schmidt et al. 1997). Furthermore, we do not know whether the higher turbidity levels observed in this system will persist or not, but we do know that reduced plankton production and lower fish yield are tied to increased turbidity. Therefore, we strongly caution against increasing the current BEG. Unfortunately, due to budget constraints funding for fry (hydroacoustic and tow net) surveys and limnological (zooplankton, turbidity, etc.) sampling for Skilak/Kenai lakes has been discontinued. Lack of continued data collection will limit our understanding of variability in juvenile sockeye production and preclude our developing mechanistic models that integrate limnological data with stock-recruit information to better predict future adult returns.

Recommendation: 500,000-800,000 spawners.

Crescent River

Through much of the 1980s and early 1990s productivity of the Crescent River sockeye stock steadily declined as evidenced by lower adult returns (Figure 8A-B). For brood years 1984-1988 and 1990 recruit-per-spawner values fell below replacement. Concern over the decline in productivity initiated limnological studies in 1996 to determine whether sockeye production was

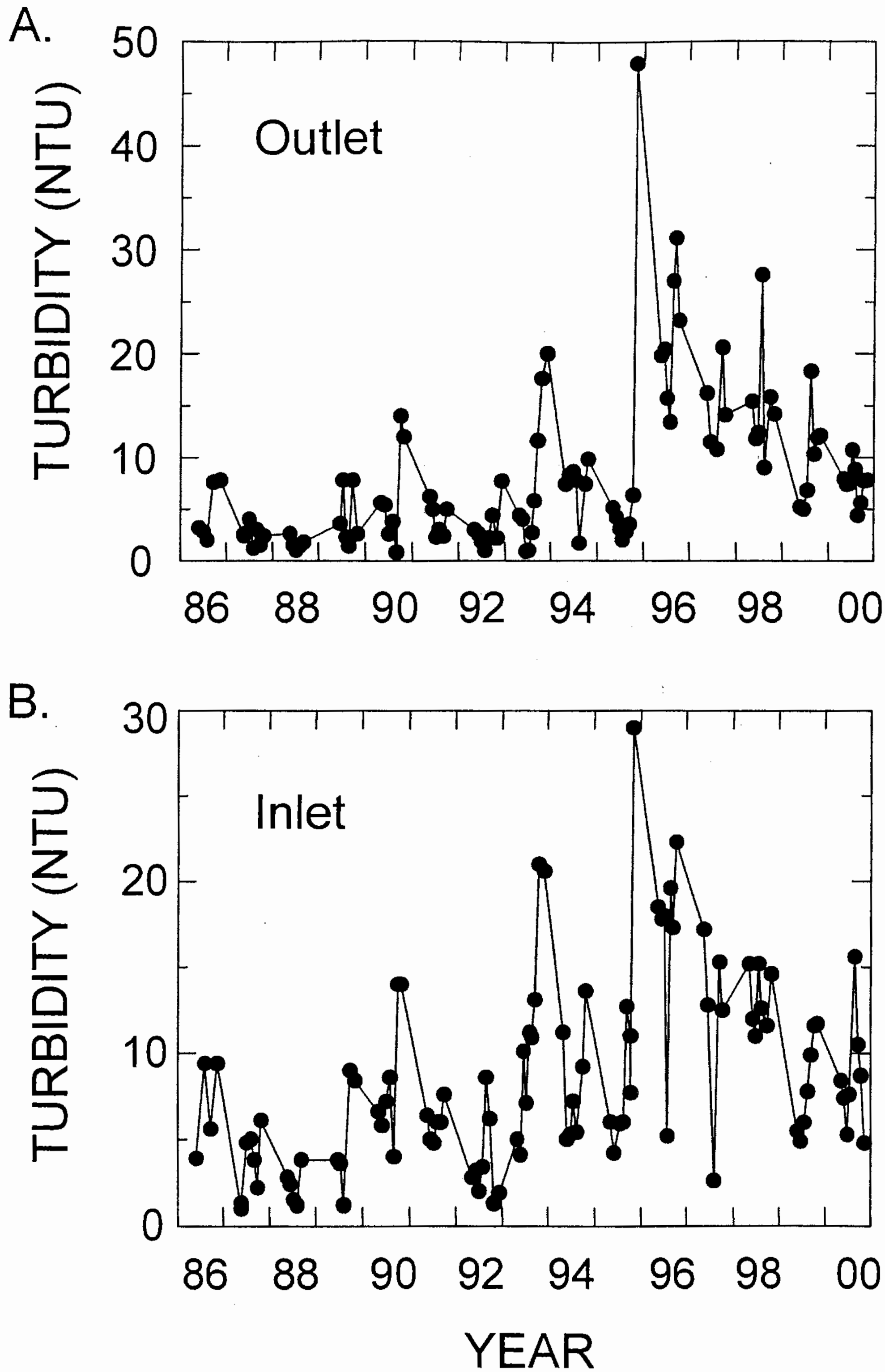

Figure 6. Temporal pattern of turbidity within the 1-m stratum at two stations in Skilak Lake, 1986-2000.

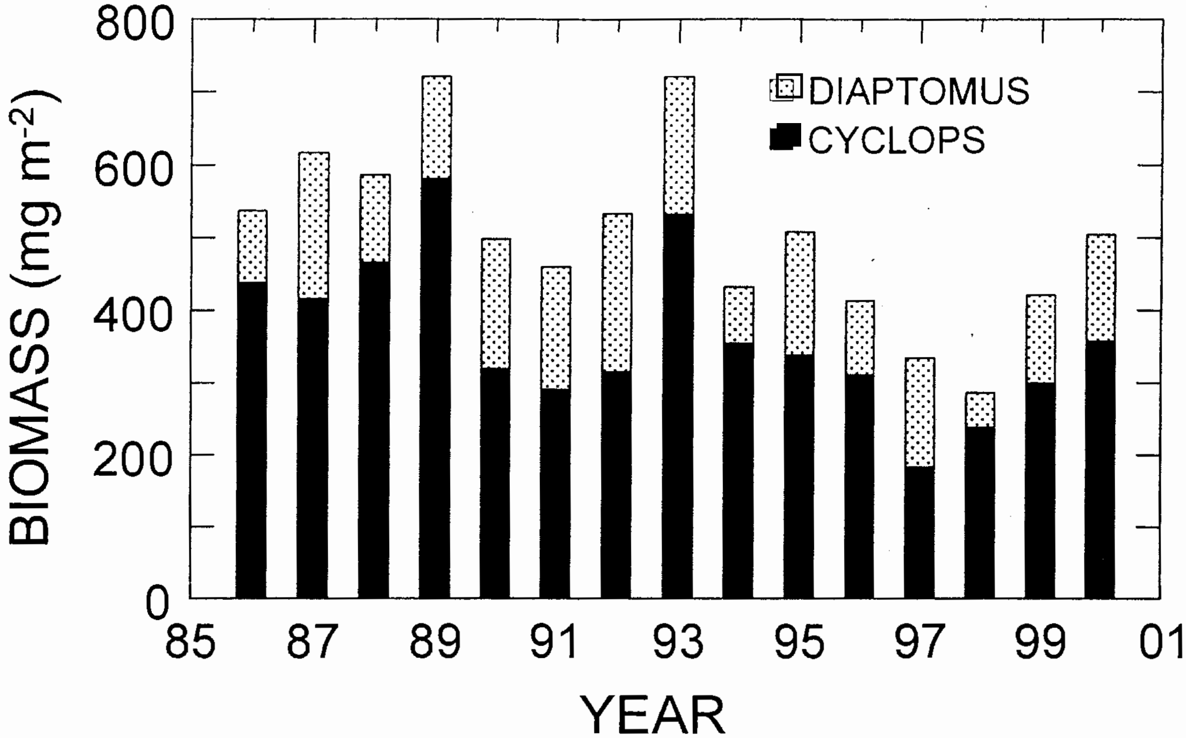

Figure 7. Interannual changes in Cyclops and Diaptomus biomass density in Skilak Lake, 1986-2000.

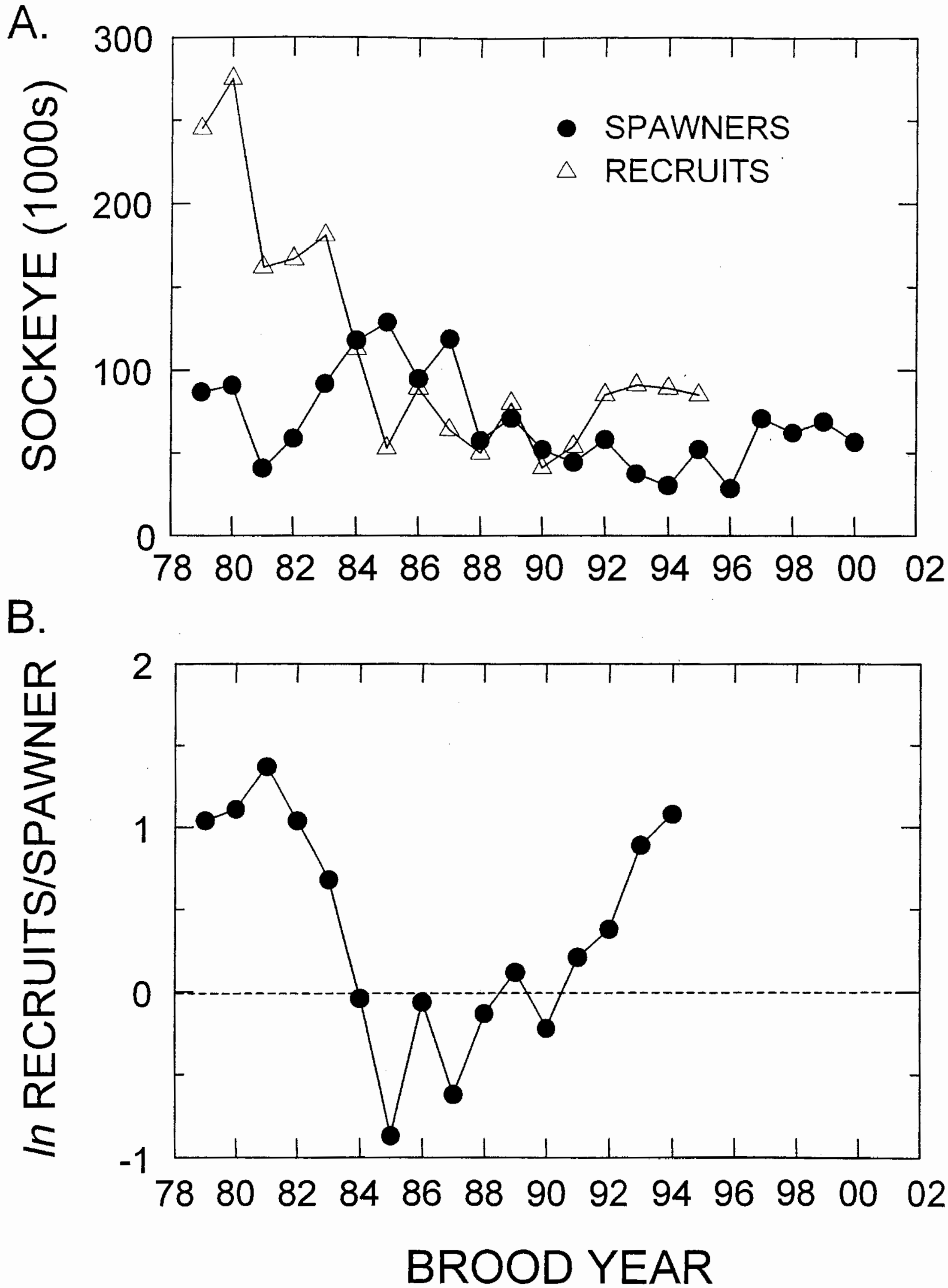

Figure 8. Brood year production plots of (A) sockeye spawners and adult recruits and (B) natural logarithm recruits per spawner for Crescent Lake. Dashed line represents replacement.

related to variability in conditions of the major nursery lake (Crescent Lake) of this system. The BEG range was lowered in 1998 from 50,000-100,000 to the current 25,000-50,000 range in part based on the low density of cyclopoid copepods (*Cyclops*), the primary food resource (zooplankton) for rearing sockeye juveniles, and an increase in turbidity (Fried 1999). Since then (1998), turbidity has lessened and the euphotic zone depth (EZD) has increased, but copepod abundance has not (Figure 9A-B). However, sockeye escapements exceeded the BEG in both 1999 (69,000) and 2000 (57,000). At this time we cannot determine whether zooplankton densities are trapped at low levels because of the limited reproductive capacity of *Cyclops* or because of high predation rates by juvenile sockeye fry (overgrazing) or both. Therefore, we recommend keeping the current BEG, at least for a few more years. Continued limnological monitoring may help us determine if escapement (fry recruitment) is appropriately balanced with available forage under the current BEG. Unfortunately, due to budgetary constraints, funding for future limnological studies of Crescent Lake has been discontinued.

Recommendation: 25,000-50,000 spawners.

Packers Creek

Packers Lake has a long history of manipulation in terms of whole-lake fertilization and fry stocking associated with sockeye enhancement programs. This makes deriving an optimum escapement goal somewhat problematic. We analyzed a 16-yr data set on nutrients, zooplankton density and biomass, and juvenile sockeye abundance, size, and age composition to understand the effects of fertilization and fry stocking on juvenile sockeye growth (Mazumder and Edmundson 2001). The various treatments of supplemental phosphorus loading rates (0-200 mg P m^{-2} per year) and stocking densities (50-150 fry m^{-2}) produced a wide range of nutrient concentrations, algal biomass, zooplankton densities, and juvenile sockeye abundance and sizes. As such, we attempted to establish an escapement goal for Packers Lake, independent of adult return data, by determining system carrying capacity for rearing sockeye juveniles based on lower trophic level responses. We found a strong inverse and curvilinear (quadratic fit) relationship between fall fry density (FFD), obtained from hydroacoustic and tow net surveys, and mean population size of age-1 smolts (Figure 10A-B). Between a density of 10-40 fry 100 m^{-2}, smolt weight and length decreased sharply with increasing FFD; above 40 fry 100 m^{-2} there was little, if any decrease in size with increasing density. Hence, we interpreted this threshold density as the system carrying capacity. Based on average (1987-1995) spring-to-fall fry survival estimates (37%), an assumed survival of 10% from potential egg deposition to spring fry, an average fecundity of 2,300 eggs/female (Fandrei 1996), and an assumed female/male spawner ratio of 1.04 our threshold FFD was equivalent to 8,400 female spawners or 16,500 total spawners. Therefore, we support the lower end of the current sustainable escapement goal (SEG) range (15,000-25,000). Currently there is no funding for escapement monitoring, juvenile fisheries assessment or limnological studies on the Packers Creek system.

Recommendation: 15,000 spawners

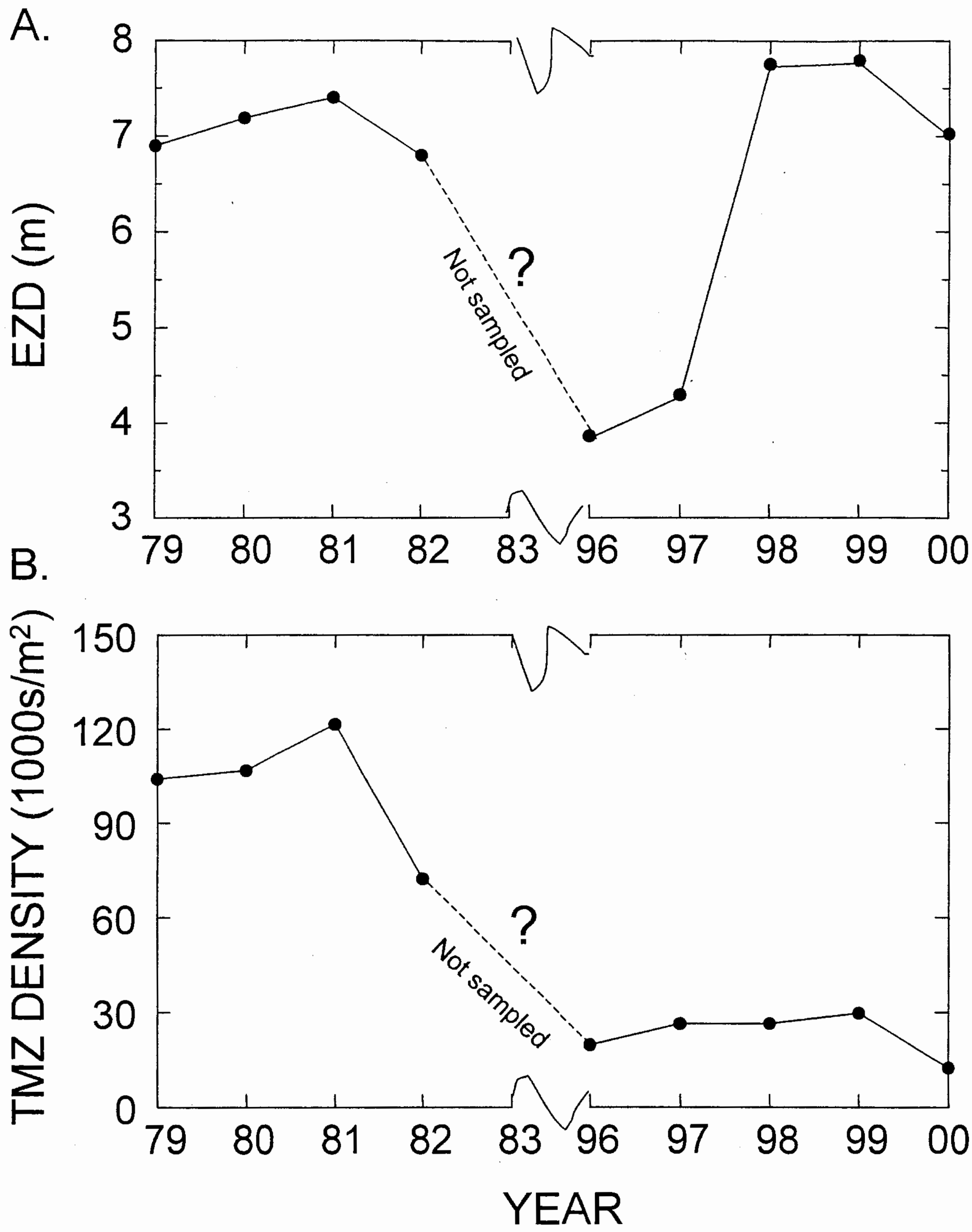

Figure 9. Interannual changes in (A) mean euphotic zone depth (*EZD*) and (B) total macrozooplankton (*TMZ*) density in Crescent Lake, 1979-1982 and 1996-2000.

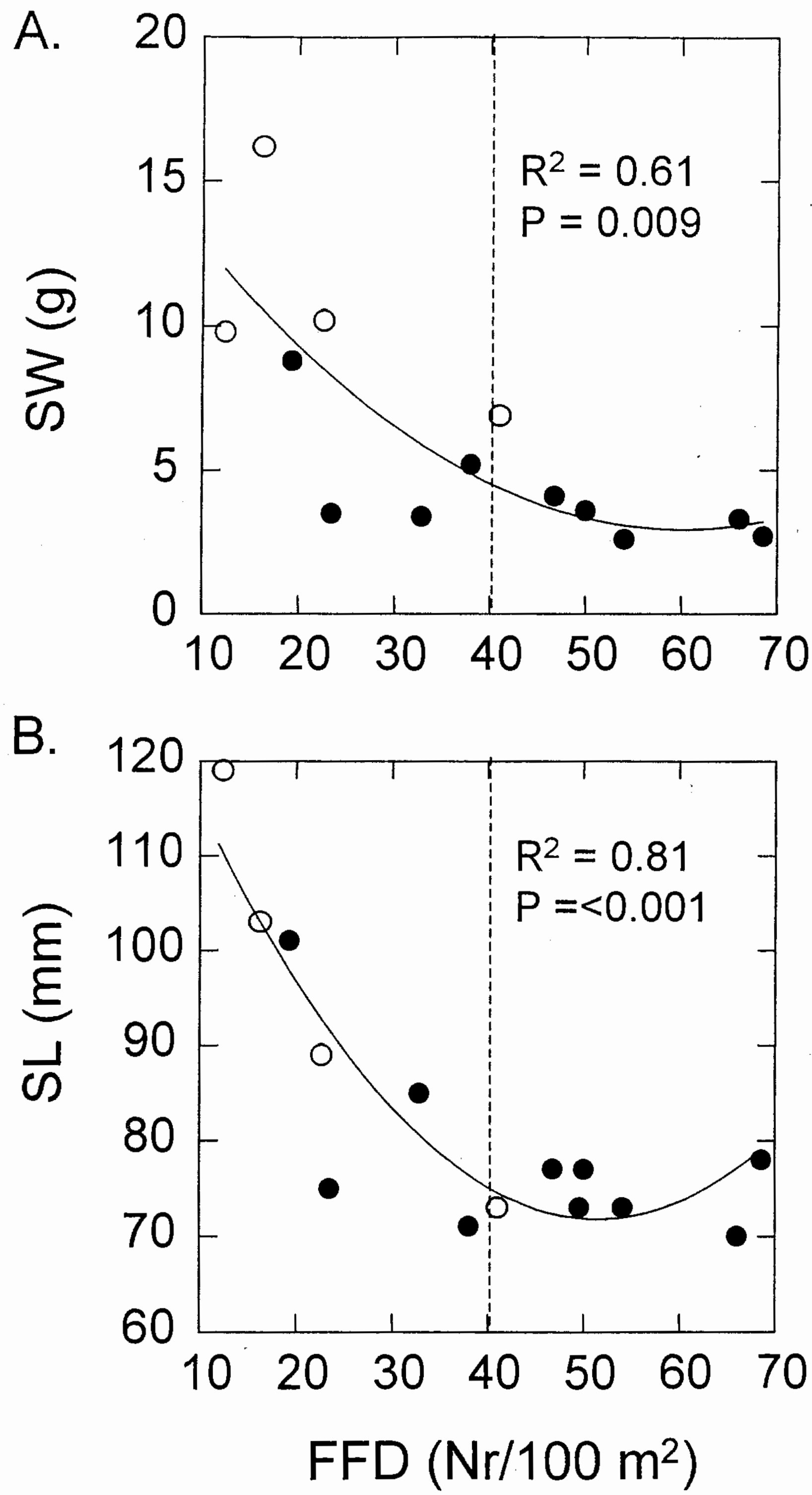

Figure 10. Curvilinear relationship between (A) age 1 smolt weight (*SW*) and (B) length (*SL*) as a function of fall fry density (*FFD*) in Packers Lake. Data are fitted to a quadratic model, the dashed lines represents system carrying capacity. Open circles denote years of high supplemental phosphorus loading.

Fish Creek (Big Lake)

A sockeye enhancement program has been ongoing in this system since 1975. Hatchery-reared sockeye fry are stocked annually in Big Lake, the major nursery area of the Fish Creek system. However, despite management restrictions and low harvest rates, the escapement goal (50,000) for the Fish Creek system has not been met in each of the last 3 years (1998-2000). The recent poor returns were the focus of an ADF&G inter-divisional technical meeting in spring 2001. Several possible causes for the apparent decline in adult returns were suggested by staff including: 1) loss of natural spawning habitat; 2) changes in water quality or nutrient status of Big Lake; and 3) effect of hatchery production on the wild stock or a reduction in fry stocking rates.

First, there was concern over increased watershed development or changes in water flow within Meadow Creek, an important salmon spawning area of the Fish Creek system, which may have led to a loss of spawning habitat. However, at this time we cannot directly link any specific watershed or hydrologic "milestone" events to the recent decline in adult returns. We simply point out that staff believes that there has probably been some loss or alteration of spawning habitat as a consequence of rapid urban expansion in this area.

Second, staff raised the issue that the decline in sockeye production may be due to the addition of more nutrients (phosphorus) by residential and commercial development, untreated sewage, or agricultural runoff into the Fish Creek system that led to excessive water column phosphorus concentrations and water quality problems in Big Lake. The potential for nutrient enrichment or eutrophication of Big Lake certainly exists (Woods 1986). Since the 1983-1985 studies by Woods (1986), there has not been a comprehensive limnological investigation of Big Lake. However, ADF&G collected a few water quality samples from Big Lake in summer 1999 (Edmundson et al. 2000). We found total phosphorus (TP) concentrations in 1999 (mean 7.0 $\mu g\ L^{-1}$) similar to TP levels during the 1983-1985 survey period (mean 8.8 $\mu g\ L^{-1}$) suggesting there has been little, if any shift in trophic state over the past 15 years or so. In addition, based on an empirical relationship between TP and chlorophyll concentration (algal biomass) derived for 25 sockeye and non-sockeye producing lakes in the Matanuska-Susitna area, Big Lake falls near the oligotrophic-mesotrophic boundary (Figure 11).

Third, Chlupach and Kyle (1990) suggested that hatchery production might affect survival of wild sockeye smolts in this system. In particular, they found no significant relationship between the number of wild smolts produced and the subsequent number of adult recruits. We found a significant (P=0.049) positive relationship between the number of sockeye fry stocked in Big Lake and subsequent total adult recruits (hatchery + wild) to the Fish Creek system (Figure 12A). However, the regression model explained only a small portion (24%) of the total variance in brood-year returns. The effect of stocking on adult recruits was further assessed using analysis of variance (ANOVA) to test for a difference between low (<10 million) and high ($\geq$10 million fry) stocking treatments. As expected, results of ANOVA suggested higher (P=0.33) adult returns under high stocking than low stocking (Figure 12B).

We believe the recent poor returns to Fish Creek have more to do with a reduced stocking program and a lack of wild spawners rather than a fundamental change in the trophic (nutrient)

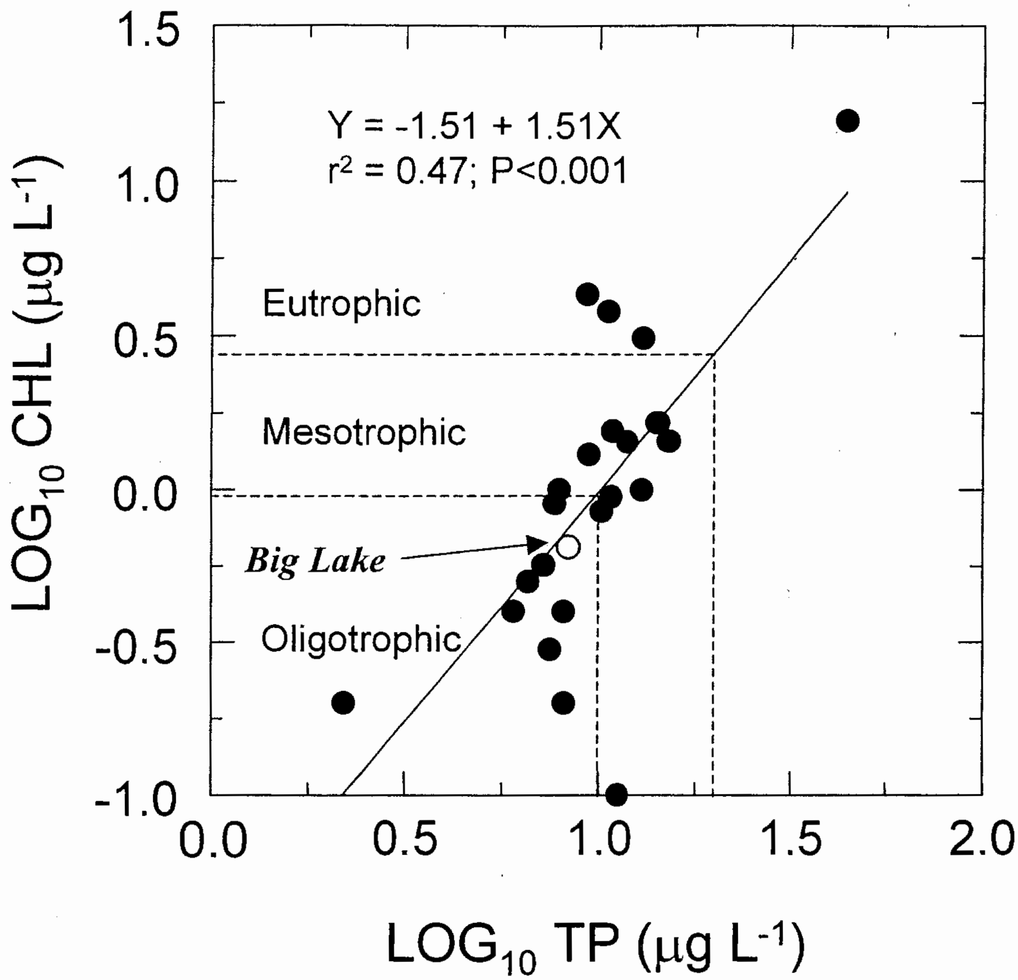

Figure 11. Total phosphorus (*TP*)-chlorophyll *a* (*CHL*) relationship derived from 25 lakes within the Matanuska-Susitna Borough relative to trophic classification based on TP concentration. Big Lake is shown as the open circle.

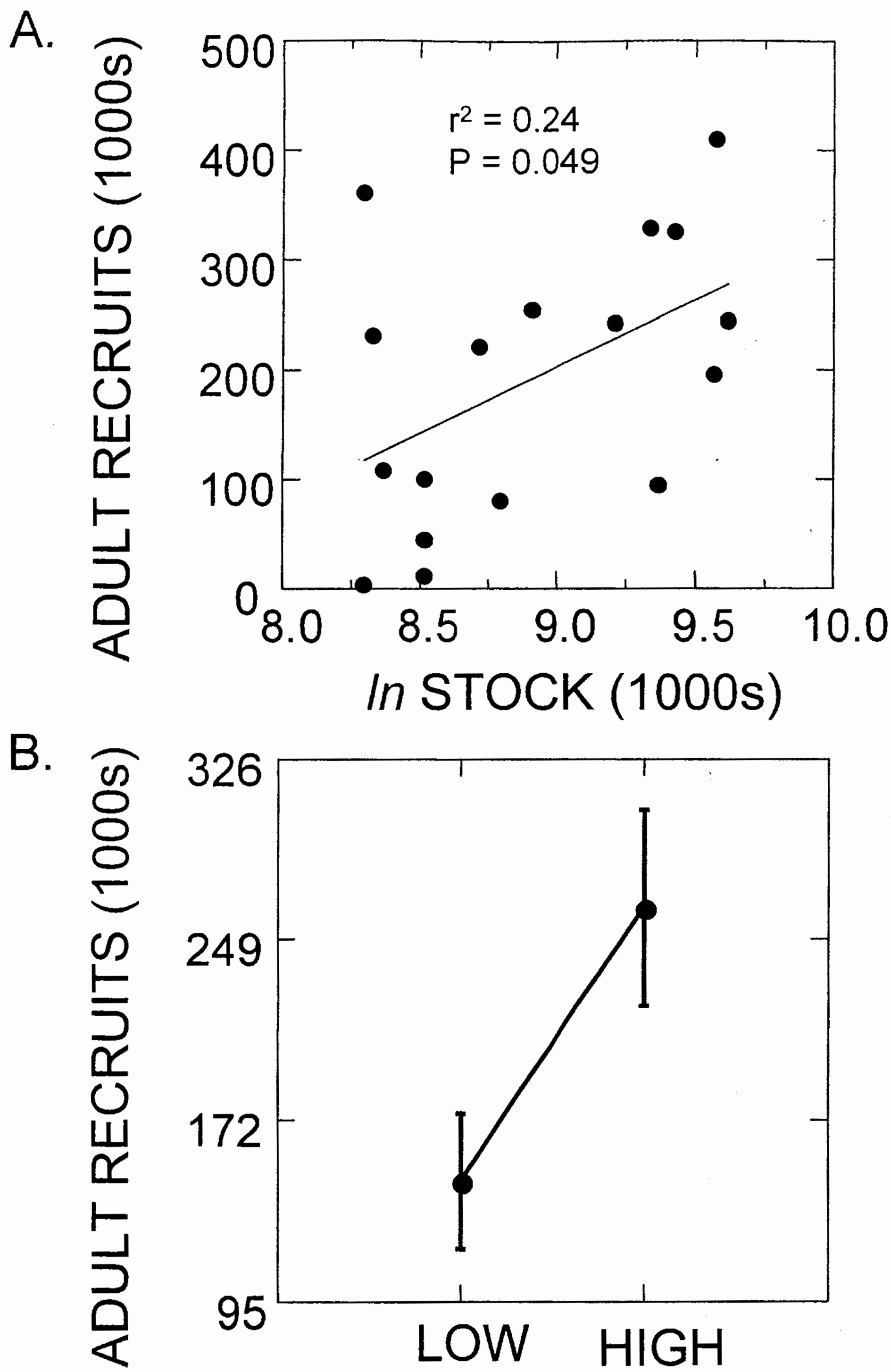

Figure 12. The relationship between (A) sockeye stocking levels (*STOCK*) in Big Lake and subsequent adult recruits from Fish Creek, brood years 1980-1996; and (B) comparison of adult recruits under low (<10 million) and high ($\geq$10 million) stocking treatments. Results of analysis-of-variance indicated a significant (P=0.029) difference between treatments. Vertical bars are standard errors of the least squares means.

status or water quality of Big Lake. Nonetheless, we are currently monitoring nutrient levels in Big Lake as part of a cooperative project with Alaska Department of Environmental Conservation and ADF&G to establish regional nutrient criteria for water quality. Unfortunately, we lack sufficient data on the extent and nature of the forage base (zooplankton), as well as juvenile sockeye information with which to quantify current system carrying capacity. Big Lake is known to produce very large-sized sockeye smolt (Chlupach and Kyle 1990) suggesting that the forage base (zooplankton) for rearing sockeye juveniles was probably not the most important factor limiting production. However, there is no funding identified for zooplankton analyses or juvenile sockeye assessment for Big Lake with which we might derive an appropriate escapement goal. Finally, there is some consensus among ADF&G staff that Fish Creek may be spawning area limited for sockeye. If this is true, recovery of the Fish Creek sockeye run may take several years, particularly under reduced stocking regimes. Therefore, we support the proposed SEG established by UCI staff.

Recommendation: 25,000-43,000 spawners.

Kasilof River

Sockeye smolt and limnology data are available for this system for many years (Todd and Kyle 1996a; Cooper and Thomas 2000). We found a significant positive relationship between the number of smolt produced and subsequent adult returns (Figure 13A). Adult recruits-per-spawner was inversely related ($r^2 = 0.46$) to the total number of smolts produced (Figure 13B), indicating depensatory effects. However, we found no significant linear relationship between spawner abundance and total (hatchery + wild) smolt output (P=0.627). Even after correcting for the hatchery component of the smolt outmigrations, there was no significant linear relationship between the number of spawners and subsequent wild smolt production (P=0.391). Consequently, we cannot determine optimum number of spawners to maximize smolt output. This lack of correlation between the numbers of smolt produced as a function of parental escapement suggests a shortage of suitable spawning areas in this system. In terms of the forage base in Tustumena Lake, *Cyclops* and *Diaptomus* (copepods) biomass seemed relatively consistent (Figure 14) and the associated forage pressure index (fry/zooplankton) for this system was low compared to other sockeye nursery lakes (Table 2). Hence, at this point in time we have no compelling evidence to revise the existing BEG (150,000-250,000) for Kasilof River sockeye.

Recommendation: 150,000-250,000 spawners.

Water Quality Investigations in the Matanuska-Sustina River Drainage

Eutrophication is the process of enrichment of waterbodies by nutrients. In many regions of the United States, eutrophication and its associated symptoms are a primary concern for lake and fishery resource managers. Although nutrient loading and subsequent changes in trophic state occur naturally, anthropogenic influences can accelerate this process. For example, excessive runoff and pollution from urban surfaces like parking lots and roads, building of flood control structures, fertilizers from agricultural and recreational areas, and untreated sewage effluents have the potential to increase phosphorus and nitrogen concentrations of a water body. In lakes,

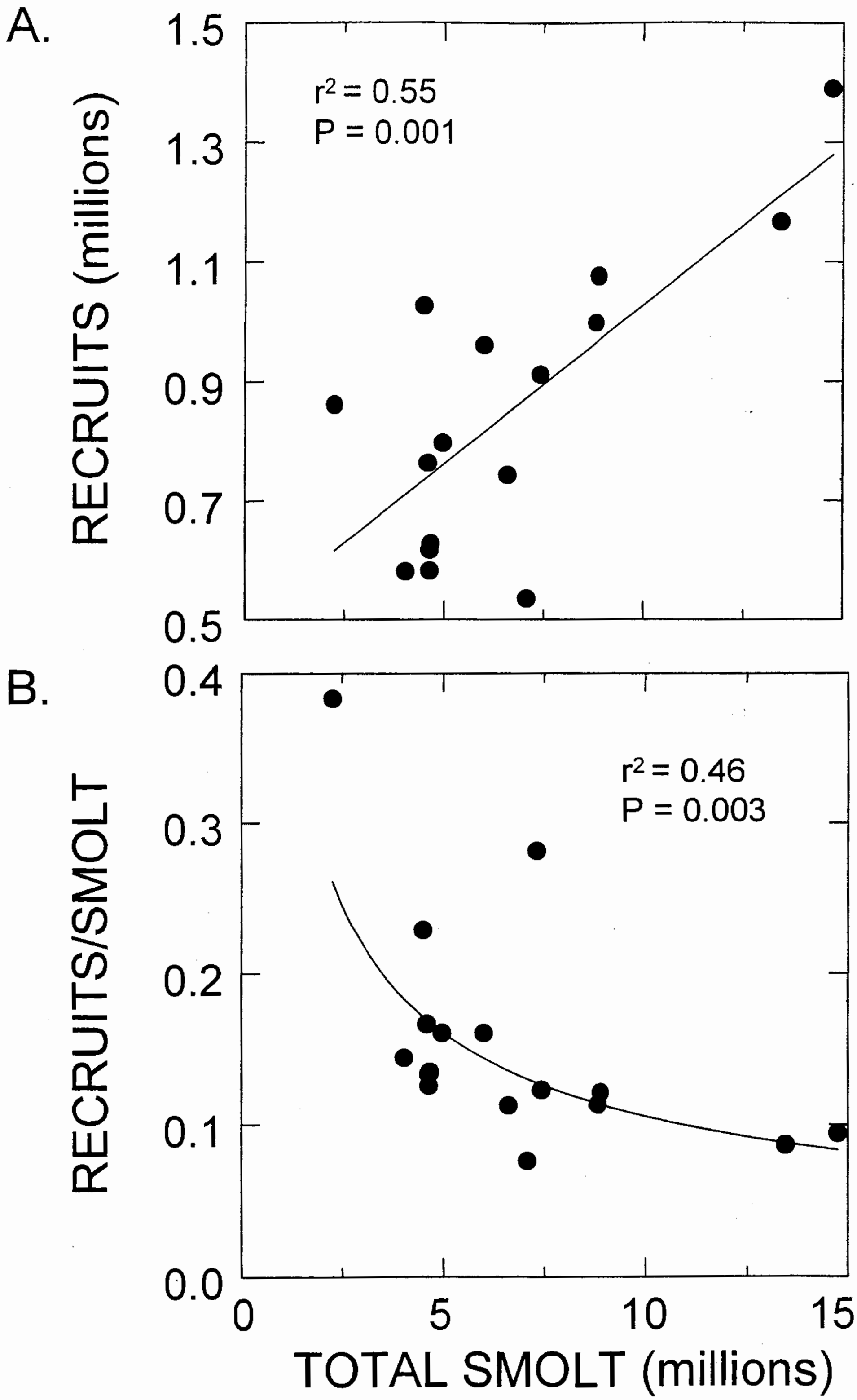

Figure 13. The relationship between (A) the total number of smolts and subsequent adult recruits, and (B) the total number of smolts and adult recruits per smolt, for Kasilof River sockeye salmon.

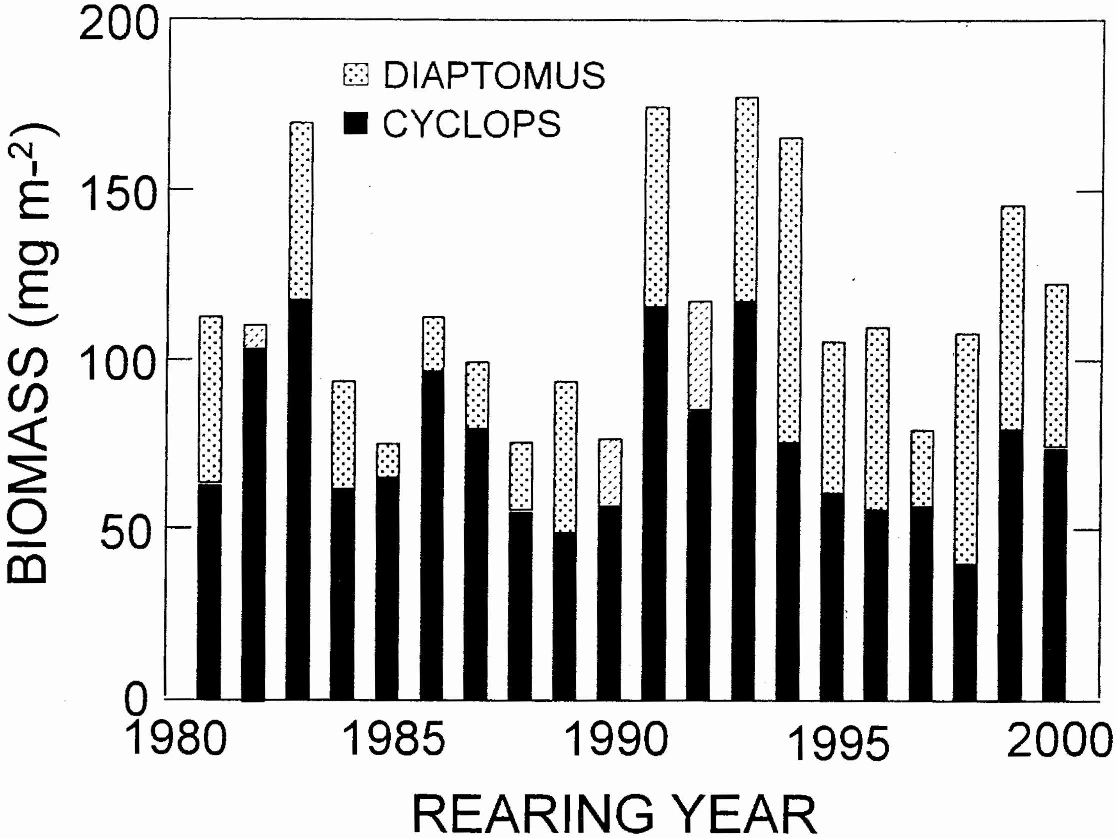

Figure 14. Interannual changes in Cyclops and Diaptomus biomass density for Tustumena Lake, 1981-2000.

Table 2. Comparison of mean spawner abundance, spawner density, zooplankton biomass and the grazing pressure index for 12 sockeye nursery lakes. Note low index value for Tustumena Lake.

System	Typology	Area (A) (km^2)	Brood years	Mean spawner abundance (P) (Nr.)	Mean spawner density (P/A) (Nr. km^{-2})	Zooplankton biomass (ZB) (kg km^{-2})	Grazing pressure index (P/A)/(ZB) (Nr. kg^{-1})
Desire	Clear	1.8	1981, 1986	13,200	7,333	17	822.8
Frazer	Clear	16.6	1984-1986	221,963	13,371	149	104.0
Coghill	Glacial	12.7	1987-1997	52,199	4,119	91	89.6
Crescent	Glacial	16.5	1995-1998	69,350	3,212	46	78.9
Karluk	Clear	39.4	1980-1993	601,997	16,370	1,125	17.3
Delight	Clear	2.8	1981, 1986	8,850	3,161	102	37.2
Big	Clear	12.1	1984	75,071	15,785	1,021	15.5
Kenai	Glacial	99.0	1985-1998	422,571[a]	4,268	485	9.5
Eshamy	Clear	3.6	1980, 1984 1988-1994	29,599	9,503	1,701	7.0
Tustumena	*Glacial*	*294.5*	*1980-1998*	*217,048*[b]	*734*	*119*	*6.8*
Ugashik	Clear	381.7	1996-1998	854,954	1,931	1,048	1.9
Becharof	Clear	1142.0	1996-1998	1,103,614	961	767	1.3

a/ The abundance was adjusted to reflect the proportion of spawners to Skilak Lake to the total number of Kenai River mainstem spawners based on fall fry abundance (hydroacoustic) estimates.

b/ A portion of the spawner abundance was back calculated from the number of stocked (spring) fry using standard freshwater survival estimates.

over-loading of nutrients from the watershed can lead to undesirable water quality conditions such as extreme algal growth (i.e., noxious blooms), murky water, oxygen depletion of the water column (anoxia), production of offensive odors, and fish kills.

The Matanuska-Susitna (Mat-Su) region of southcentral Alaska contains numerous lakes that vary with respect to numerous limnological characteristics, all of which influence their water quality and trophic state (Edmundson et al. 2000). These lakes represent a valuable natural resource to one of the most populated areas of the state. Lakes in this region offer multiple recreational opportunities including swimming, boating and wildlife viewing. In addition, many of the lakes support populations of anadromous salmon that are increasingly sought after in commercial, recreational, personal use, and subsistence fisheries. However, in the last two decades, the Mat-Su region area has seen considerable growth and development. Consequently, many of these lakes are now accessible by road and many of the watersheds have been developed with seasonal and year-round residences. Changes to such urban lakes include shoreline alteration, fishing impacts, and the accumulation of nutrients from anthropogenic sources. Eutrophication symptoms have been documented in a few of these lakes (Woods 1986; Edmundson et al. 1989). In addition, there has been discussion of a construction of a future causeway linking the city of Anchorage with Point MacKenzie, thereby increasing the potential for significant land use and hydrologic changes to the watershed and subsequent impacts on the water quality of lakes.

In order to better manage and protect lakes, water quality, nutrient levels, algal biomass and associated trophic state must be evaluated and classified on a regional basis to take into account differences in climate and geochemistry, morphometry, and lake usage. That is, development of regional nutrient criteria could provide a means to assess or predict the degree of change in the trophic state of a lake ecosystem arising from an alteration in the concentration of key limiting nutrients. Thus, the overall goal of this project is to obtain pertinent limnological information from a variety of lakes within the Mat-Su region. These data will be used in the future to aid in the development of regional nutrient criteria for Alaskan lakes.

In May 2001, CRL developed a project operational plan and implemented a monitoring program in cooperation with Alaska Department of Environmental Conservation (DEC) to collect limnological data from 6 lakes (most of which support anadromous runs of salmon) spanning a range in trophic state in the Mat-Su region. Our primary objective is to develop a database on morphometry, light penetration and water clarity, temperature, dissolved oxygen concentrations, water chemistry, nutrient (nitrogen and phosphorus) concentrations, and algal biomass (chlorophyll *a*) levels. These data will be used as part of the U. S. Environmental Protection Agency (EPA) nutrient criteria program. Our second objective is to provide an analysis (report) on water quality and nutrient data, and make recommendations for future studies aimed at developing appropriate regional nutrient criteria for lakes. Lake surveys and analysis of limnological samples are currently underway.

Sockeye Salmon Stocking at Solf Lake

The sockeye salmon stocking project at Solf Lake is an EVOS funded restoration project aimed at developing a sockeye salmon run through the annual stocking of fry. The U. S. Forest Service is the principal investigator and CRL is the cooperating agency responsible for assessing juvenile sockeye production and collecting and analyzing limnological data. Solf Lake is an extremely oligotrophic system and it supports a rather unique population of pigmented *Diaptomus sp.* Populations of pigmented zooplankton have only been found in two other lakes in Alaska. Given that they are conspicuous prey items to visually attuned planktivores such as sockeye fry and the limited refugia from grazers, we hypothesized that the zooplankton forage base would decline quickly with stocking. Surprisingly, we found little evidence of grazing in terms of changes in zooplankton population characteristics (density, biomass, and mean size). However, our smolt program and hydroacoustic surveys over the last few years revealed that stocked fry are not over-wintering in the lake, but migrating from the system soon after stocking (i.e., in early summer). Unfortunately, EVOS funding for continued juvenile sockeye assessment and limnological work at Solf Lake did not extend past 30 September 2000, though stocking continues. However, EVOS provided funding to CRL for a technical report summarizing our juvenile sockeye assessment and limnological studies. A final report is scheduled for completion by 30 October 2001.

Salmon Lake Nutrient Enrichment

CRL provided technical assistance and expertise for an ongoing sockeye salmon restoration project at Salmon Lake (Region III), which was initially investigated in 1994 (Todd and Kyle 1996b) and continues today. The lake system is unique in that it is the northernmost sockeye producing system in the State. This is a joint project with ADF&G, U.S. Bureau of Land Management (BLM) and Norton Sound Economic Development Corporation (NSEDC). CRL personnel assisted with smolt enumeration in the spring, hydroacoustic surveys of fry populations in the fall, and CRL laboratory staff processed water and plankton samples. Lake enrichment continued during the 2001 field season, the last year of a five-year fertilizer program. Preliminary analytical results revealed there were positive responses in lower trophic level (nutrients, phytoplankton, and zooplankton) production to nutrient additions. As 2001 was the final year of fertilization, a planned technical report by CRL staff on the overall outcome of the nutrient enrichment program is scheduled for winter 2002.

Laboratory Operations

In addition to ADF&G's regional projects, CRL provided technical support for various State, federal, and private non-profit agencies (Table 3). During FY 2001, CRL laboratory processed 890 water and biological samples representing 24 lakes statewide (Table 4). These samples equate to a total of 14,500 individual analyses for all measured parameters.

CRL developed quality control charts (APHA 1998) to compute process variation for the most important analytes (Figures 15-21). Low and high range reference standards were analyzed and

Table 3. Agencies and organizations contracting Central Region Limnology laboratory services, fiscal year 2001.

STATE
Alaska Department of Fish and Game, Commerical Fisheries Division (Region I)
Alaska Department of Fish and Game, Commercial Fisheries Division (Region III)
Alaska Department of Environmental Conservation, Division of Water Quality Regulations (Anchorage)
FEDERAL
U. S. Bureau of Land Management (Fairbanks)
PRIVATE NON-PROFIT
Cook Inlet Aquaculture Association
Northern Southeast Regional Aquaculture Association
Southern Southeast Regional Aquaculture Association
Norton Sound Economic Development Corporation

Table 4. Summary of water bodies for which Central Region Limnology laboratory processed samples, fiscal year 2001.

Region	Area	Lake
Central (II)	Upper Cook Inlet	Bear
		Big
		Crescent
		Finger
		Hazel
		Hidden
		Leisure
		Lorraine
		Skilak
		Threemile
		Tustumena
		Wasilla
	Bristol Bay	Iliamna
		Becharof
		Lower Ugashik
		Upper Ugashik
Southeast (I)	Northern Southeast	Auke
		Chilkat
		Chilkoot
		Deer
	Southern Southeast	Virginia
		McDonald
		Hugh-Smith
Arctic-Yukon-Kuskokwin (III)		Salmon

their measured concentration was then plotted with each run of samples. These charts include a center line which is the average concentration for the time being charted, upper and lower (or inner) warning levels, and upper and lower (or outer) control levels. We set warning levels at $\pm 2\sigma$ and control limits at $\pm 3\sigma$, where σ is the pooled standard deviation. Quality control outside these limits or a trend in the process statistic is evidence of special causes or unacceptable error in the analytical procedure. Out-of-control error includes, but is not limited to, improper equipment calibration or malfunction, inappropriate methods, calculation errors, or sample contamination. Corrective action is taken when the analyst deems the procedure out-of-control. Our quality control charts developed for sample runs over the past year revealed that the process statistics did not exceed the outer control limit and fell within the inner warning limits or within $\pm 1\sigma$. In addition, there was no apparent trend or pattern in tracking the reference samples (process statistic) suggesting random process error was in effect.

In addition to internal quality control measures, quality assurance of analytical results was maintained through our annual participation in the U.S. Geological Survey's analytical evaluation program for standard reference samples including trace constituents, major constituents, and low ionic strength nutrients. Laboratory determination of each analyte or constituent is rated on a scale from 4 to 0, based on the absolute Z-value, as listed below:

Performance Rating	Absolute Z-value
4 (excellent)	0.00 to 0.50
3 (good)	0.51 to 1.00
2 (satisfactory)	1.01 to 1.50
1 (marginal)	1.51 to 2.00
0 (unsatisfactory)	>2.00

Results of the 2000 program (Conner et al. 2001) indicated that for most constituents, our performance ratings were considered good to excellent (Table 5). The exception was our poor ratings for nitrate nitrogen analysis. CRL laboratory reported lower concentrations for both the low (N-67) and high (N-68) inorganic nutrient references compared to the most probable value (MPV) derived for those references. The apparent negative bias was –22% and –11%, respectively for the N-67 and N-68 samples. The results suggested a problem or deficiency with our method, which was tentatively traced to incomplete or partial cadmium reduction of nitrate to nitrite. CRL has since modified its autoanalyzer configuration/methodology to reduce the bias and variability of analytical results and improve performance. In addition, we routinely analyze multiple (usually 6-8) standards of known concentration with each sample lot and these are used to formulate a linear equation (calibration curve) by regressing absorbance against concentration. Together, both our internal and external quality control programs resulted in a high quality level of analytical work associated with accuracy and reproducibility. Table 6 presents the most recent evaluations of analytical methodologies used by CRL laboratory. These laboratory performances meet our specific project requirements for the type and quality of analytical data needed. This list of operating ranges, detection limits, and precision and accuracy replaces that found in Koenings et al. (1987).

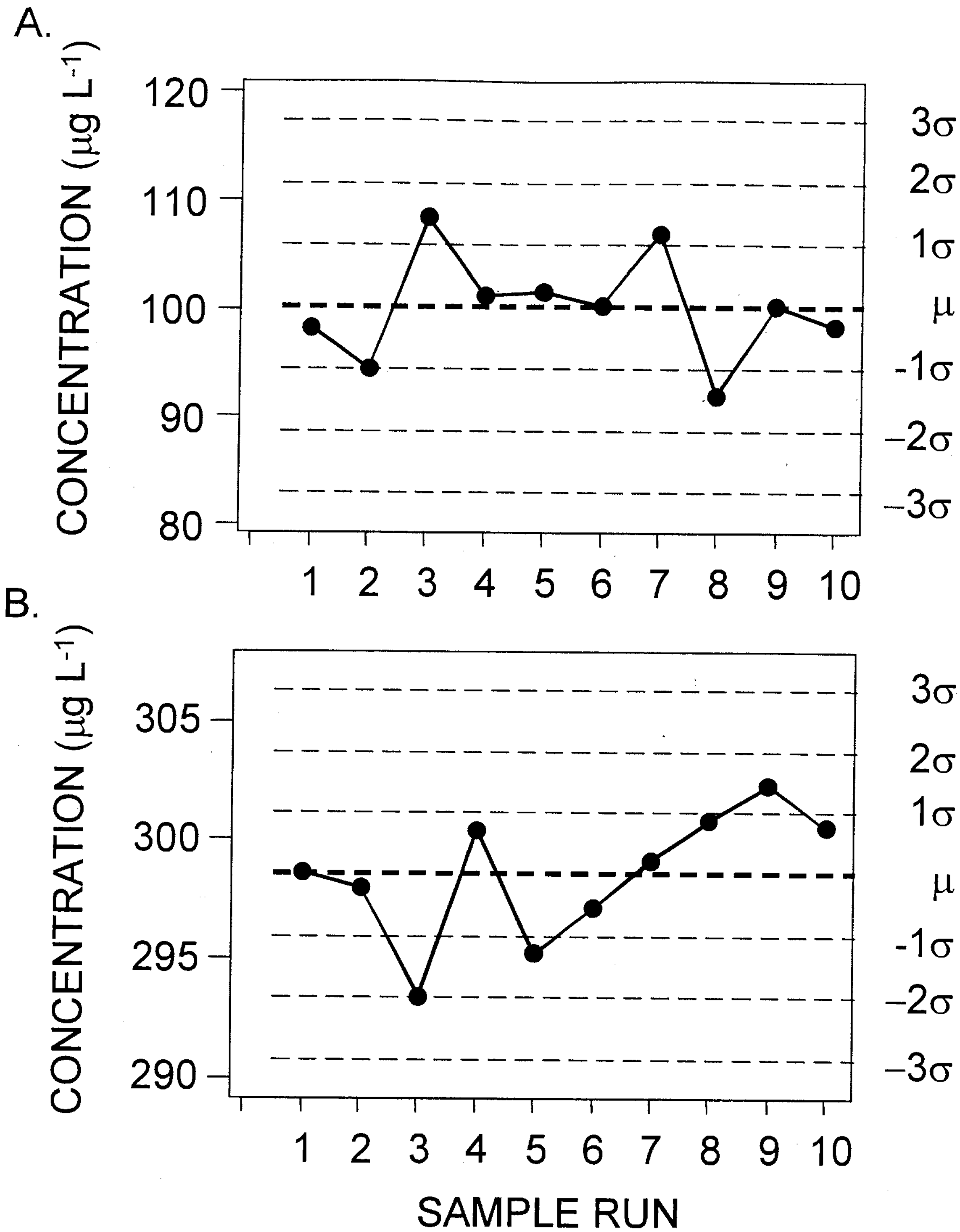

Figure 15. Control chart for Kjeldahl nitrogen standards at low (A) and high (B) concentration showing the mean (µ), inner control limit (±2σ) and outer control limit (±3σ).

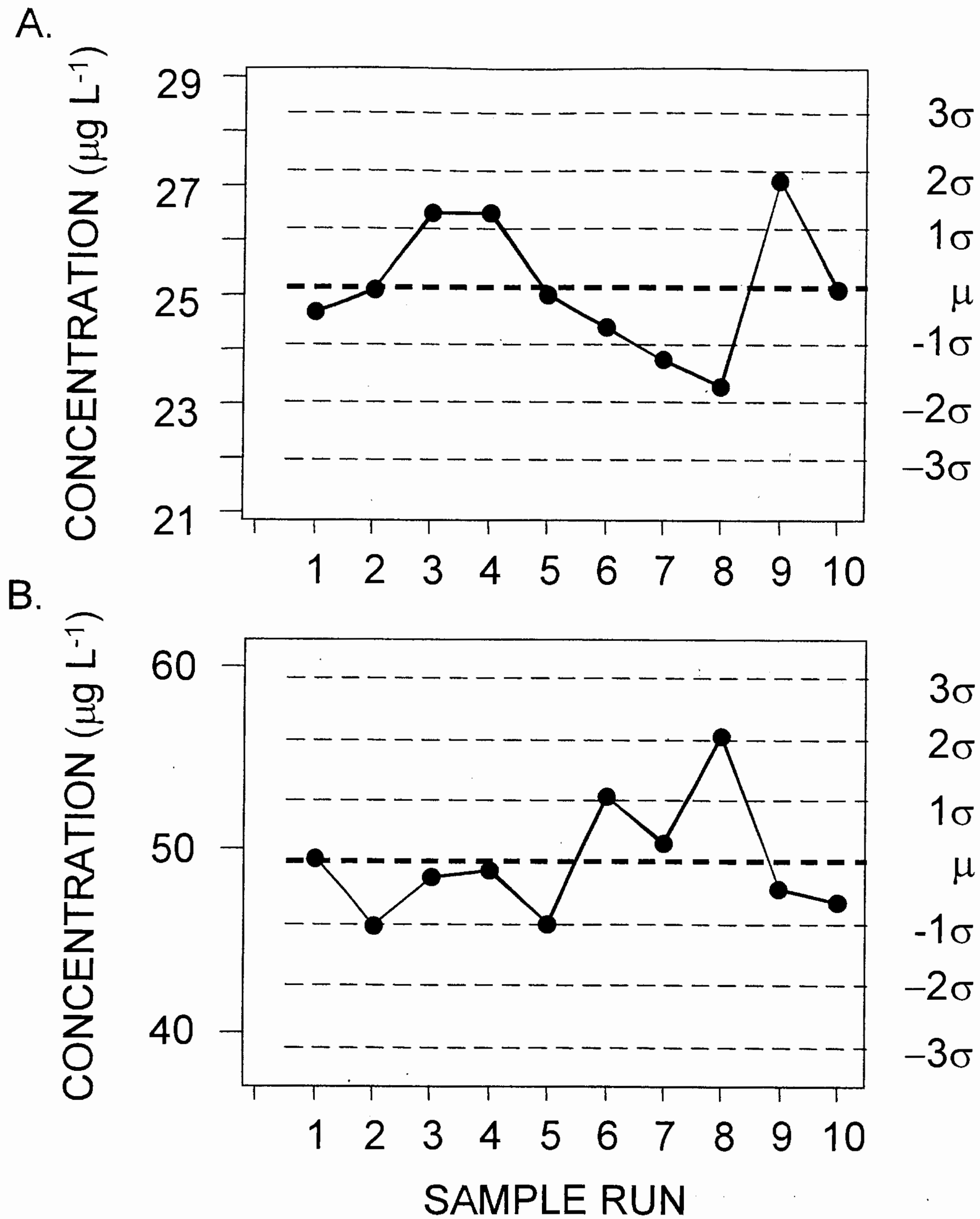

Figure 16. Control chart for ammonia nitrogen standards at low (A) and high (B) concentration showing the mean (μ), inner control limit (±2σ) and outer control limit (±3σ).

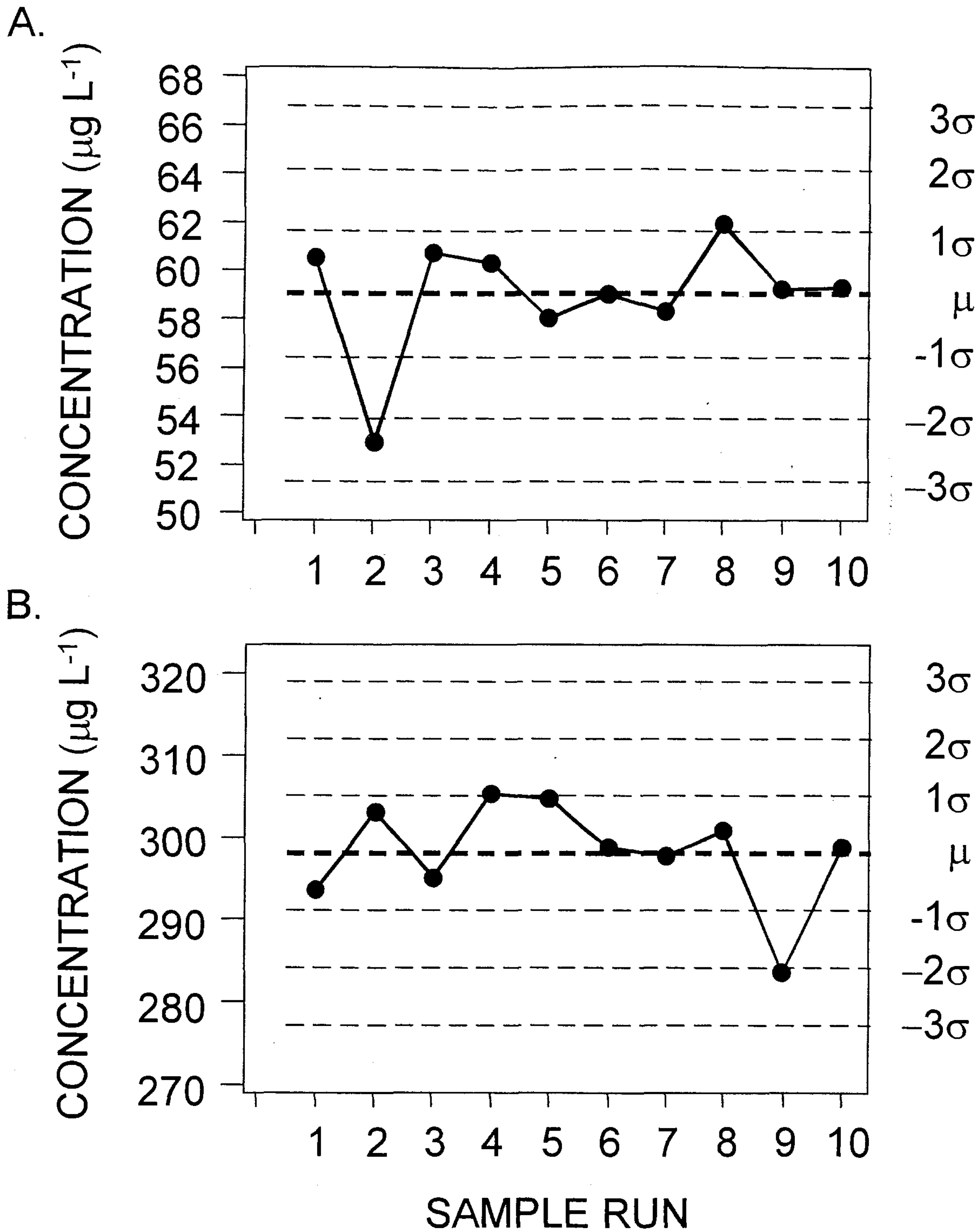

Figure 17. Control chart for nitrate nitrogen standards at low (A) and high (B) concentration showing the mean (μ), inner control limit (±2σ) and outer control limit (±3σ).

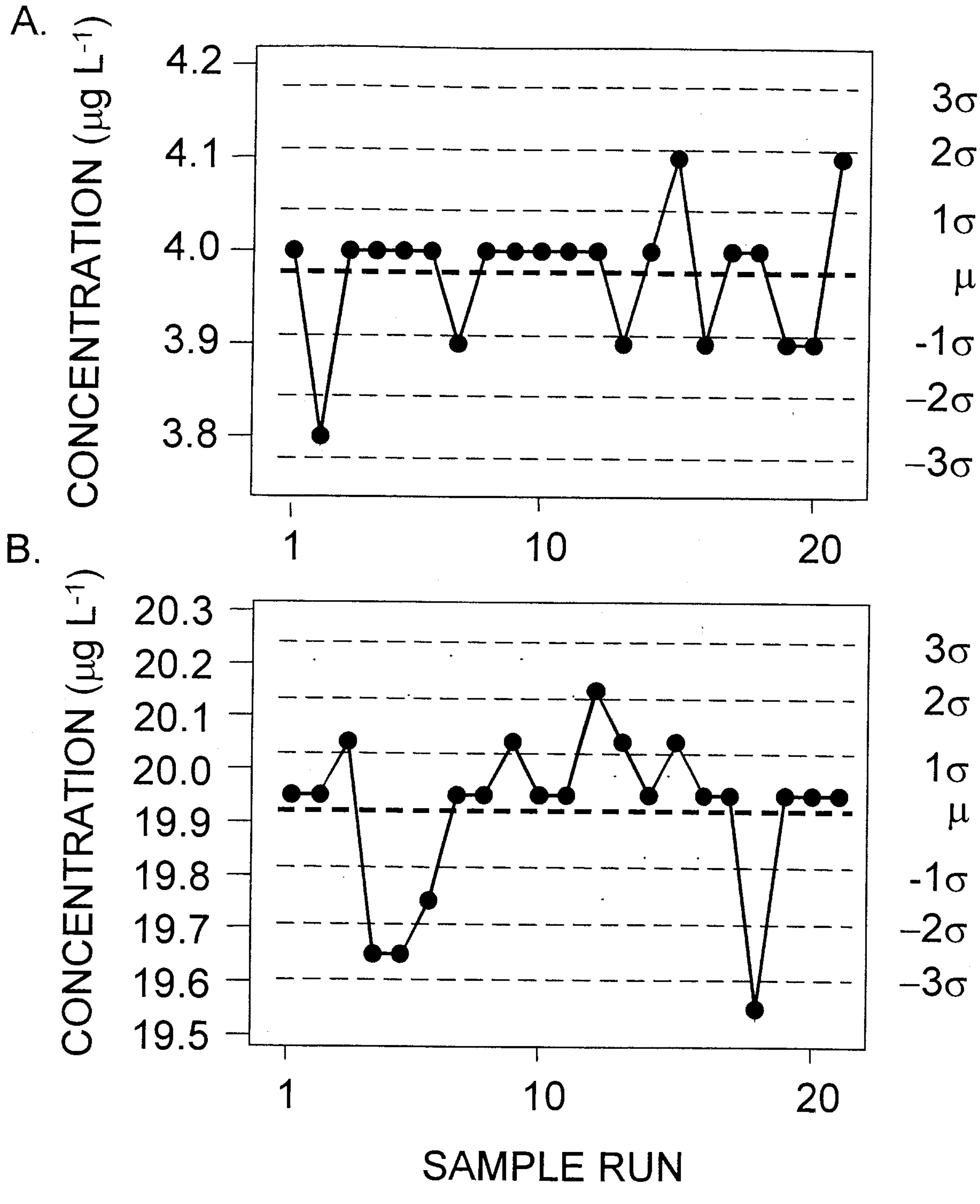

Figure 18. Control chart for total phosphorus standards at low (A) and high (B) concentration showing the mean (μ), inner control limit (±2σ) and outer control limit (±3σ).

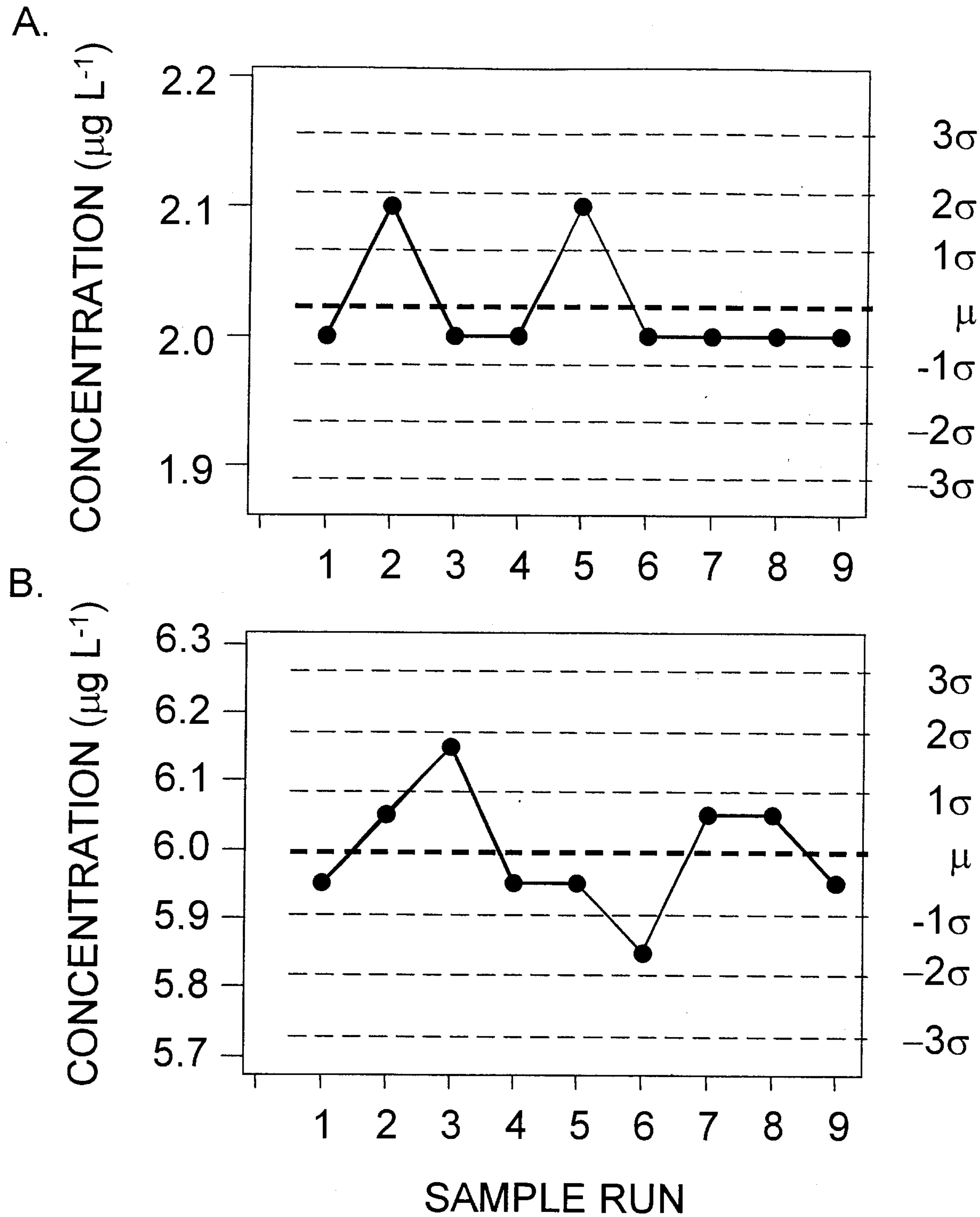

Figure 19. Control chart for filterable reactive phosphorus standards at low (A) and high (B) concentration showing the mean (µ), inner control limit (±2σ) and outer control limit (±3σ).

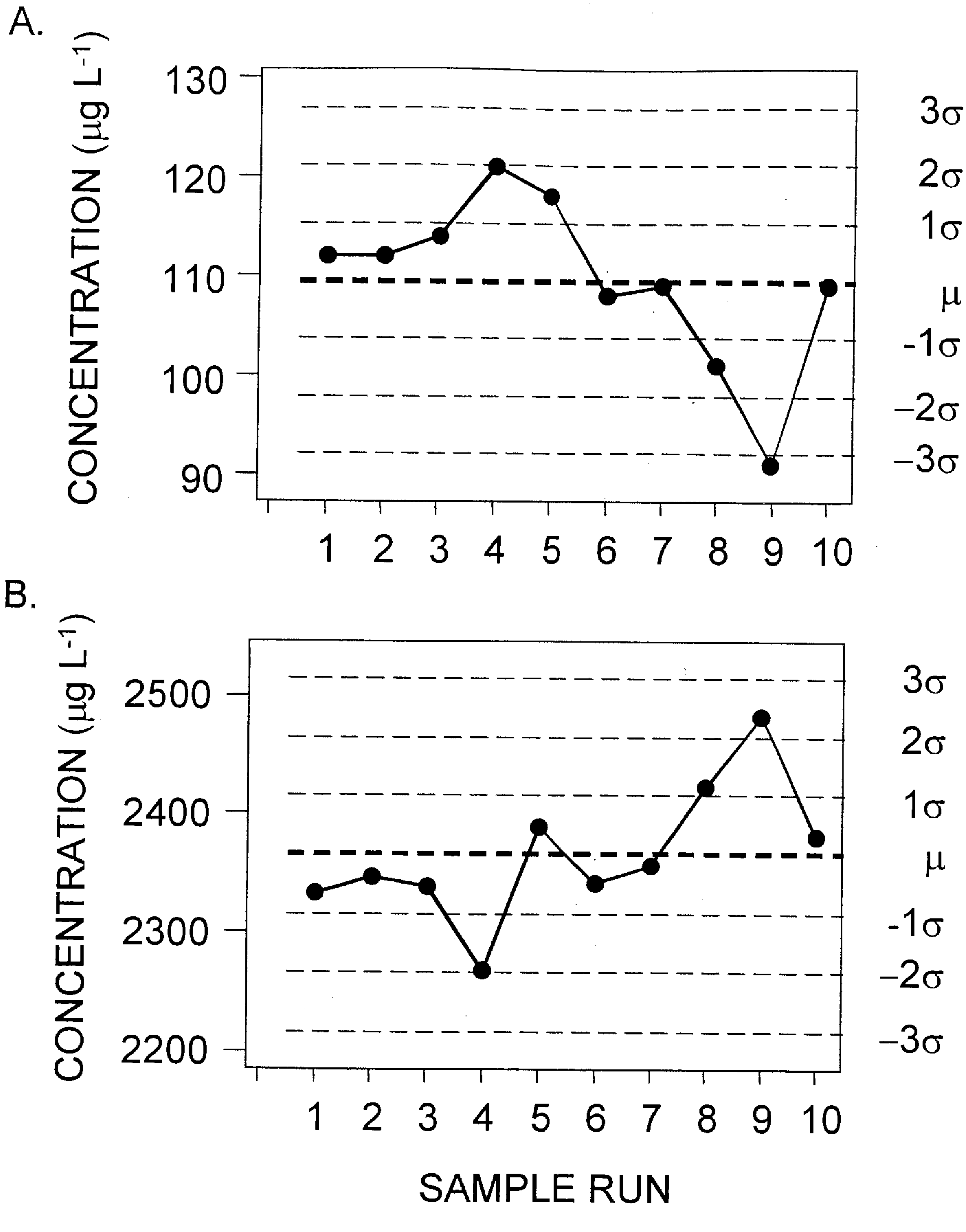

Figure 20. Control chart for reactive silicon standards a low (A) and high (B) concentration showing the mean (µ), inner control limit (±2σ) and outer control limit (±3σ).

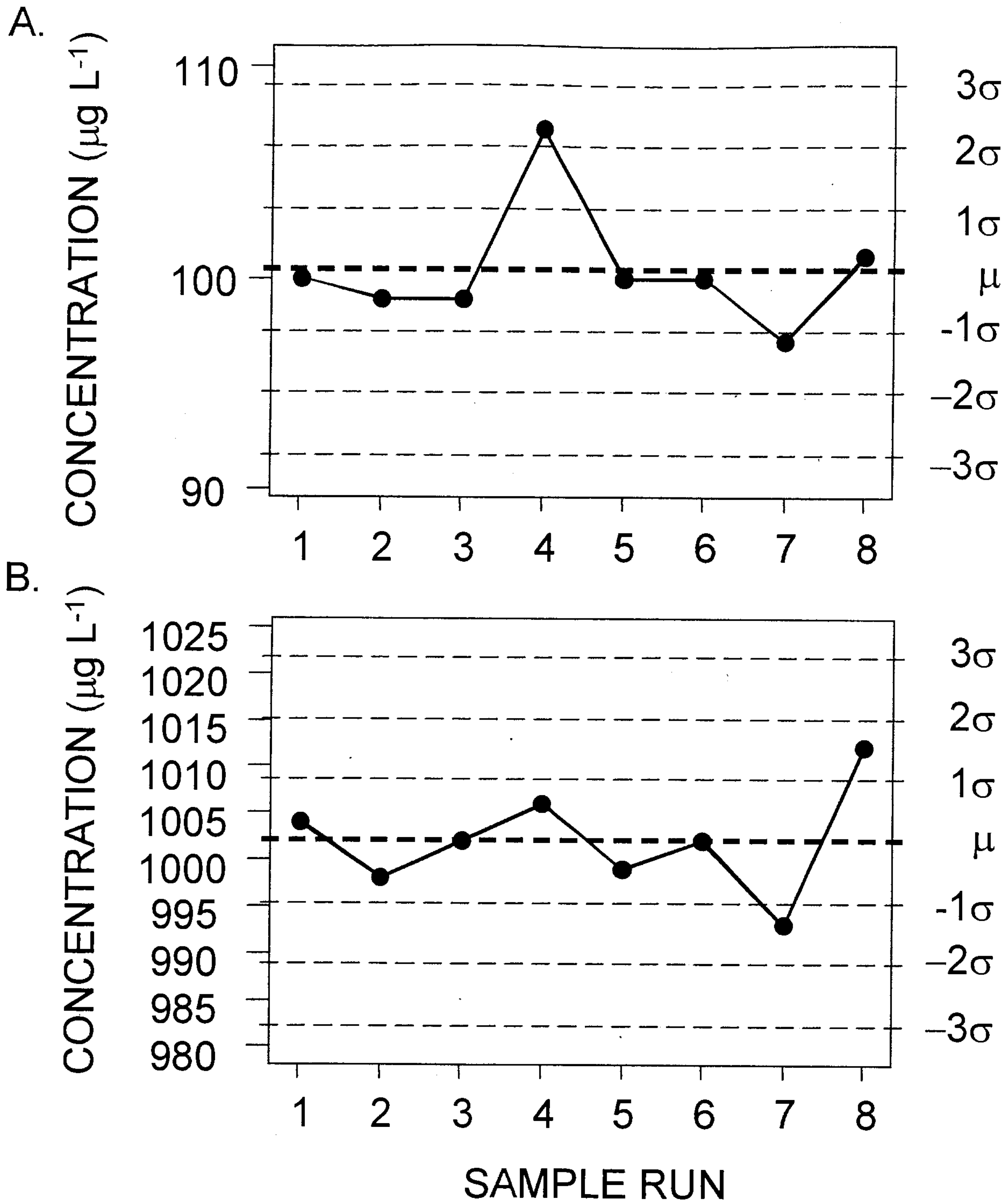

Figure 21. Control chart for total iron standards at low (A) and high (B) concentration showing the mean (µ), inner control limit (±2σ) and outer control limit (±3σ).

Table 5. Results from the fall 2000 (FY 2001) U. S. Geological Survey Standard Water Reference Sample program showing the identity of the reference sample, constituents analyzed, reported value by Central Region Limnology (RV), most probable value (MPV)[a], and rating[b].

Reference Sample	Constituent	Units	RV	MPV	Rating
N-67 (nutrients)	Ammonia nitrogen	µg L^{-1}	0.433	0.433	4
	Kjeldahl nitrogen	µg L^{-1}	0.435	0.450	4
	Nitrate + nitrite nitrogen	µg L^{-1}	0.174	0.222	0
	Total phosphorus	µg L^{-1}	0.280	0.279	4
	Filterable reactive phosphorus	µg L^{-1}	0.272	0.274	4
N-68 (nutrients)	Ammonia nitrogen	µg L^{-1}	0.490	0.480	4
	Kjeldahl nitrogen	µg L^{-1}	0.604	0.650	4
	Nitrate + nitrite nitrogen	µg L^{-1}	1.487	1.680	0
	Total phosphorus	µg L^{-1}	0.814	0.830	4
P-35 (low ionic strength)	Calcium	mg L^{-1}	0.66	0.54	0
	Magnesium	mg L^{-1}	0.11	0.90	1
	pH	units	4.81	4.89	4
	Filterable reactive phosphorus	µg L^{-1}	0.023	0.022	4
	Conductivity		25.8	27.0	3
M-156 (major consituents)	Alkalinity	mg L^{-1}	59.4	61.8	3
	Calcium	mg L^{-1}	30.9	30.2	4
	Magnesium	mg L^{-1}	6.3	6.9	1
	Total phosphorus	µg L^{-1}	0.579	0.578	4
	pH	units	7.83	7.95	4
	Conductivity	µmhos cm^{-1}	422	440	3
	Silica	mg L^{-1}	4.94	4.73	3

a/ MPV is the statistic that represents the amount of analyte most likely present in the sample, based on national test data.

b/ See text for explanation of rating.

Table 6. Statistical evaluation of analytical methodologies used by Central Region Limnology laboratory.

Parameter	Methodology	Lower limit of detection	Upper limit of detection	Precision	Accuracy (+ _)
Specific conductance	electrometric (compenstated @ 25° C)	0.1 μmhos c	NA[a]	3% @ Full scale	5% @ Full scale
pH	electrometric	0.1 Unit	14 Units	1% @ pH Unit	3% @ pH Unit
Alkalinity	titration (0.02 N H_2SO_4)	0.6 mg L^{-1}	NA	3% @ 10 mg L^{-1}	7% @ 10 mg L^{-1}
Turbidity	nephelometric	0 NTU	1000 NTU	1% @ Full scale	1% @ Full scale
Color	absorbance 400 nm	3.0 Pt units	NA	NA	NA
Calcium	EDTA titration	0.2 mg L^{-1}	150 mg L^{-1}	6% @ 5 mg L^{-1}	4% @ 5 mg L^{-1}
Magnesium	EDTA titration	0.3 mg L^{-1}	175 mg L^{-1}	12% @ 3 mg L^{-1}	10% @ 3 mg L^{-1}
Total iron	colorimetric (HCl digestion)	11.2 μg L^{-1}	7000 μg L^{-1}	15% @ 100 μg L^{-1}	5% @ 100 μg L^{-1}
Reactive silicon	colorimetric (heteropoly blue)	20.4 μg L^{-1}	3000 μg L^{-1}	5% @ 700 μg L^{-1}	2% @ 700 μg L^{-1}
Kjeldahl nitrogen	colorimetric (block digestion, phenate)	4.6 μg L^{-1}	3000 μg L^{-1}	8% @ 100 μg L^{-1}	3% @ 100 μg L^{-1}
Total ammonia	colorimetric (phenyl hypochlorite)	1.7 μg L^{-1}	500 μg L^{-1}	4% @ 100 μg L^{-1}	2% @ 100 μg L^{-1}
Nitrate + nitrite	colorimetric (cadmium reduction)	4.1 μg L^{-1}	500 μg L^{-1}	6% @ 100 μg L^{-1}	1% @ 100 μg L^{-1}
Total phosphorus	colorimetric (persulfate digestion, molybdenum blue)	0.3 μg L^{-1}	1100 μg L^{-1}	6% @ 6 μg L^{-1}	3% @ 6 μg L^{-1}
Reactive phosphorus	colorimetric (molybdenum blue)	0.3 μg L^{-1}	1100 μg L^{-1}	5% @ 6 μg L^{-1}	2% @ 6 μg L^{-1}
Particulate organic carbon	colorimetric (wet oxidation)	7.4 μg L^{-1}[b]	600 μg L^{-1}	7% @ 300 μg L^{-1}	3% @ 300 μg L^{-1}
Total particulate phosphorus	colorimetric (block digestion, molybdenum blue)	0.4 μg L^{-1}[b]	27 μg L^{-1}	6% @ 5 μg L^{-1}	7% @ 5 μg L^{-1}
Total particulate nitrogen	colorimetric (block digestion, phenate)	0.1 μg L^{-1}[b]	60 μg L^{-1}	4% @ 40 μg L^{-1}	3% @ 40 μg L^{-1}
Chlorophyll *a*	fluorometric	0.05 μg L^{-1}[b]	NA	13% @ 1.5 μg L^{-1}	12% @ 10 μg L^{-1}

a/ NA = not available/applicable.

b/ detection limit for in-lake concentration assumes volume of lake water filtered is 1.0 liter.

RESEARCH PRODUCTS and PUBLICATIONS

The following is a list of research papers/reports that have been published or submitted for publication within the last year and their publication status. We have also included papers and reports that are in revision or those that are in preparation. Also listed are research and technical findings presented by CRL staff at various professional symposia, seminars, workshops, and public forums.

Professional Papers

Edmundson, J. A. and A. Mazumder. 2001. Linking growth of juvenile sockeye salmon to temperature in Alaskan lakes. *Transactions of the American Fisheries Society* 130:644-662.

Edmundson, J. A. and A. Mazumder. 2001. A regional and hierarchical perspective of thermal regimes in subarctic, Alaskan lakes. *Freshwater Biology* 46:1-17.

Edmundson, J. A. and A. Mazumder. 2001. Pacific salmon cacasses – what's all the stink? *BioScience* (In preparation).

Mazumder, A. and J. A. Edmundson. 2001. Impacts of fertilization and stocking on trophic interactions and growth of juvenile sockeye salmon. *Canadian Journal of Fisheries and Aquatic Sciences* (Submitted).

Mazumder, A. and J. A. Edmundson. 2001. Biodiversity in extreme environments: glacial versus non-glacial lakes. *Limnology and Oceanography* (In preparation).

Technical Reports

Edmundson, J. A. and G. L. Todd. 2000. Limnological perspectives on stock and recruitment for Egegik and Ugashik River sockeye salmon. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 2A00-33:90 pp.

Edmundson, J. A., M. S. Dickson, and W. A. Bucher. 2001. Limnological and fishery investigations concerning sockeye salmon production in Delight and Desire Lakes, *Exxon Valdez* Oil Spill restoration Project Final Report (Restoration Project 98254), Alaska Department of Fish and Game, Commercial Fisheries Division, Soldotna, Alaska (Re-submitted).

Edmundson, J. A., V. P. Litchfield, G. L. Todd, J. M. Edmundson, and L. Brannian. 2001. Central Region Limnology 2000 annual report of progress. Alaska Department of Fish and Game, Commercial Fisheries Division, Regional Information Report No. 2A00-27: 25 pp.

Edmundson, J. M. 2001. Sockeye salmon production relative to changes in rearing capacity of Crescent Lake, Upper Cook Inlet. Alaska Department of Fish and Game, Commercial Fisheries Division, Regional Information Report No. 2A01-XX (In preparation).

Litchfield, V. P. 2001. A technical review of the Big Lake sockeye enhancement program. Alaska Department of Fish and Game, Commercial Fisheries Division, Regional Information Report No. 2A01-XX (In preparation).

Todd, G. L. 2001. Limnological evaluation of a fry stocking program in Solf Lake, Prince William Sound. Alaska Department of Fish and Game, Commercial Fisheries Division, Regional Information Report No. 2A01-XX (In preparation).

Todd, G. L., S. R. Carlson, P. A. Shields, D. L. Westerman, and L. Brannian. 2001. Sockeye and coho salmon escapement studies in the Susitna drainage 1998. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 2A01-11:83 pp.

Research Proposals and Operational Plans

Edmundson, J. A. 2001. Trophodynamics of sockeye salmon in relation to stock and recruitment. Ph.D. Research Proposal. Biology Department, University of Victoria.

Hauser, W. J., J. A. Edmundson, and A. Mazumder. 2001. Detecting and understanding marine-terrestrial linkages in a developing watershed: nutrient cycling in the Kenai River watershed. *Exxon Valdez* Oil Spill (EVOS) Project Proposal 02612.

Litchfield, V. 2001. Water-quality monitoring of lakes in the Matanuska-Sustina River drainage. Project Operational Plan, Alaska Department of Fish and Game, Division of Commercial Fisheries.

Presentations (Presentor is bolded)

Edmundson, J. A. Linking growth of juvenile sockeye salmon to habitat temperature in Alaskan lakes. 13th Annual Biology Graduate Student Symposium. University of Victoria, British Columbia. February 21-22, 2001.

Edmundson, J. A. Biology Department Seminar. Marine versus freshwater influences on the productivity of Pacific salmon. University of Victoria, British Columbia. January 22, 2001.

Edmundson, J. A. Biology Department Seminar. Biodiversity: do many species matter? University of Victoria, British Columbia. February 26, 2001.

Edmundson, J. A. Trophodynamics of sockeye salmon in relation to stock and recruitment. Ph.D. Research Proposal, Biology Department, University of Victoria, British Columbia. May 08, 2001.

Edmundson, J. A. and **G. L. Todd**. Limnological perspectives on stock and recruitment for Egegik and Ugashik River sockeye salmon. Alaska Department of Fish and Game, Division of Commercial Fisheries. Southwest Alaska Interagency Fisheries Meeting, Dillingham, Ak. February 22, 2001.

Mazumder, A. and J. A. Edmundson. Importance of nutrient-foodweb dynamics in setting escapement goals: examples from Alaskan sockeye lakes. 7th Alaska Salmon Workshop, Escapement and the Realities of the New Salmon Management. Anchorage, Ak. February 21-23, 2001.

Staff Development

Jim A. Edmundson completed the first year of a doctor of philosophy program in biology at the University of Victoria, British Columbia. In May 2001, he successfully defended his research proposal on trophodynamics of sockeye salmon ecology in relation to stock and recruitment. Jim A. Edmundson was also selected to organize a special session at the upcoming American Society of Limnology and Oceanography (ASLO) 2002 Summer Meeting in Victoria (http://www.aslo.org/), British Columbia. The theme of his session is titled *Ecological Links to Population Dynamics of Salmon*. John Edmundson, Virginia Litchfield, and Gary Todd attended the ADF&G 7th Alaska Salmon Workshop, *Escapement and the Realities of the New Salmon Management* (Anchorage, Alaska, 21-23 February 2001).

ADDENDUM

In-situ Water-Quality Monitoring

The procedures detailed below apply to the Hydrolab Surveyor 4a (Surveyor) and DataSonde 4a multi-sensor (Sonde). With the Surveyor power on and display screen active, the top four keys (buttons) correspond to the respective boxes shown on the bottom of the screen. The Go Back (top left) key will return the previous screen, and pressing several times will return to the initial screen. When deploying the instrument, use the pulley assembly to avoid damaging the data cable. Place the cables (data cable and steel-wire tether) from spool onto pulley system and lower the Sonde in the water.

<u>Calibration/Storing Field Data</u>

1. Plug Surveyor into cable (external battery) and plug other cable end to cable spool (out).
2. Attach external battery cable to 12-V battery by clips or through cigarette lighter adapter.

3. Plug Sonde into cable (spool out). Apply silicon grease to the O-ring and align large pin on Sonde with arrow on cable end. Push firmly to seat and tighten retaining cap. Attach steel support cable to Sonde bail with locking shackle.
4. Remove protective cover from Sonde and replace with weighted sensor guard. Place Sonde into the water (sensor guard should be under water) and cables on pulley assembly.
5. Turn Suveyor on (very bottom right hand key, printed O I 1). After approximately 1 minute data fields should be displayed on screen (date/time, depth, dissolved oxygen [DO], specific conductivity, turbidity).
6. Select (press) Setup/cal key (top left hand key, of top four keys). Select calibrate key (bottom right key, top four). Select Sonde key (bottom right key, top four).
7. Scroll down (arrow key pads) to DO :mg/l, press Select key. Manually enter 760.0 for new BP (barometric pressure) even though new reading (highlighted) is 760.0. Scroll left (arrow keys) to 7 press Select, scroll right to 6 and Select. Continue until 760.0 is shown in new field, select Done (top right key, top four).
8. Enter new DO reading from Hach kit test. Follow same procedure as entering BP (above). Select Done when finished. Screen will show (calibration successful) if successful, if not attempt again starting at entering the BP. If still not successful after second attempt press the Go Back key and store data anyway (below). If successful press any key (as displayed on screen bottom) of the top four.
9. Calibrating the turbidity sensor should be done in the laboratory using known turbidity standards. Complete procedures are covered in the HydroLab DataSonde manual.
10. Press the Go Back key (several times) until Files and Store show in the right top and bottom positions on the screen. Sonde should be acclimated by now (Hydrolab recommends approximately 5 minute wait after unit is turned before storing real data).
11. Press the Store key (bottom right, top four). Scroll down or up (arrow keys) until station is highlighted. Then press Select, the current readings and depth are now stored. If the station-lake template is not already entered into the Surveyor memory, store in one of the test (1, 2, 3) templates, as entering new templates require a re-setup of all station templates and measured parameters.
12. Lower Sonde to the next depth (depth is shown on screen) and press Store. The Surveyor defaults to the previous station so you will not need to scroll through all the stations each time, only when at a new station (site).
13. If the screen shuts off, hit any key and the screen will re-activate. The Surveyor is currently programmed to shut the screen off in two minutes and the power off after five minutes. These setting shut the Surveyor off if you forget, between stations or when finished with the whole lake survey, to conserve battery power.

New Station Template

1. Turn Surveyor on (very bottom right hand key, printed O I 1). Press (Select) Files key (top right, of top four keys).
2. Scroll down (arrow keys) to Create and press Select. Select Manual (highlighted).
3. Enter template name (Lake and station name, SKILAK A) by scrolling and pressing Select. To enter a space scroll down anywhere on space line (line with back and forward arrows) and Select. To backspace to remove or change a letter use the backspace key (bottom left).

4. When finished with lake-station name press Done key (top right, top four). Enter all additional templates following the same procedures.
5. To keep the current spreadsheet format when data is transferred, add parameters (highlighted) in sequence as numbered. You will scroll past some parameters to add, to keep them in numbered sequence. 1: D/T Syrv4a:MDY/HMS (month, day, year / hours, minutes, seconds), press Add key (bottom left, top four). Scroll down to second (next) parameter. 2: Dep200:meters (depth 200 meters), and press Add. Continue scrolling and add remaining parameters. 3: Temp:C (temperature °C). 4: DO:mg/l (dissolved oxygen mg l^{-1}). 5: SpCond:uS/cm (specific conductivity µmhos cm^{-1}). 6. Turb:NTU (turbidity NTU). Do not use (enter) Turb:NTUs as this is for a different model sensor and the Sonde will not read the values correctly.

As mentioned in the calibration storing section (No. 11.) entering new templates requires a re-setup of all station templates and measured parameters. Complete directions are covered in the Surveyor manual.

Downloading Files to Computer

1. On the computer go to Start, then Programs, Accessories, Hyperterminal, Hydrolab.
2. In Hydrolab go to Transfer, Receive File. The page will have (place received file in following folder), which is set to K:\HydrolabPhys.
3. Click on Receive, the the next page asks for the file name. Type in file name (SkilakA.csv). You need to put the file extension (.csv) to be able to open the files in Excel. After connecting the Surveyor to the computer click on OK and the next sheet will open and when the file is transferring it will have the file name and bytes transferred.
4. Connect the Surveyor to the 9-pin connector (Hydrolab) cable and turn the Surveyor on (key on very bottom right hand).
5. Select Files (top right key), scroll down (arrow keys) to (Transmit) and select.
6. Scroll down the file (lake-station) you want to transfer and select. Then in the next screen scroll down to (SS-importable) and select. The Surveyor will say (press any key) to start file transfer.
7. After the transfer is complete the Surveyor will show (transfer successful, press any key). The computer screen will have shown the file transfer also. Press any key then the (Go Back) key to begin transfer for the next file. Repeat step 3 again on the computer, and steps 5 and 6 for the Surveyor for each file to be transferred.
8. In Excel go to the file type and use all or text to open and the files will open correctly. Make sure all files were transferred and stored correctly before wiping files from the Surveyor.
9. Wiping (deleting) files from the Surveyor. Go to files (No. 5), scroll down to wipe and select. Scroll to file to be wiped and select, then type 1 for yes, select and then done and the file is cleared. Repeat for remaining files. The templates remains in memory for the next trip.

ERRATA

Limnological Perspectives on Stock and Recruitment for Egegik and Ugashik River Sockeye Salmon

In our reporting of macrozooplankton taxa in Becharof and Ugashik lakes (Edmundson and Todd 2000), we have become aware of some errors in Table 2 (page 30). Several species names were incorrectly reported. The corrected table is given below. The overall conclusions of the report remain unchanged.

Table 2. Mean length (millimeters) of macrozooplankton in Becharof and Ugashik lakes, 1997-1999.

Lake	Group	Taxon	1997	1998	1999
Becharof	Cyclopoid	Cyclops scutifer, non-ovigerous	0.71	0.85	0.72
		Cyclops scutifer, ovigerous	1.22	1.29	1.16
	Calanoid	Diaptomus gracilus, non-ovigerous	0.96	0.96	1.02
		Diaptomus gracilus, ovigerous	1.24	1.26	1.26
	Calanoid	Eurytemora yukonensis, non-ovigerous	1.08	1.06	1.06
		Eurytemora yukonensis, ovigerous	1.26	1.47	1.26
	Cladoceran	Bosmina coregoni, non-ovigerous	0.37	0.41	0.37
		Bosmina coregoni, ovigerous	0.42	0.47	0.46
	Cladoceran	Daphnia longiremus, non-ovigerous	0.71	0.78	0.70
		Daphnia longiremus, ovigerous	0.94	1.17	0.96
	Cladoceran	Holopedium gibberum, non-ovigerous	0.42	0.45	0.49
		Holopedium gibberum, ovigerous	0.75	0.60	0.60
	Cladoceran	Chydoridae sp., non-ovigerous	0.21	0.28	0.27
		Chydoridae sp., ovigerous	np[a]	0.31	np
Ugashik	Cyclopoid	Cyclops scutifer, non-ovigerous	0.65	0.70	0.69
		Cyclops scutifer, ovigerous	1.12	1.12	1.12
	Calanoid	Diaptomus gracilus, non-ovigerous	0.87	0.86	0.93
		Diaptomus gracilus, ovigerous	1.05	1.19	1.28
	Calanoid	Eurytemora yukonensis, non-ovigerous	1.03	np	1.36
		Eurytemora yukonensis, ovigerous	1.45	np	np

a/ species not present; no measurement.

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