OKANAGAN LAKE ACTION PLAN

YEAR 3 (1998) REPORT

by

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RESULTS OF IMPLEMENTATION OF THE OKANAGAN LAKE OLAP

by

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ABSTRACT

This second report of the Okanagan Lake Action Plan (OLAP) confirms many of the initial results report by Ashley et al. (1998). Kokanee escapements in 1998 were the lowest on record thus underlining the reason for accelerated, comprehensive research on their biology, habitat requirements and their food sources. The OLAP is designed to gain a better understanding of whole lake biological relationships, define limiting factors and identify and implement remedial measures. Lake productivity decline, mysid competition with kokanee for zooplankton and deterioration of spawning habitat have all been all identified as limitations to kokanee. The OLAP is comprised of six components—priority remedial measures, sustained monitoring, comparative analysis studies, large scale experiments, applied research and functional studies. This report summarizes the results and progress of the OLAP for 1998.

In 1998 there was a shift in emphasis towards mysis research and their impacts on kokanee. A small reduction in routine limnological sampling occurred as baseline data is becoming sufficient. Stream habitat protection remains paramount and some positive progress is reported on stream restoration opportunities. Analysis of the lake level drawdown regime suggests it has a negative impact on shore spawning kokanee eggs. Work continued in 1998 to evaluate an alternative method of predicting watershed snowpack, which in turn may allow for regulation of lake level drawdown more conducive to kokanee egg survival. Baseline kokanee data from Mission Creek was updated and summarized. The genetic analytical techniques used to differentiate between shore and stream spawning kokanee were demonstrated to be valid.

Mysid harvest was advanced to a commercial scale level with successful use of a large net and commercial shrimp boat. Some of the 1998 *mysis* research results will assist in a more intensive full-scale commercial harvest proposed in 1999.

Implementation of the OLAP is well underway and momentum is building. Some promising results with mysid distribution information, mysid harvesting, stream restoration proposals and stock differentiation are of particular significance in the quest to ensure Okanagan Lake kokanee recovery.

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RESULTS OF IMPLEMENTATION OF THE OKANAGAN LAKE OLAP

1998

INTRODUCTION

The initial years (1997 to 1998) results of the Okanagan Lake Action Plan (OLAP) were reported by Ashley et al. (1998). This report summarizes the priority limnological and fisheries work conducted in 1998 and attempts to present linkages with preliminary work conducted in previous years. This is the second report of the OLAP.

Ashley et al (1998) emphasized the need for a long-term view for kokanee stock recovery on Okanagan Lake. The OLAP is designed to improve the knowledge base of whole lake relationships and identify limiting factors so that remedial measures can be implemented. Progress is being made towards problem identification and some potential solutions are coming forward. It has been acknowledged since the inception of the OLAP that quick solutions to the complexity of problems on the lake were not evident. Some of the work in 1998 reinforces that view while other results provide some encouragement for the near future.

BACKGROUND

For more than 50 years there has been a series of troubling events related to Okanagan Lake and its sport fisheries. While many of the changes have been previously documented (Okanagan Basin Study) and remedial action has been quite successful, especially regarding water quality, the downward spiral for fish has continued. Fisheries biologists, local anglers and naturalists for years have observed noticeable declines in catch success and numbers of stream spawners. Shore spawning kokanee also underwent tremendous declines from the 1970s to the 1990s. Ashley et al. (1998) documented some of the actions taken by government in response to the alarming decline in kokanee abundance.

A significant milestone in Okanagan Lake fisheries conservation occurred in 1995. A technical workshop attended by various resource experts and some public members was held June 28 to 30, 1995 at the Okanagan College campus. The workshop used the Adaptive Environmental Assessment (AEA) format whereby Dr. Carl Walters of the UBC Fisheries Centre led an interdisciplinary group of participants through interpretation of existing data, ideas and policy issues. The workshop reviewed changes to the lakes’ nutrients, water quality, plankton, kokanee and rainbow trout populations. A review of the possible reasons for the decline of kokanee was conducted and potential restoration options were discussed.

Based on input from this workshop a working computer simulation model was used for predicting the dynamics of the lakes’ trophic levels including predictive capabilities for the primary fish stocks. A key finding was that kokanee declines in both stream spawning and shore spawning could be attributed to reductions in nutrients and or competition from mysid shrimp.

Ashley and Shepherd (1996) documented the results of the workshop including development of a comprehensive and forward thinking 20 year OLAP. The initial findings of the OLAP were published by Ashley et al. (1998).

Declining fish populations in British Columbia's large lake systems are a common occurrence as evidenced in Kootenay Lake (Ashley et al. 1997), Arrow Lakes (Sebastian et al. 1999) and Shuswap Lake (I. McGregor, Kamloops, pers. comm.). In the case of Arrow and Kootenay lakes the reason for the decline is clearly associated with reservoir development(s) and reduction in lake productivity (Ashley et al. 1997). When faced with such large scaled problems elsewhere in North America fisheries managers have usually opted for increasing the specie of concern (e.g., kokanee in Okanagan Lake) by means of hatchery introductions. This was attempted during the late 1980s and early 1990s on Okanagan Lake without any measureable success. A second common strategy has been introduction of a species of fish to deal with the perceived problem (e.g., mysid shrimp). These two management options were dismissed at the Okanagan Lake workshop with the rationale best explained by repeating verbatim the observations of Walters (1995, MS) regarding the conclusions drawn from the simulation model:

"Five lines of evidence presented during the workshop led us to conclude that the kokanee decline may be at least partly due to reduced capacity of the lake to produce juvenile fish from all stock sources:

(1) both stream and lake spawning stocks declined in parallel, which would be unlikely if stream spawning and rearing habitat loss were the main cause of the decline;

(2) fishing mortality rate is low, making it unlikely that the stocks were all overfished at the same time;

(3) there is a weak inverse relationship between stream and shore spawning abundance since 1980, suggesting a possible competitive interaction between these stocks in the lake, where they share food resources;

(4) declines in survey estimates of age 0 fall abundance have not been accompanied by declines in estimates of abundance of older fish, i.e., survival from age 0 to 1-2 appears to be improving as age 0 abundance declines; and

(5) enhancement of stream fry production through habitat improvement measures and hatchery production has not resulted in increases in total lake spawning runs; instead, enhanced production appears to be replacing natural production while overall spawning stocks continue low.

These patterns are not surprising; density dependence in overwinter mortality of age 0 sockeye salmon is probably widespread in O. nerka, and appears to be associated with food competition during the first summer of lake rearing. Depression of food density during the first lake summer, especially cladocerans, when fry abundance is high may lead to the fry having insufficient energy reserves to survive the difficult period in late fall when food densities are falling rapidly but water temperature is still high enough to imply significant metabolic demands.

Decreasing lake fertility due to reduced P loads and/or competition with mysid for available zooplankton production could easily have led to large enough decreases in food supply for age 0 fry (decreases in lake carrying capacity) over the period 1970 to 1980 to explain the overall population decline. If carrying capacity has indeed decreased, there may be a pathological side effect of enhancement efforts targeted mainly on stream spawning stocks: enhancing survival of these stocks will cause them to “fill” more of the available carrying capacity and hence drive down natural spawning populations (unenhanced streams, shore spawners) even more rapidly. Under an overall carrying capacity limit, any individual stock can still be enhanced successfully, but only at the expense of other stocks. This dreadful possibility is well known in freshwater fisheries; there is a long history of problems with competition between wild and hatchery fish in lakes.

To further evaluate the carrying capacity hypothesis and to provide a tool for evaluating long-term impacts of improving carrying capacity versus enhancement of single stocks, we developed a spreadsheet population dynamics model. We fit the model to available spawning abundance, survey index, and catch data using a sum of squares criterion for goodness of fit of the model to the data, and Excel’s Solver method.

Model Structure and Assumptions

The model is mainly just a population age structure accounting system (abundances of age 0, 1, 2, 3 fish) for three spawning stock units: stream, shore, and enhanced. Survival rates (natural and fishing mortality) are applied to each age of fish each year to predict numbers of the next age the next year, predicted spawners being the number that survive to age 3. Fecundity times egg-to-fry survival rate is then applied to the spawners to predict the number of age 0 fry the next fall; egg-to-fry survival rate is assumed to be density dependent for each stock, representing carrying capacity limits within each spawning habitat type. Total age 0 fry (over all stocks) is calculated for each model year, and this total fry density is used to predict a density-dependent overwinter survival rate to age 1 with all stocks assumed to share this rate (all stocks assumed subject to the same lake carrying capacity limit, expressed as an effect of density on survival). The density dependent egg-fry and fry overwinter survival relationships are all assumed to be of Beverton-Holt recruitment relationship form:

$$s_i=s_{maxi}/(1+s_{maxi}N_i/K_i)$$

where s_i is survival rate through the life stage for stock unit i, N_i is number of eggs or fry entering the stage, and K_i is a carrying capacity parameter (output $N_{after}=s_iN_i$ approaches a limit K_i as input N_i increases). The lake carrying capacity parameter K_{lake} is treated as time varying by calculating it for each year as a product $K_{lake}=K_{base}R_{year}$, where the relative capacity R_{year} values are set to 1.0 for 1970-71, and are then estimated by the Excel Solver method for years 1972-93. A weak sum of squares condition $\Sigma(R_{year}-1.0)^2/1000$ is included in the estimation sum of squares to prevent the relative values from “wandering” in a meaningless way from the base value 1.0 in the absence of evidence in the data that lower (or higher) values of relative carrying capacity would actually help to explain observed population variation.

Fishing mortality (age 2 to 3 fish) is predicted each year as q (observed fishing effort), where q is a catchability coefficient. This fishing mortality rate is assumed to affect all three stocks equally. Observed fishing efforts were not available for 1972 to 1980; these were estimated by linearly interpolating effort growth between the estimates for 1971 and 1981.

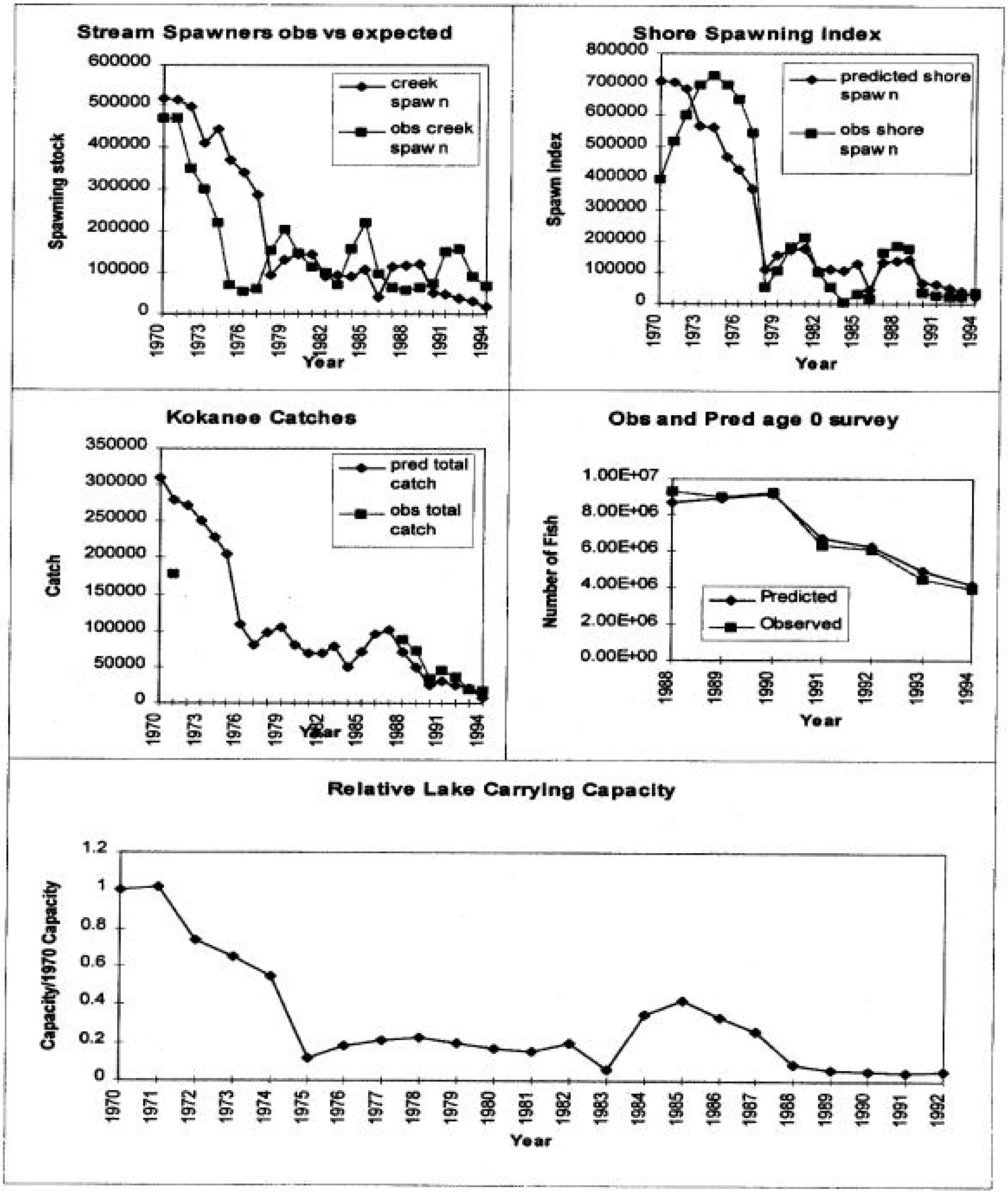
Only the lake carrying capacity K_{lake}, relative carrying capacity multipliers R_{year} and the catchability coefficient q were estimated by fitting the model to the data using Solver. Net age 0 fry production per spawner (24 for both wild stocks, 100 for enhanced stocks), annual natural survival rate (0.55), maximum age 0-age 1 survival rate s_{max}=0.33, and stream-shore spawning carrying capacities were assessed from independent analysis of abundance data and/or guesses based on historical abundances. For data fitting, shore spawning numbers were corrected upward by a factor of 2, representing an estimate based both on observations about spawning behaviour and on early model runs which indicated that observed shore spawning stocks are not large enough to explain observed numbers of fall age 0 fish in the echosounding and trawl surveys.

Model Estimation Results and Basic Predictions about Stock Rebuilding

The model provides quite a credible “fit” or reconstruction of observed population and harvest trends (Fig. 1). Predicted stream spawning stocks are somewhat below observed for the most recent years; this is because “observed” values include fish subject to enhancement, while the model plot for stream stocks shows only spawning numbers in unenhanced streams. The best fitting estimates of relative lake carrying capacities (R_{year}) indicate a major decline at about the time expected from both when *Mysis* became abundant and when various decreases in anthropogenic P loading occurred. Fishing effects on modelled abundance are trivial; the model estimates very low exploitation rates even for recent years. Model estimates are lower than MELP assessments because model estimates of shore spawning stocks (and total lake abundance) of age 2 to 3 fish are substantially higher than used in MELP calculations of harvest rate.

Increasing enhanced stock fry capacity in the model causes a stock replacement (increasing percentage enhanced fish, no total stock increase) much as observed in the late 1980s and 1990s. This is a combined effect of taking wild spawners to seed the enhancement facilities, plus competition for food resources with wild fry in the lake.

The model makes three disturbing predictions about the future of the lake: (1) closing the kokanee fishery will have no measurable effect on rebuilding spawning runs; (2) abundance will remain low, and wild stocks will continue to be replaced by enhanced stocks, unless lake carrying capacity is somehow increased; and (3) even if lake carrying capacity is suddenly increased, it will take at least 20 years for stocks to recover to fully utilize this restored capacity. That is, spawning runs are now low enough that recruitment rate per spawner will be a limiting factor for stock recovery even if the capacity problem is indeed real and can be solved quickly. As shown in Figure 2, rebuilding rates may be somewhat higher if fish from enhancement facilities are able to disperse out into and re-seed other habitats as enhancement capacities are filled, but it would not be wise to plan on that ability”.



Stream Spawners obs vs expected

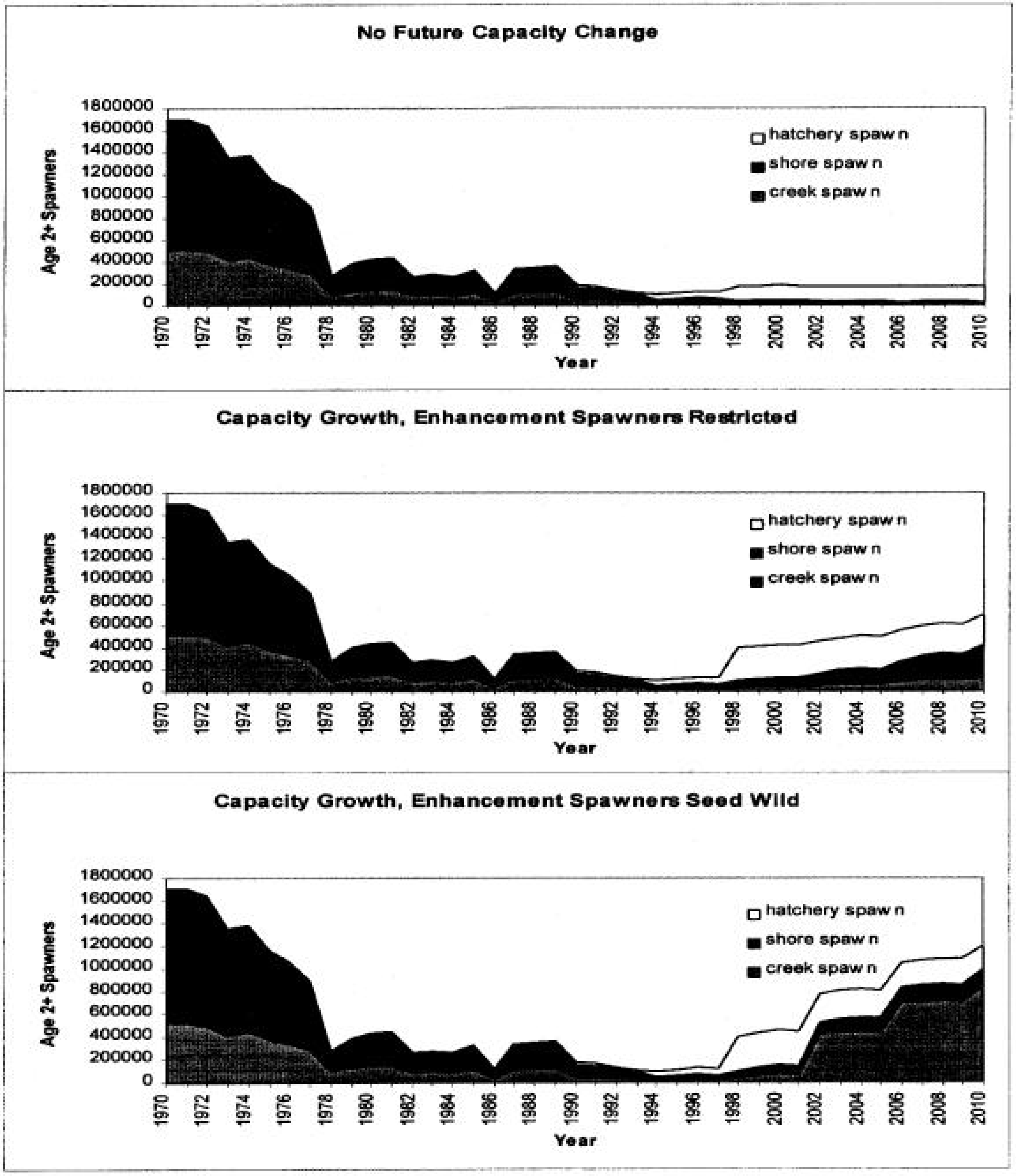
Shore Spawning Index

Kokanee Catches

Obs and Pred age 0 survey

Relative Lake Carrying Capacity

Figure 1. Okanagan Lake kokanee spawner and harvest trends.



No Future Capacity Change

Capacity Growth, Enhancement Spawners Restricted

Capacity Growth, Enhancement Spawners Seed Wild

Figure 2. Okanagan Lake kokanee numbers with and without enhancement relation to lake carrying capacity.

The insight of Dr. Walters and experience gained from the on-going fertilization experiment on Kootenay Lake have significantly narrowed down what actions could be undertaken on Okanagan Lake. Two options were identified for increasing the carrying capacity of Okanagan Lake for kokanee:

1) increasing productivity by introducing fertilizer similar to that on Kootenay Lake;
2) reducing the mysid population to ease competition with kokanee.

The fertilization strategy has been initially rejected due to differing regional interests regarding water quality vs. fish. Consequently, mysid control and habitat protection/restoration have become the focus of the OLAP. It was also understood that no “quick fix” solutions were available.

As previously mentioned a long-term approach to resolving Okanagan Lake kokanee problems is necessary hence the proposed OLAP encompasses a twenty-year period in four blocks of five years duration. Under this scenario, the OLAP will be initially weighted in Phase 1 (1996 to 2001) towards conservation of native stocks and habitat protection (e.g., priority remedial measures and monitoring) and collection of priority information (e.g., comparative analysis studies, functional studies, applied research and large scale experiments).

In Phases 2 and 3 (2001 to 2006 and 2006 to 2011), the emphasis in the OLAP will shift towards continued monitoring, completion of priority data collection, initial implementation of new information and development of innovative resource management techniques. Phase 4 (2011 to 2016) will involve long-term monitoring and the application of new information and innovative resource management techniques obtained from the comparative analysis studies, functional studies, applied research and large scale experiments. Tables in Appendix I outline each of the four phases of the OLAP, which has been reviewed and approved by the members of the Okanagan Lake Scientific Advisory Panel (see details *in:* Ashley and Shepherd 1996).

Results of the initial three years work on Okanagan Lake may allow for some acceleration of certain components of the plan. As kokanee continue to dwindle in numbers there is growing pressure to implement potentially feasible remedies. Techniques for harvesting mysids is a good example. However, if mysid harvest is to become a reality then better baseline data of mysids distribution and densities will be required. Commitment to the long-term vision of the OLAP must be adhered to if effective long-term solutions are to be found.

OBJECTIVE OF OLAP

To rebuild and maintain the biodiversity of the wild kokanee stocks in Okanagan Lake. The plan seeks to determine the biological relationships, define causal problems and implement innovative solutions to remediate the declining kokanee population.

Phase 1 rationale: Conservation of native stocks and habitat protection to preserve remaining stocks and collection of priority information to improve present management and develop innovative future resource management techniques.

There are six components to phase 1 of the OLAP that will be reported upon in the remainder of this report. These are:

1) priority remedial measures;
2) monitoring program;
3) comparative analysis studies;
4) large scale experiments;
5) applied research;
6) functional studies.

An impressive number of scientists, fisheries biologists and technicians as well as the interested public have participated in the OLAP activities during 1998. A list of the participants and their primary focus is as follows (Table 1):

Table 1. Okanagan Lake Action Plan Participants.

PROJECT FOCUS	PERSONNEL	AFFILIATION
Project coordination and scientific liaison	Ken Ashley	Fisheries Management Branch, Ministry of Fisheries, UBC
	Ian McGregor	Regional Fisheries, Kamloops, MELP
	Dale Sebastian	Fisheries Management Branch, Ministry of Fisheries, Victoria
	Ted Down	Fisheries Management Branch, Ministry of Fisheries, Victoria
	Steve Matthews	Regional Fisheries , Penticton, MELP
Regional support and logistics	Ian McGregor	Regional Fisheries Kamloops, MELP
	Bruce Shepherd	Regional Fisheries Penticton, MELP
	Dave Smith	Regional Fisheries Penticton, MELP
	Brian Jantz	Regional Fisheries Penticton, MELP
	Steve Matthews	Regional Fisheries Penticton
	Graham Young	Penticton contractor
Habitat restoration	Jan den Dulk	Watershed Restoration Program contractor, Kamloops
	Harvey Andrusak	Watershed Restoration Program contractor, Victoria
	P. Epp	Watershed Restoration Program, Penticton BC MELP
	M. Zimmerman	Watershed Restoration Program Contractor, Nelson BC
	R. Finnegan	Watershed Restoration Program Contractor, Coquitlam BC
	Regional District Central Okanagan	Kelowna, BC
	Dr. Peter Ward	Engineering Consultant, Vancouver
Okanagan Lake rule curve	Dr. Hansen A. Yassien	Engineering Consultant, Vancouver
Limnology	Laurie McEachern	Biological contractor, Penticton
Water quality	Vic Jensen	MELP Pollution Prevention Program ,Penticton BC
	Laurie McEachern	Biological contractor, Penticton
Phytoplankton Zooplankton	Laurie McEachern	Biological contractor, Penticton
Mysid biology	Dr. Dave Lasenby	Biology Department, Trent University, Ontario
	Janice Quirt	Grad Student, Trent University
	J.D. Whall	Grad student, Trent University
Mysid harvest techniques	Ken Ashley	
	Bruce Shepherd	
	Dave Smith	
	Graham Young	
	Bob McIIlwaine	Cantrawl, Richmond BC
	Bob Bowker	Tofino, BC
Kokanee enumerations	Brian Jantz	Regional Fisheries, Penticton
	Steve Matthews	Regional Fisheries, Penticton
	Bruce Shepherd	
	Dave Smith	
Kokanee biology	Dr. Peter Dill	Okanagan College, Kelowna
	Lisa Thompson	Fisheries Centre, UBC
	Bruce Shepherd	Regional Fisheries, Penticton, MELP
	Harvey Andrusak	Contract biologist, Victoria BC
Kokanee genetics	Dr. Eric Taylor	Dept Zoology UBC
Kokanee stock identification	Susan Pollard	Fisheries Branch Ministry of Fisheries, Victoria
	A. Kuiper	Dept Zoology UBC
	P.M. Troffe	Dept Zoology UBC
Kokanee trawl and acoustics	Dale Sebastian	Fisheries Management Branch Ministry of Fisheries, Victoria
	George Scholten	Fisheries Management Branch Ministry of Fisheries, Victoria
	Bruce Shepherd	Regional Fisheries, Penticton, MELP
	Dave Smith	
	Laurie McEachern	
Shore habitat classification	Dr. Hans Shreier UBC	Resource Management Dept UBC
	Cecilia Wong	Resource Management Grad student
Paleolimnology	Ken Ashley	
	Dr. Lidija Vidmanic	Contract scientist, UBC

Budget for Year 3 (1998 to 1999) OLAP

The annual expenditure for implementing the OLAP is provided in Tables 2 and 3. Approximately two thirds of the money has been provided by the Habitat Conservation Trust Fund (HCTF) with lesser amounts secured from Forest Renewal BC, the Ministry of Environment, Lands and Parks and Ministry of Fisheries.

Okanagan University College has provided invaluable student assistance and waived substantial administration fees. Okanagan Carp Co. has provided equipment and labour in mysid harvest work and the US National Marine Fisheries Service provided assistance and support for genetic analysis.

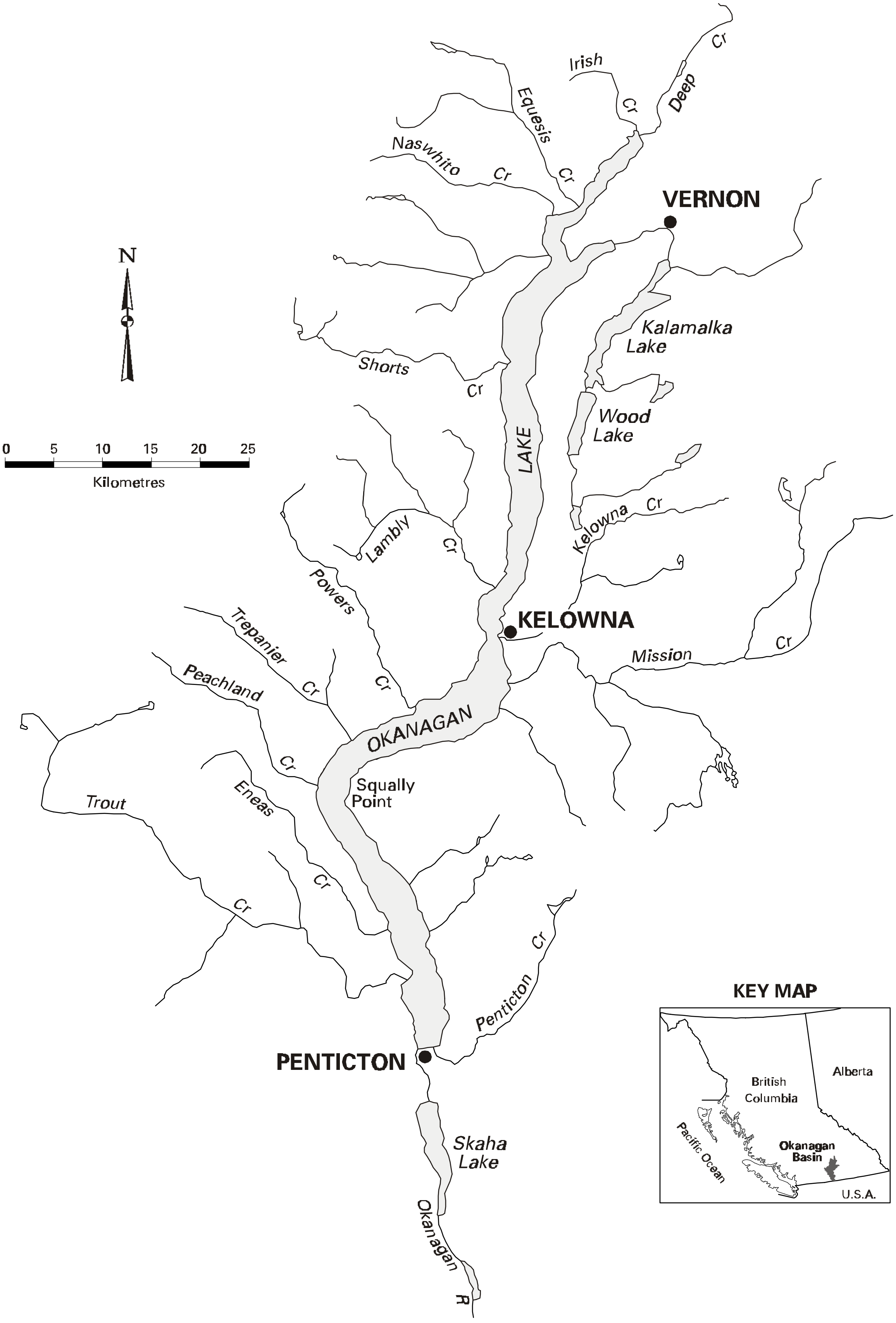
Table 2. Estimated cost of Okanagan Lake OLAP by fiscal year.

Year	Amount requested of HCTF	Amount approved by HCTF	Expended	Funding additional to HCTF
1996/97	$200,000	$200,000	$200,000	$159,000
1997/98	$268,600	$268,600	$268,600	$110,000
1998/99	$285,000	$269,000	$269,000	$177,000[1]

[1] WRP: $89K for habitat restoration/feasibility work on Mission/Trout Creeks, MELP Waste Man Br: $10K for water sample analysis, the NFMS – Washington, $18K in-kind for Genetic, MELP Fisheries and Fisheries Ministry: $60K for staff involvement.

Table 3. Approximate expenditure in 1998/99 by major components of Phase 1 of OLAP.

Activity	Expenditure
Monitoring	$106,000
Comparative analyses	$ 21,000
Large scale experiments	$ 0
Priority remedial measures	$ 34,000
Applied research	$ 50,000
Functional studies	$ 0
Communication	$ 58,000
Total	**$269,000**



Map 1. Okanagan Lake and tributary streams.

Map 2.

CHAPTER 1

PRIORITY REMEDIAL MEASURES

This category involves measures that should be undertaken as soon as possible to preserve remaining kokanee habitat and stocks in Okanagan Lake. In 1998 emphasis was placed on methods of predicting snowpack levels that may allow water managers to regulate Okanagan Lake in a manner more amenable to successful shore spawning kokanee. As well, two stream restoration projects were prioritized for action.

OKANAGAN LAKE WATER LEVEL MANAGEMENT REVIEW OF PAST TRENDS WITH RECOMMENDATIONS

INTERIM REPORT #2

by:

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INTRODUCTION

Water supplies in the Okanagan basin are controlled mainly by inflows and outflows from Okanagan Lake. This is a large lake with relatively small average throughflow. Hydrologically the area is arid, with low annual runoff amounts and large inter-annual fluctuations. In addition, the evaporation from Okanagan Lake is high, so the outflow in wet years vastly exceeds the outflow in dry years. A map of the area is shown (Fig. 1), with the downstream river (Okanagan River), leading via Skaha, Vaseau and Osoyoos lakes to the US border, and from there to the confluence with the Similkameen River. The Okanogan River (as it is called in Washington State) joins the Columbia River about 100 km south of the international border.

Capacity of the channelized Okanagan River downstream of Okanagan Lake is not large. The peak flow that it can pass depends on factors such as the backwater exerted by Skaha Lake, and by tributary steams. The design flow of the channelized river is 60 m^3/s. Under optimal conditions higher flows can be released (for example, during the early part of August 1997, a flow estimated at about 77 m^3/s was passed). Prolonged release of high flows sometimes causes damage to drop structures in the river downstream of Skaha Lake. The maximum daily volume (about 7.5 million m^3) that may be released from Okanagan Lake at this flow rate is a small fraction (1.8%) of the live storage volume of the lake. Thus many days and weeks of outflows are needed to significantly change the water surface level of the lake.

Water supply management, water quality and related issues for Okanagan Lake were comprehensively investigated in 1972 to 1973, and in 1974 a series of reports which included the *Comprehensive Framework Plan*. A summary of selected recommendations from this report is included in Section 3.0. The Plan emphasized aspects such as flood reduction, water supply for irrigation and municipal use, phosphate reduction from treated sewage waters, and flow needs for Okanagan River sockeye salmon. A clause was inserted relative to shore spawning kokanee and regulation of lake levels.

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Engineering and other work set out in the Plan were executed, and a report was published at the end of the implementation period (September 1982). The report was titled *Report on the Okanagan Basin Implementation Agreement* included details of the management of lake surface levels. Recommendations were made specifically directed at mitigating the effects of man made water surface changes in lake levels on shore spawning kokanee populations.

For the last 15 years the lake has been operated by Water Management Branch staff, following guidelines set out in the Plan of the Implementation Report. The Plan permits late winter drawdown of the lake, if needed, to create storage for larger than average anticipated runoff events the next spring and summer.

This procedure has the following attributes:

1. ***Benefit*** in creating space in the reservoir so that high runoff flows appearing weeks or months later can be stored and slowly released. This reduces maximum water surface levels the following summer, and reduces summer flow peaks in the Okanagan River. Lakeside residents, particularly those with low basements, benefit from reduced flood levels, because inundation of basements is minimized.

2. ***Detriment*** for lake and riverine spawning fish, because a) the lake may be drawn down sufficiently that lake spawning kokanee eggs may be left high and dry prior to completion of incubation and hatching, and b) high flows in the Okanagan River during the winter months may mobilize gravels and cause wash out of sockeye salmon spawning sites. In this context, both the sockeye salmon run on the Okanagan River and the Okanagan Lake kokanee populations are particularly valuable. The sockeye salmon run is one of only two substantial runs left on the Columbia River system, and the Okanagan Lake shore spawning kokanee are unique, with very different spawning behaviour and habitat preference compared to other kokanee. They therefore have a high intrinsic value from the point of view of genetic diversity.

Difficulties in managing the system from the point of view of spawning fish and egg survival stem from the large lead-time involved. The fish (both lake and riverine salmonids) spawn during the month of October, and select sites based on water levels (in the river and the lake) that they experience at the time. These water levels need to be kept at a fairly constant level at spawning time (sometime in mid or late October) to ensure optimum survival. Water levels must be maintained until early or mid April for the kokanee alevins to mature successfully. However, if these levels are held and an unusually high snow pack year occurs (as in the 1996 to 1997 winter) there is insufficient time during the April to early May period to create storage space in the lake prior to the onset of flooding. The result is very high lake levels and flooding of homes and other facilities. Although the flood construction level has been set at a relatively high elevation (343.66 m) for many years, there are a lot of non-conforming residences and other properties. If the level in Okanagan Lake is lowered starting in late January (as was done in 1997), then it is possible to create sufficient storage to reduce flooding in the summer months. However this is done at the expense of shore spawning kokanee.

In the natural system, with uncontrolled flow over a gravel or cobble bar at the outlet of Okanagan Lake (Fig. 2), the changes in outflow were gradual and determined by slowly changing lake levels as the winter months progressed. No provision was possible to reduce peak water elevations during the summer, by pre-releasing water following large snowfall winters. With the installation of a sill and gates at the outlet (starting in 1915), the possibility has existed for the last eighty years of significant lowering ("pulling the plug") of the lake, below previously occurring natural lows. This is done during high snow pack winters, to create room for storage of anticipated flood events.

ANALYSES AND RESULTS

1. Available Hydrological Data

Large amounts of hydrological data have been collected for Okanagan Lake and the Okanagan River system. A listing of a selection of the most important types of data for water level management is provided in Table 1. Water licence information was obtained from the Water Rights Information System computer files, at Water Management Branch, MELP. Meteorological and hydrological information was obtained from Environmental Services and Information Division, Environment Canada.

2. Okanagan Basin Framework Plan and Okanagan Basin Implementation Agreement

Two important sets of documents were produced, detailing what engineering, construction and administrative work had to be done, and how to operate Okanagan Lake and its tributaries. These were the report on the Canada-British Columbia Okanagan Basin Agreement, 1974 and the report on the Okanagan Basin Implementation Agreement, 1982. The first of these sets of documents included a comprehensive framework plan, referred to as the Plan. Recommendations from these documents were incorporated into the Water Management Branch's operating schedule, which specifies target lake levels and river flows at different times of the year.

A comprehensive analysis of water supply, flood potential and eutrophication possibilities for Okanagan Lake was carried out in the early seventies. Under a joint Federal-Provincial effort, a Canada-British Columbia Consultative Board was set up to oversee the work that had been funded in October 1969 under the Okanagan Basin Agreement. This work culminated in a report, published in 1974 in three parts:

1. Summary Report, including the Comprehensive Framework Plan: Canada British Columbia Okanagan Basin Agreement, March 1974, 42pp.
2. Main Report: Canada British Columbia Okanagan Basin Agreement, March 1974, 536 pp.
3. Twelve Technical Supplement Reports, including Volume 1: Water Quantity Report: Canada British Columbia Okanagan Basin Agreement, March 1974, 610 pp.

The study analyzed three growth projections for the period 1970 to 2020. With the highest growth projection (2.6% per annum) of the three, the report concluded that there was sufficient water in the basin to supply all projected withdrawals and to meet proposed fishery and recreation requirements. This scenario assumed withdrawal of larger volumes of water from Okanagan Lake during prolonged drought periods than had occurred in the past. Also forecast was the need for additional headwater storage of water.

Forecast ranges of Okanagan Lake water surface levels were as follows:

- *Not normally to exceed four feet in any one year, but a total variation of nine feet may occur between an extreme flood level in one year, and an extreme low lake level following a succession of drought years.*

Table 1. Summary of available data on Okanagan Lake

TYPE OF DATA	SAMPLING PERIOD	YEARS AVAILABLE
Evaporation:		
Kelowna Airport	Monthly	1971 to present
Penticton Airport	Monthly	1951 to 1980
Summerland	Monthly	1962 to 1992
Precipitation:		
Kelowna Airport	Monthly	1971 to present
Penticton Airport	Monthly	1951 to present
Water Surface levels:		
Okanagan Lake at Kelowna	Daily	1943 to present
Okanagan Lake at Penticton	Daily	1920 to 1974
Stream flow on Okanagan River:		
Okanagan River near Oliver	Daily	1944 to present
Okanagan River at Penticton	Daily	1921 to present
Okanagan River at Okanagan Falls	Daily	1915 to present
Okanagan River at Oroville	Daily	1942 to present
Stream Flow in main tributaries which supply 60% of the inflow to Okanagan Lake:		
Mission Creek near East Kelowna	Daily	1949 to present
Vernon Creek at outlet of Kalamalka Lake	Daily	1927 to present
Trout Creek at the mouth	Daily	1969 to 1982
Penticton Creek above Dennis Creek	Daily	1970 to present
Equesis Creek near the mouth	Daily	1969 to 1982
Kelowna Creek near Kelowna	Daily	1922 to present
Powers Creek at the mouth	Daily	1969 to 1982
Peachland Creek at the mouth	Daily	1969 to 1982
Water Licences:		
919 licences leading to a total licenced diversion of 110 mm^3 annually.		

The projected maximum elevation of Okanagan Lake during a 200-year flood event was 1,125.5 feet (343.05 m). This maximum elevation was based on statistical projections, but is hard to interpret for practical application. The maximum levels attained in Okanagan Lake depend on inflows and how the outflow gates are regulated during the weeks leading up to the major flood event.

In the section concerning "Detailed Recommendations", "Part A Water Quantity", of the Basin report water levels in Okanagan Lake are recommended to be regulated to target values (Table 2). Target water surface elevations for Okanagan Lake and sill elevations at the lake outlet are summarized on a scale drawing (Fig. 3). Values shown in Figure 3 are from the Plan.

Table 2. Target Water Surface Elevations for Okanagan Lake Recommended in the Plan (1974).

Normal Operating Conditions:	Regulated within its normal four foot range (1,119.8 to 1,123.8 feet, 341.32 to 342.54 m) in all years except extreme flood years (inflows projected to exceed 500,000 acre feet/yr., 617 million m^3/yr) and successive drought years (inflows less than 200,000 acre feet/yr., 247 million m^3/yr).
Flood Conditions Predicted:	Lake to be drawn down below its normal low water elevation of 1,119.8* feet (341.32 m) prior to freshet by up to one foot (0.305 m). (Drawdown to as low as 341.01 m is thus recommended, if necessary).
Drought Conditions Predicted:	Maintain the lake level as high as possible. Under prolonged drought conditions, the lake level may reach as low as 1,116.8 feet (340.4 m). The bottom 0.92-m of water storage is known as "emergency storage".

* Normal low water elevation specified in Plan of 341.32 m. Note that operational experience has shown that in most years meeting this target would result in excessive and unnecessary drawdown. In practice, a minimum level in an average year of 341.5 to 341.6m is usually sufficient.

The Plan also had the following recommendations:

- Flood plain zoning be implemented and enforced by a regional water management authority up to 1,127.5 feet (343.66 m) elevation around Okanagan Lake. Further development on this floodplain should be limited to recreation, parks and agriculture.

- Irrigation and domestic intakes around Okanagan Lake be adjusted as required to be operable at a minimum lake elevation of 1,116.8 feet (340.4 m).

- As of March 1974, future intakes, wharves, boat ramps and other structures around Okanagan Lake are built to operate with a lake elevation range of 1,116.8 to 1,125.5 feet (340.4 to 343.05 m).

- Water requirements for sockeye salmon in Okanagan River should be met in all years, except consecutive drought years, using the following guidelines:

DATES	FLOWS, OLIVER GAUGING STATION	
August 1 to September 15	300 to 450 ft^3/s	(8.5 to 11.3 m^3/s)
September 16 to October 31	350 to 550 ft^3/s	(9.9 to 15.6 m^3/s)
November 01 to April 30	175 to 1,000 ft^3/s	(5.0 to 28.3 m^3/s)

"In two or more consecutive drought years, these flows may have to be reduced".

- Clause 40: That due consideration be given to shore spawning kokanee when regulating Okanagan Lake water levels over the winter months. To minimize damage to shore spawning kokanee during the fall and winter months, the drawdown of Okanagan Lake between October 01 and February 28 should not normally exceed six inches. In anticipated high runoff years however, greater drawdown may be necessary to accommodate the spring runoff.

Without long-term forecasting, the Plan's recommendations for drought conditions cannot in practice be met. During times of very low inflows, it is not possible to maintain high water levels, because of demands on the system. For example, during the winter months the Okanagan River flows must be maintained relatively high to avoid exposing sockeye salmon eggs. The Plan's recommendations for flood conditions to draw the lake down prior to freshet is impossible to do in practice without causing damage to the lake kokanee population (see next section).

Clearly, when the Plan's requirements for fish habitat and fish spawning are combined with requirements for flood and drought management there is a conflict. In our opinion, this conflict could be mitigated with long term trend forecasting, i.e., determining by July or August what the following spring's snowmelt runoff conditions are likely to be.

3. Implementation Agreement Report

Nearly all of the engineering work outlined in the Plan was undertaken during the period 1976 to 1982, and this document describes what was achieved. Of importance to lake levels and outflows are the following:

Okanagan Lake Intakes

In order for the intakes to be operable at an extreme low lake elevation of 340.4 m (1,116.8 feet), the Plan advised that *all irrigation and domestic intakes be adjusted (lowered) as required.* Because of the expectancy that there was a high chance of zero benefit from these changes over the life expectancy of these intakes, and because the work could be done relatively quickly if needed, the Implementation Report quotes the Board as advising that *any intake modifications should not be undertaken until such a time as an actual drought event may occur.*

All new intakes (1977 onwards) were built to operate at a lake surface elevation of 340.4 m.

Sockeye salmon flows.

The allowed flow for the period August 1 to September 15 was changed, to allow more flexibility in releasing flows from Okanagan Lake. The revised schedule was:

DATES	FLOWS, OLIVER GAUGING STATION	
August 1 to September 15	300 to 1000 ft^3/s	(8.5 to 28.3 m^3/s)
September 16 to October 31	350 to 550 ft^3/s	(9.9 to 15.6 m^3/s)
November 01 to April 30	175 to 1000 ft^3/s	(5.0 to 28.3 m^3/s)

> "After February 1, flood control requirements are given priority over fishery flows and it may on occasion be necessary to exceed the 28.3 m^3/s upper limit".

Kokanee Spawning

During the Okanagan Basin Study a multi-agency water analysis was conducted for salmon flows and conditions for kokanee (determining how to minimize the drawdown of Okanagan Lake during the winter months). One of the outcomes of this study was key lake level elevations that the operator should aim for in most years. These were:

- February 1st flood control target elevation of 1,121.3 feet, preceded by
- October 15th secondary target elevation of 1,121.8 feet

> “If this secondary target level of 1,121.8 ft on October 15 is met, then the drop in lake level between October 15 and February 01 should not exceed six inches in most years”.

The Implementation Agreement Report modifies Recommendation 40 of the Plan, to read:

> “To enhance shore spawning kokanee conditions over the fall and winter months, Okanagan Lake will be operated such that, when possible, the lake level is not greater than 1121.8 feet on October 15, subject to flow restrictions for sockeye salmon”.

For reasons that are not known, the need to preserve water levels within a close range from the spawning period until 28 February (as envisaged in the Plan) were changed, and the February 01 date adopted. This modified date is too early to protect kokanee spawn, because emergence occurs after this date, even in warmer than average winters. Approximately six additional weeks are required after emergence, for successful development of the alevins in the shore side gravel.

4. Other Selected Reports

Three reports are reviewed as follows:

Obedkoff, W., 1994. “Okanagan Basin Water Supply”. File No. 42500-60/S, Study No. 384, Province of British Columbia, Ministry of Environment, Lands and Parks.

A review, including modeling of monthly inflows and outflows to Okanagan Lake and the downstream river, was carried out. The purpose of the review was to establish what additional future withdrawal of water from the system would be possible, under the operating conditions of the Plan, and assuming a worst case hydrological period, equal to three drought years in succession (as occurred in 1929 to 1931).

The conclusion of the report was that an additional 63 million m^3 per year of water could be abstracted from the system, if the maximum lake draws down (i.e., all the emergency storage) was used. Following this drought period, it would take three years of at least average inflow conditions for the lake water surface to return to its normal range. Management of flood events was not discussed. Winter fluctuations of Okanagan Lake surface levels during drought periods were not discussed in the report.

McNeil, R. 1991, MS "Report on Frequency Analyses of Flood Flows and Levels for Okanagan Valley, Mainstem System", File No. S5111, S5211. Water Management Division, Hydrology Section, Ministry of Environment, Lands and Parks.

An analysis of peak flow events and maximum water levels for Okanagan, Skaha and Osoyoos lakes and for the Okanagan River were computed. The 200-year and 20 year return period events were listed. The author is careful to point out that because the system is dominated by releases from Okanagan Lake, and because this is not natural but is human controlled, the normal statistical projections do not apply. However, in the absence of a better way to proceed, the statistical analyses were done, with the data set being tested with all the data (1921 to 1990) and modern data (1951 to 1990). A change in operating procedure for the system occurred after 1951, hence the split in the data set.

The values computed provide guidance for flood construction levels around the lakes, and for peak channel capacity. The report states that with 0.61 m freeboard above the 200-year peak water surface level for Okanagan Lake, the flood construction level should be 343.66 m, the same level that has been in effect since 1974.

Operational aspects, such as the need to lower Okanagan Lake ahead of a predicted high snow pack season, are not discussed.

Shepherd, B.G. 1997, MS. "Impacts of Regulating Okanagan Lake Water Levels on Shore Spawning Kokanee Stocks". Okanagan Sub-region Fisheries Section, Ministry of Environment, Lands and Parks. Draft report, 17 February 1997.

The history of water level regulation activities is summarized in the first section of the report. Reference is made to Volume 1 of "Report of Joint Board of Engineers on Okanagan Flood Control" 1946. The outlet of Okanagan Lake prior to 1909 was controlled by a natural bar, whose elevation was surveyed at 341.3 m. Control dams, with sills at elevations 340.8 m were constructed in 1914 to 1915, and 1920. The present control structure was built in 1953, with the sill set at 339.75 m. Clearly, with the gates of the control structure open, there is the capability of discharging much more water at low lake levels than could be discharged in the original (uncontrolled) situation, because the sill elevation has been lowered.

The report includes a section concerning an overview of water level patterns, and a section concerning kokanee shore spawning. The Okanagan Lake shore spawning kokanee stock utilize water depths of less than 3 m for spawning with depths of less than 0.5 m preferred. In a recent report by

Dill (1997, MS), the majority of embryos were found at substrate depths of 15 to 20 cm, with a prediction for optimal incubation conditions at about 15 to 30 cm. The likelihood of increased mortality of kokanee embryos from man-induced water level drops during the winter months is discussed. Declines in the kokanee population due to other causes, such as the introduction of *Mysis relicta* in the lake, are mentioned.

5. Licenced Withdrawals of Water from Okanagan Lake

A considerable volume of water is taken from Okanagan Lake for industrial, agricultural and domestic purposes. Licenced and actual withdrawal of water may be significantly different. This is particularly true of large waterworks licences that are intended to provide for future growth in demand.

Currently, there are about 919 water licences allowing diversion of water from the lake. The water licences grant a total diversion volume of 110 Mm^3 of water annually, and this diversion volume is about 23% of the mean annual outflow of Okanagan River at Penticton. Out of the 996 water licences, 17 licences grant about 83% of the total diversion volume, with each licence allowing more than 1 Mm^3 diversion annually. The City of Kelowna has the highest licenced abstraction volume of 47 Mm^3/year, mainly for municipal water supply purposes. Table 3 shows the sum of diversions from Lake Okanagan, the total number of licences, and details of the major licences.

Note that:

1. A considerable return flow exists for water pumped from the lake and utilized for various purposes. A factor of 65% return flow is recommended in the Plan, for municipal/domestic water withdrawals, and

2. Several water users abstract water in volumes that are significantly below their annual licenced amounts.

Since the inception of the Plan in 1974, all intakes have been designed to function at an extreme low lake level of 340.4 m. We do not know how many old or non-complying intakes exist.

Table 3. Water licences on Okanagan Lake.

Licence No.	Licensed Purpose	Quantity at POD	UNITS	Annual Diversion Volume ($1000m^3$)	Priority Date	Licensee	Licensee address
C032633	COOLING	12,000,000	GD	19,910	19670203	RIVERSIDE FOREST PRODUCTS LTD	820 GUY ST KELOWNA BC V1Y7R5
C032829	WATERWORKS LOCAL AUTH	3,285,000,000	GY	14,929	19670726	KELOWNA CITY OF	1435 WATER ST KELOWNA BC V1Y1J4
C022362	WATERWORKS LOCAL AUTH	2,190,000,000	GY	9,953	19541108	KELOWNA CITY OF	1435 WATER ST KELOWNA BC V1Y1J4
C108281	WATERWORKS LOCAL AUTH	1,934,500,000	GY	8,791	19690623	WINFIELD & OKANAGAN CENTRE IRRIG DIST	10591 OKANAGAN CNTRE RD E WINFIELD BC
C032828	WATERWORKS LOCAL AUTH	1,825,000,000	GY	8,294	19670726	KELOWNA CITY OF	1435 WATER ST KELOWNA BC V1Y1J4
C027158	WATERWORKS LOCAL AUTH	1,095,000,000	GY	4,976	19611214	KELOWNA CITY OF	1435 WATER ST KELOWNA BC V1Y1J4
C019680	WATERWORKS LOCAL AUTH	912,500,000	GY	4,147	19500803	PENTICTON CITY OF	171 MAIN ST PENTICTON BC V2A5A9
C025236	WATERWORKS LOCAL AUTH	730,000,000	GY	3,318	19590212	PENTICTON CITY OF	171 MAIN ST PENTICTON BC V2A5A9
C040839	WATERWORKS LOCAL AUTH	730,000,000	GY	3,318	19720724	KELOWNA CITY OF	1435 WATER ST KELOWNA BC V1Y1J4
C032615	WATERWORKS LOCAL AUTH	584,000,000	GY	2,654	19670606	SUMMERLAND CORP OF THE DISTRICT OF	BOX 159 SUMMERLAND BC V0H1Z0
C014633	WATERWORKS LOCAL AUTH	547,500,000	GY	2,488	19380802	KELOWNA CITY OF	1435 WATER ST KELOWNA BC V1Y1J4
C015910	IRRIGATION LOCAL AUTH	1,800	AF	2,221	19310320	GLENMORE-ELLISON IMPROVEMENT DIST	C/O D MCFADDEN 445 GLENMORE RD KELOWNA BC
C066159	WATERWORKS (OTHER)	1,077,000	GD	1,787	19861120	TRANSPORTATION & HIGHWAYS MINISTRY OF	523 COLUMBIA ST KAMLOOPS BC V2C2T9
C019098	WATERWORKS LOCAL AUTH	365,000,000	GY	1,659	19490510	KELOWNA CITY OF	1435 WATER ST KELOWNA BC V1Y1J4
C034312	IRRIGATION LOCAL AUTH	1,000	AF	1,234	19680925	OKANAGAN-SIMILKAMEEN REGIONAL DIST OF	101 MARTIN ST PENTICTON BC V2A5J9
C018611	IRRIGATION	900	AF	1,110	19480316	OKANAGAN INDIAN BAND	RR 7 COMP 20 SITE 8 VERNON BC V1T7Z3
C020914	IRRIGATION LOCAL AUTH	900	AF	1,110	19520605	WEST BENCH IRRIGATION DISTRICT	PO BOX 537 PENTICTON BC V2A6K9
				91,897	SUM OF THE ABOVE 17 LICENCES CONTRIBUTING TO OVER 83% OF THE TOTAL DIVERSION FROM THE LAKE.		
				18,424	OTHER 902 LICENSEES		
				110,321	TOTAL LICENCED DIVERSION FROM OKANAGAN LAKE		

6. Annual Water Outflows and Approximate Inflows for Okanagan Lake

The intent of this Section is to provide some approximate values to understand the nature of the water management problem associated with Okanagan Lake. Because the regional climate is very dry, the runoff from year to year fluctuates a great deal. During dry years and wet years net inflows of about 100 Mm^3 and 1,000 Mm^3 respectively are noted. The year 1997 provided a record inflow volume of about 1,400 Mm^3.

Few of the tributary streams are gauged, so that annual inflow volumes can only be approximated based on the hydrological balance for Okanagan Lake. This method is subject to error because evaporation from the lake is unknown and difficult to determine yet is a very important part of the water balance.

Ministry of Environment, Lands and Parks Flood Forecasting Branch annually compute data on net annual inflow volumes into Okanagan Lake, for the periods 01 October to 30 September the following year. These inflows were computed from outflows, with a correction for changes in storage in Okanagan Lake. Outflows were taken from data from Water Survey of Canada gauging station No. 08NM050, *Okanagan River at Penticton* (see Fig. A1, Appendix A). Evaporation is not included in the calculation, so actual inflows are considerably higher than the computed net inflows. The data concerning net annual inflows from 1922 to present are shown in the Appendix A, as Figure A2.

Data for climate are available in the Plan, see for example Table 3.2, page 64, Technical Supplement No. 1. The long-term annual precipitation averaged for the whole basin is about 560 mm. For the lake itself the precipitation is much lower, and high summer temperatures lead to relatively high lake evaporation. Evaporation from the lake basin is estimated at 420 mm per year. The long-term average precipitation on the lake is estimated to be 315 mm per year, which is about 56% of the average precipitation for the whole basin.

Evaporation from the lake is hard to assess. Temperature differences from one year to the next have a significant effect on annual total evaporation. The value listed in the Plan is 965 mm per year, and we believe that an error of ±15% should be attached to this value, because of uncertainties in the actual value, and because of year to year fluctuations. This approximate value is confirmed by other published data (Calculated Lake Evaporation data) based on meteorological measurements at Summerland and Kelowna, (see Canadian Climate Normals, 1951 to 1980, Volume 9).

Mean evaporation from the lake is approximately three times that of the precipitation on the lake. Evaporation is a major factor in the water budget for the lake (see Table 4). A summary of mean annual water budget value is given in Table 4. Errors of measurement are estimated as follows:

- up to 15% is estimated for assessment of precipitation and up to 15% for evaporation directly from the lake,
- up to 5% error on the net runoff from the basin and flow measurements at Penticton, and
- an error of up to 15% on abstraction, to account for abstracted flows less than licenced amounts.

Table 4. Approximate Annual Water Budget for Okanagan Lake

Description	Annual Volume (Mm^3)	Estimated Error* (Mm^3)	Record period	Reference
Net runoff on the lake basin (without lake)	780	±39	1921-1970	Canada-BC Okanagan Basin Agreement, 1974
Contribution from precipitation on the lake	100	±15	1931-1960	Assuming annual precipitation on the lake of 315 mm ± 48 mm
Evaporation from the lake	330	±50	1921-1970	Canada-BC Okanagan Basin Agreement, 1974
Abstraction	96	±14	1997 Record	BC Government Water Rights Information System
Return flow from abstraction	62	±9		Return flow assumed as 65% of the total diversion
Outflow at Penticton	470	±24	1921 to present	HYDAT CD ROM

** Our estimate of measuring/calculation error.*

7. Water Levels Following the Fall Spawning Period

An analysis of water surface elevations on 01 February for the last 40 years was carried out (Fig. 4). In addition, an analysis was made to determine the amount of surface level lowering of the lake during the period 15 October to 01 February the following year (over winter drawdown).

Since the inception of the Plan in 1974:

- the water surface on 01 February has been within the range +0.15 m to -0.28 m of the target level of 341.77 m. The lowest level (01 Feb 1993) in recent years was associated with drought runoff conditions the previous summer;
- the water surface on 15 October has been within the range +0.33 m to -0.36 m of the target level of 341.92 m. The two highest levels were prior to preparation of the Okanagan Basin Implementation Report (1982), and the lowest level was associated with the 1992 drought;
- the over-winter drawdown has exceeded 6 inches (15 cm) eight years out of 23 years. Since the Implementation Report of 1982, the overwinter drawdown has exceeded 6 inches (15 cm) three years in 15 years, see Figure 4.

Figure A3 (Appendix A) illustrates water surface elevations for the whole year, for all years from 1960 to present. The graphs show changes in water surface elevations during the weeks following the 01 February date. These weeks are important to kokanee spawning success because egg incubation and fry development takes place until mid-April.

7.2. Drawdowns in Recent Years During the Spawning Period

As previously mentioned the weeks after 01 February are important to kokanee spawning success, because fry emergence does not occur until approximately 01 March, with approximately six weeks needed after this date for successful alevin growth (Dill 1997, MS). Therefore a stable water surface level up to the end of March is considered vital for overall development of kokanee fry. To assess possible impacts on kokanee fry survival an analysis of water surface drawdown for the period between 15 October and 01 April of the next year was carried out. Results are illustrated on Figure 5. The water surface elevations for the last 38 years are presented in Figure A3 with the 15 October and 01 April levels highlighted.

Since the inception of the Okanagan Basin Plan in 1974, the lake surface drawdown has exceeded 6 inches (15 cm) in 17 years out of 23 years, and has exceeded 12 inches (30 cm) 9 years in the past 23 years (Fig. 5).

8. Linkage Between Southern Oscillation Index and Snow Pack/Runoff

The Southern Oscillation Index (SOI) is a measure of sea level barometric pressure differences between Tahiti and Darwin, Australia in the southern hemisphere tropics. During El Niño events, unusually high atmospheric sea level pressures develop in the western tropical Pacific Ocean with abnormally low sea level pressures developing in the eastern tropical Pacific Ocean. An accompanying phenomenon is significant heat build up in the surface water of the eastern Pacific Ocean, changing the ocean surface temperature by as much as 1 to 2 degrees centigrade over an extremely large area. This heat build up takes many months but once it has occurred, several months are required before the heat anomaly is dissipated. During this period, tracking patterns of the jet stream over the northern Pacific Ocean are affected, with consequences for the rain and snow bearing winds that bring frontal storms to the Pacific Northwest coast.

The SOI index measurements are updated monthly and published on the Internet so access to the data is quick and inexpensive. These SOI measurements are also available for a very long period (year 1882 to present). Ministry of Environment, Lands and Parks Flood Forecast Center has recently provided a WEB site information bulletin concerning the effect of El Niño global climate fluctuations on runoff in British Columbia. The most noticeable effect of the El Niño is along the south coast and in the southern interior. For the Okanagan basin, the April 1, 1997 snowpack was below normal a large (74%) proportion of the time following the 1997 El Niño event, having on average 16% less snow than normal.

An excellent unpublished report (G.A. McBean 1994, MS) summarizes the possibilities for long-term climate and runoff predictions for Canada. McBean found that streamflow in most BC regions was positively correlated with SOI for lagged correlations.

There is good preliminary evidence that climate and streamflow in the US northwest is influenced by world scale climate fluctuations. For example, Redmond and Koch (1991) have shown that the ENSO (El Niño Southern Oscillation) measured by the SOI has an effect on temperature, precipitation and runoff in mountainous parts of the US northwest. Snow accumulation is likely impacted by combined changes in temperature and precipitation. During El Niño years, the winter climate tends to be both slightly drier, and slightly warmer than normal. Additionally there is a suggestion of cause-effect relationships, with the SOI change preceding the climate change by as much as 4 to 6 months.

8.1. Runoff Correlation vs SOI Values for High Altitude Basins

We selected a number of medium and high altitude basins in the Okanagan region with Water Survey of Canada gauges (Fig. 6). These basins were in or adjacent to the Okanagan valley. The flow during the snow melt period at these stations was totaled, and possible correlations with the Southern Oscillation Index values were investigated. In almost all basins analyzed, over two thirds of the annual flow occurs in the two months of the spring freshet. Volume of flow over the two months was checked for any significant correlation with the mean SOI of the previous summer. In the analysis, the SOI was averaged over three to six months for the periods: April to September, May to September, June to September, July to September, and June to August. In all cases, the best correlation was found between the mean SOI over the six months period of April to September to the total volume of flow in May and June of the following year.

In summary, results of correlation analysis indicate that there is a significant correlation between the six month average SOI and stream flows in the following spring. The coefficients are provided in Table 5. Most of the correlation coefficients are significantly different from zero (the null hypothesis) at the 0.1% level. Scatter plots of the average stream flow for the months of May and June versus the average April to September SOI are illustrated in Figure 7 for selected basins. The examples in Figure 7 cover basins with areas ranging from 5 km^2 to 185 km^2.

Table 5: Correlation between April to September Mean SOI and the following Year May to June Stream Flows.

Station Name and Number	Record Length	Elevation at Station (m)	Basin Area (km^2)	Correlation Coefficient
Whipsaw Creek below Lamont Creek, Station No. 08NL036	30	785	185	0.545
Camp Creek at mouth near Thirsk, Station No. 08NM134	29	1,005	33.9	0.556
Vaseux Creek above Terrace Creek, Station No. 08NM171	24	1,100	117	0.320
Two Forty Creek near Penticton, Station No. 08NM240	11	1,630	5	0.607
Two Forty One Creek near Penticton, Station No. 08NM241	11	1,610	4.5	0.565
Dennis Creek near 1780 Metre Contour, Station No. 08NM242	10	1,780	3.73	0.517
Trapping Creek near Mouth, Station No. 08NN019	28	1,040	144	0.605

8.2. Snow Pack Correlation

We selected a number of snow survey measurement stations in the Okanagan region. Three of the snow courses selected were near the Okanagan basin, but outside the catchment area. At each snow course station, the maximum snow pack was investigated to determine possible correlations with the SOI values. In the analysis, the SOI values were averaged over the six months period of April to September for each year and correlated to the maximum snow pack of the following year.

Results of the correlation analysis show that there is a reasonable correlation between the six month average SOI and maximum snow pack for most of the high altitude stations. For eight of the twelve stations the correlation is good, and for four of the twelve stations the correlation is very good. For one station (Mount Kobau) there is no significant correlation (Table 6).

Table 6: Correlation between April to September Mean SOI and following year maximum snow pack.

Station Name and Course Number	Elevation at Station (m)	Record Length	Record Period	Correlation Coefficient
Trout Creek, Course No. 2F01	1,430	61	1935-1997	0.390
Summerland Reservoir, Course 2F02	1,280	56	1942-1997	0.449
Graysoke Lake, Course No. 2F04	1,810	27	1935-1997	0.470
Mission Creek, Course No. 2F05	1,780	58	1939-1997	0.523
Whiterocks Mountain, Course No. 2F09	1,830	41	1953-1997	0.210
Silver Star Mountain, Course No. 2F10	1,840	39	1959-1997	0.338
Isintok Lake, Course No. 2F11	1,680	33	1965-1997	0.453
Mount Kobau, Course No. 2F12	1,810	32	1966-1997	0.092
Esperon Creek (upper), Course No. 2F13	1,650	28	1966-1997	0.337
Morrissey Ridge No 1, Course No. 2C09[a]	1,860	28	1961-1988	0.576
Mission Ridge, Course No. 1C18[b]	1,850	29	1967-1995	0.548
Blackwall Peak, Station No. 2G03P[c]	1,940	30	1968-1997	0.518[d]

[a] *The station is located in East Kootenay Sub Basin.*
[b] *The station is located in Middle Fraser Sub Basin.*
[c] *The station is located in Similkameen Sub Basin.*
[d] *Water equivalent data used in stead of snow pack.*

8.3. Correlation of Streamflows Allowing for Delay in Runoff Associated with Groundwater Storage

For high altitude headwater basins, the contribution of groundwater to streamflows is relatively small. However, for medium and low altitude basins in the region, and for the Okanagan River in particular, the contribution from groundwater is significant.

Groundwater storage from previous years affects the volume of stream flows in the spring freshet of following years. After a wet year, where the annual total flow volume is clearly higher than the long-term average flow, ground water storage increases and contributes to the flows of the following year because of inter-year storage and release of water. Following wet years, the stream flows are the result of the current year precipitation and groundwater contribution from the past year. Likewise, after a dry year, the groundwater level is reduced with precipitation of the current year replenishing the storage. Therefore, the stream flows following dry years may be low even though the precipitation of the current year is medium.

In order to analyze the relationship between the SOI and the spring freshet flow, the groundwater contribution was subtracted for years following wet and dry years. For the data set analyzed it was assumed that about 25% of the years were wet, 25% of the years were dry, and the remaining 50% of the years were neither wet nor dry. For the average scenario (50% of the years) no adjustment for groundwater contribution was made.

The following crude procedure was used to account for the groundwater contribution:

- compute, long-term mean annual flow volume, V_{mean};
- compute standard deviation of annual flow volume over the record period, V_{std};
- set upper flow volume bound = $V_{mean} + 0.7 * V_{std}$;
- set lower flow volume bound = $V_{mean} - 0.7 * V_{std}$;
- compare annual flow volume of previous year (V_{i-1}) with upper and lower annual flow volume bounds;
- if V_{i-1} is greater than the upper flow volume bound, then it is assumed that the groundwater volume increases and augments the following years freshet. Thus, the adjusted freshet flow volume of the following year will be the measured freshet flow volume minus contribution from previous year;
- if V_{i-1} is less than the lower flow volume bound, then the groundwater decreases and will be replenished from the following years freshet. Thus, the adjusted freshet flow volume of the following year will be the measured freshet flow volume plus some additional flow, which was used to augment the groundwater storage; and
- if V_{i-1} lies between the upper and the lower flow volume bounds, then groundwater storage does not affect the following year freshet, and no adjustment is necessary to the following year measured freshet flow volume.

After the necessary adjustments for groundwater contribution, the SOI averaged over the six months period of April to September for each year was correlated to the spring freshet flow volume of the following year. Correlation coefficient values for selected sites are given in Table 7. Results of this analysis indicate there is about 2% to 4% higher correlation between SOI and the following year freshet flow, when groundwater storage is taken into consideration. Greater improvement of correlation coefficients is observed for flows with larger basin areas, which would definitely have higher storage capacity.

Table 7: Correlation between April to September Mean SOI and following year May to June stream flows with groundwater storage consideration.

Station Name and Number	**Record Length**	**Elevation at Station (m)**	**Basin Area (km^2)**	**Correlation Coefficient without storage**	**Correlation Coefficient with storage effect**
Camp Creek at mouth near Thirsk, Station No. 08NM134	30	1,005	33.9	0.556	0.559
Vaseux Creek above Terrace Creek, Station No. 08NM171	24	1,100	117	0.320	0.348
Two Forty Creek near Penticton, Station No. 08NM240	11	1,630	5	0.607	0.637
Tulameen River Near Penticton, Station No. 08NL024	44	640	1,760	0.437	0.462
Mission Creek near East Kelowna, Station No. 08NM116	28	427	811	0.556	0.573
Okanagan Lake, Net Inflow	65		6,090	0.355	0.401

The final column of Table 7 indicates that correlations are medium to very good. In particular there is a medium correlation for the Okanagan basin itself. In view of the contribution of rain events during June in particular to the Okanagan River flows, the correlation is surprisingly good. Scatter plots of the average stream flow for the months of May and June adjusted for storage contribution versus the average April to September SOI are illustrated in Figure 8 for the Okanagan and Tulameen basins.

8.4. Use of Southern Oscillation Index to assist Forecasting

Based on our analysis the relationship between the snowmelt component of stream flows and the SOI was found to be high. The significant correlation coefficients between the six month average (April to September) SOI, and the volume of flows in the two spring months of the following year provide a rough forecasting method for the expected volume of the spring freshet. Although this method is likely to be most useful in predicting the snow melt component of the flow, which is less than 50% of the spring runoff in some years, we believe the procedure will be extremely useful.

We suggest that the use of SOI data for approximate predictions of snow melt can be used with other tools, such as snow pack development during winter months, to refine present capabilities for forecasting. Advanced knowledge of a below average snow pack year would enable Water Management Branch staff to feel confident about entering the fall season with relatively high water levels in Okanagan Lake. This predictive information would then give added confidence that extreme drawdown of the lake during mid-winter would not be required.

Several months of advance notice about approximate snow pack will allow adjustments to be made to lake levels starting as early as the first week of September. These water level adjustments, made in advance of the fall spawning season, would greatly improve management of lake levels and provide improved lake level stability for spawning fish and egg incubation. Such improvement to lake level management would be beneficial to the lake and fish.

ACKNOWLEDGMENTS

This project was funded by the British Columbia, Ministry of Environment, Lands and Parks' Habitat Conservation Trust Fund. The support is greatly appreciated.

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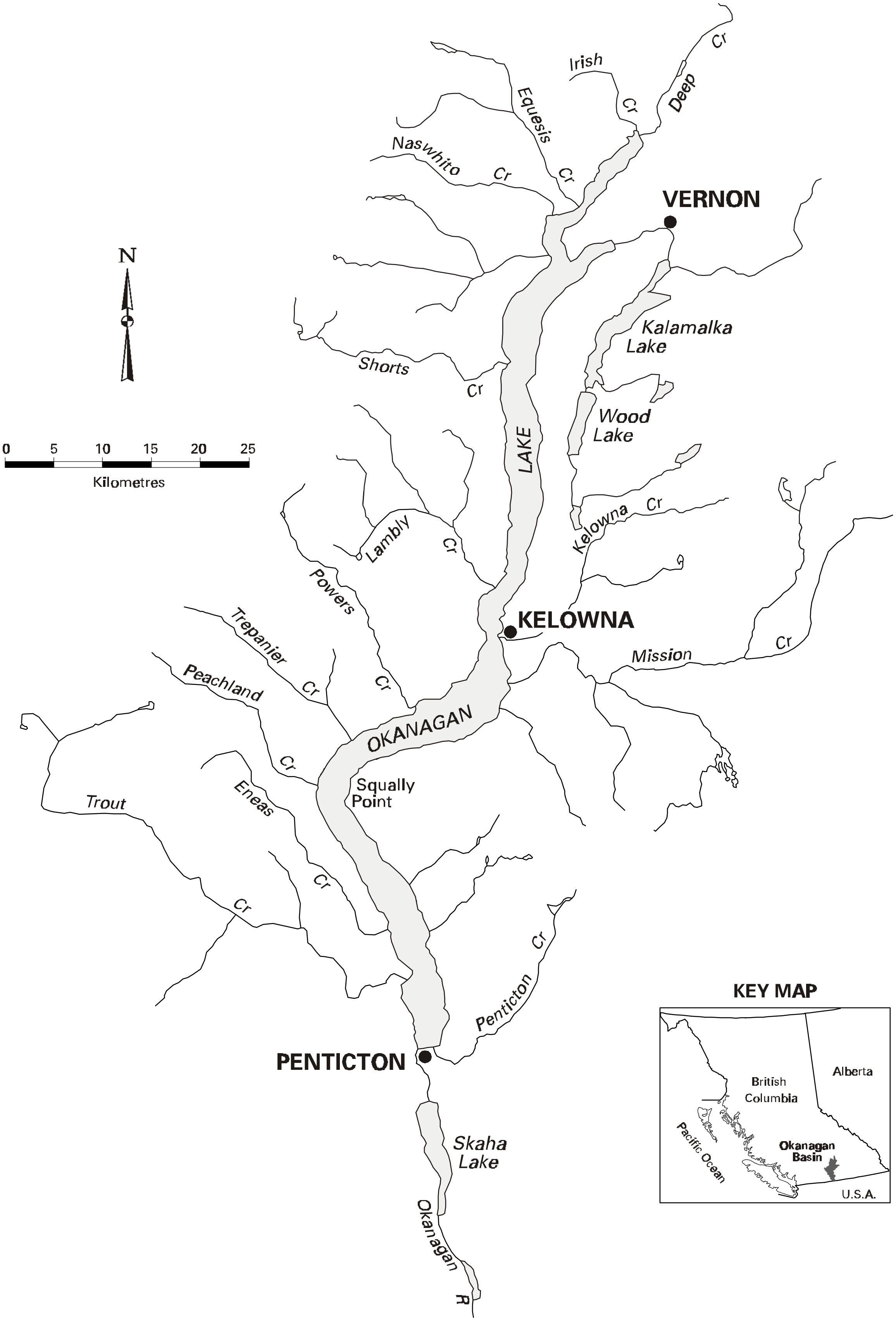


Figure 1. The Okanagan Basin.

A long wooden bridge
crossed the slough
west of Penticton,1914-28.

1942 flood waters in
front of the Incola Hotel

Lumb Stocks photo

FIGURE 2: HISTORICAL WATER LEVELS AT PENTICTON

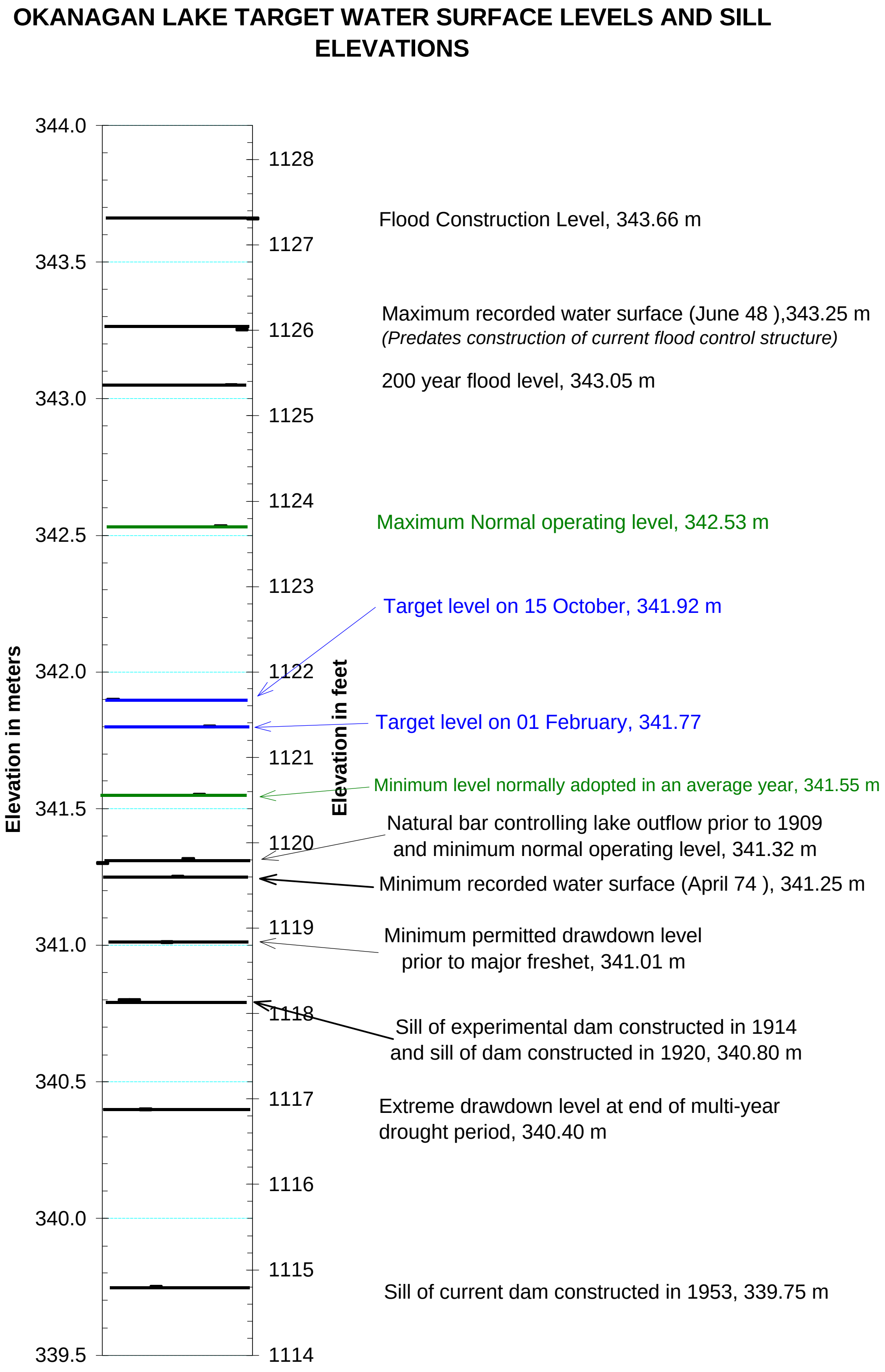


Figure 3. Okanagan Lake target water surface levels and sill elevations.

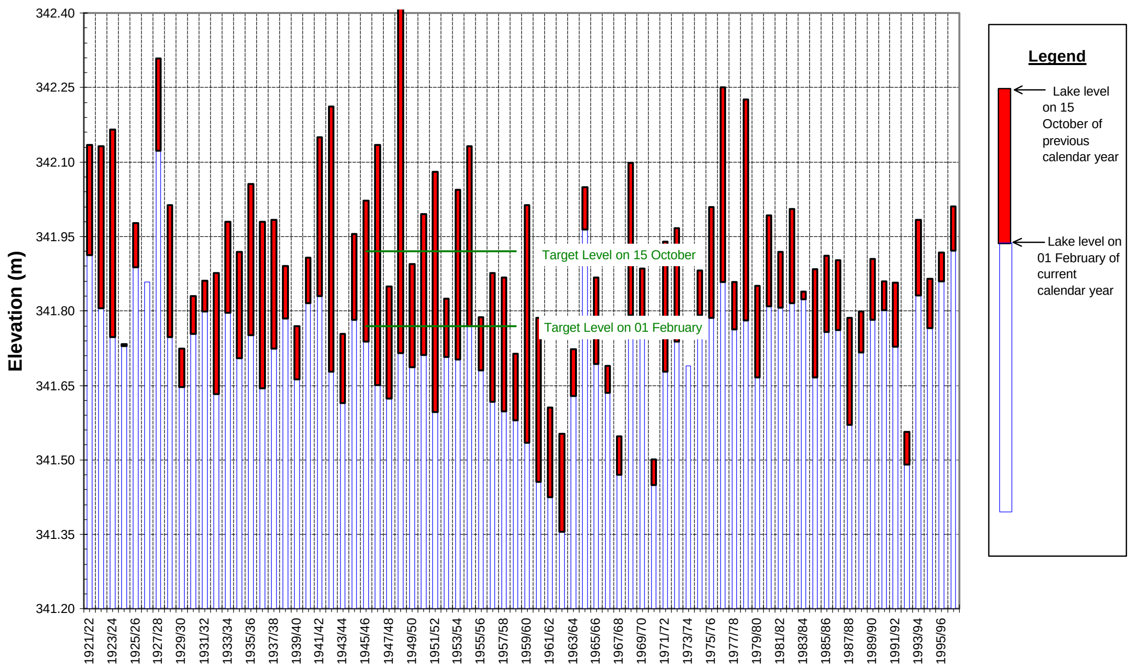


Figure 4. Water surface elevation on 15 October and 01 February (the following year) for all years of record.

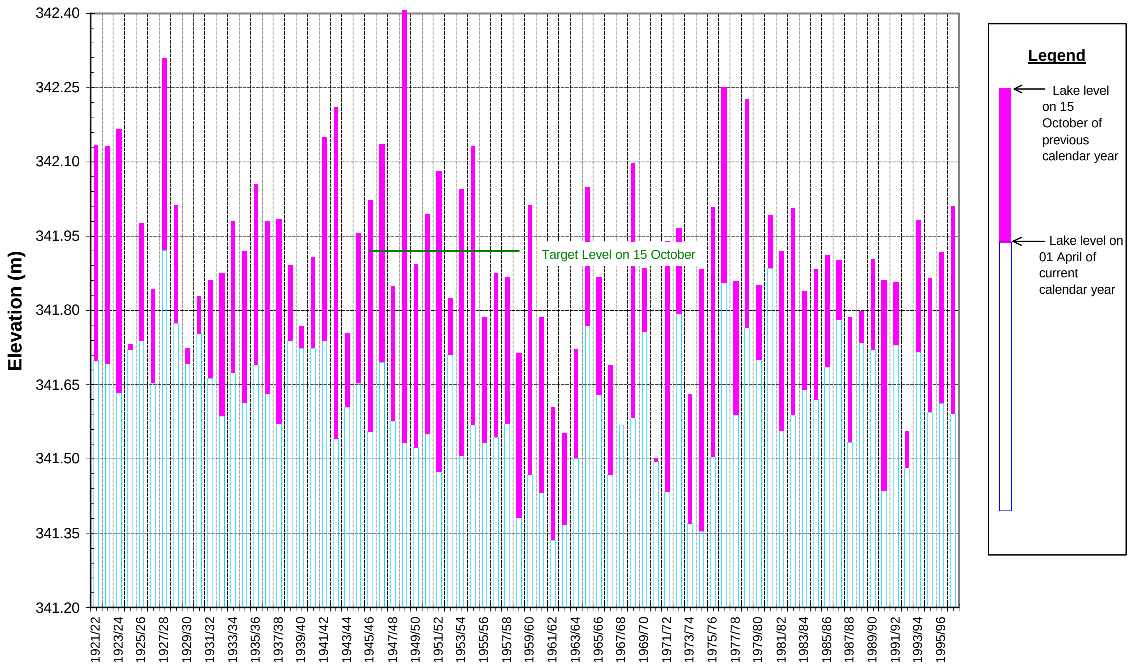


Figure 5. Okanagan Lake Water Surface Elevation on 15 October and following year 01 April for the years 1960 to 1997.

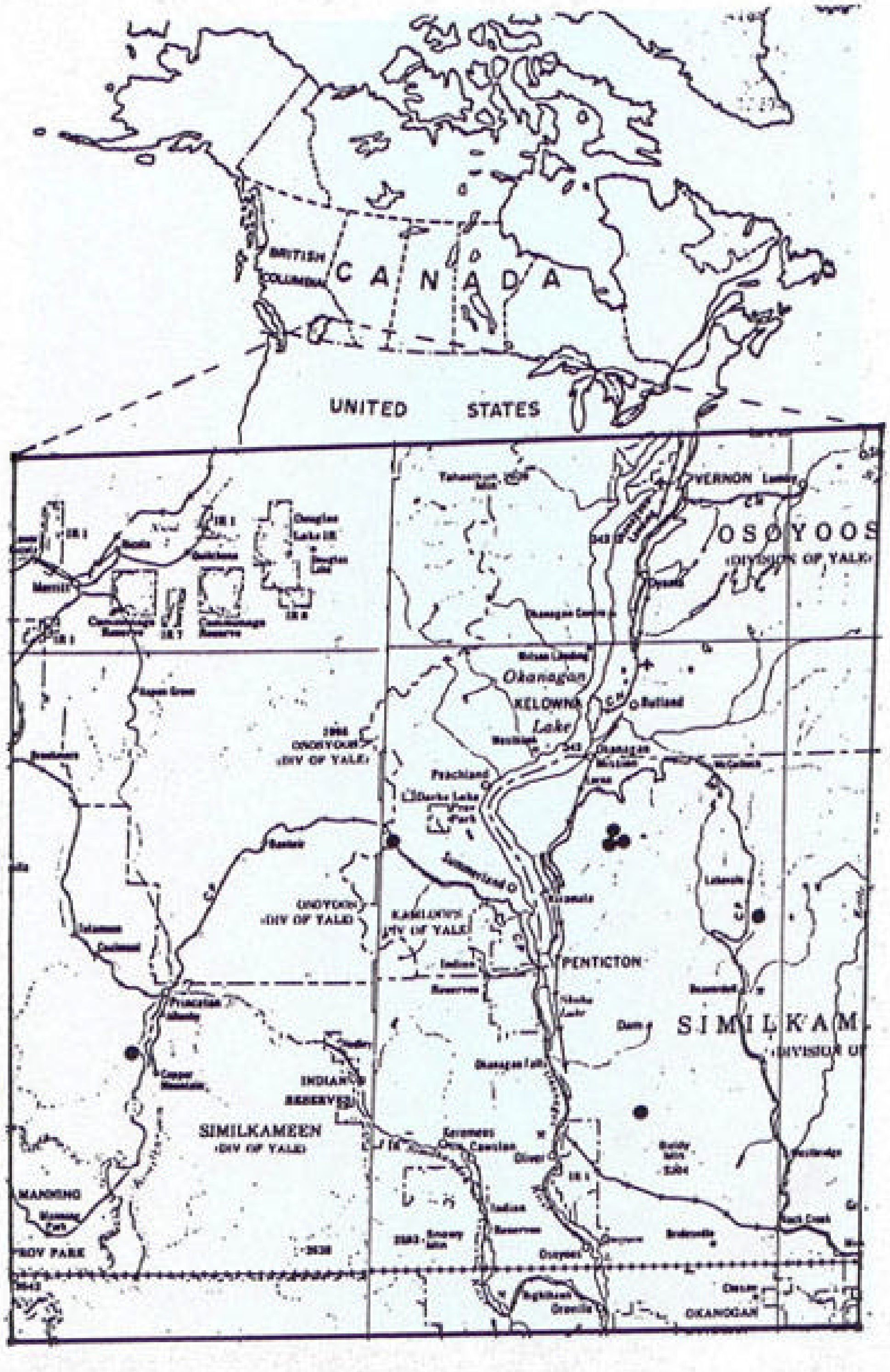
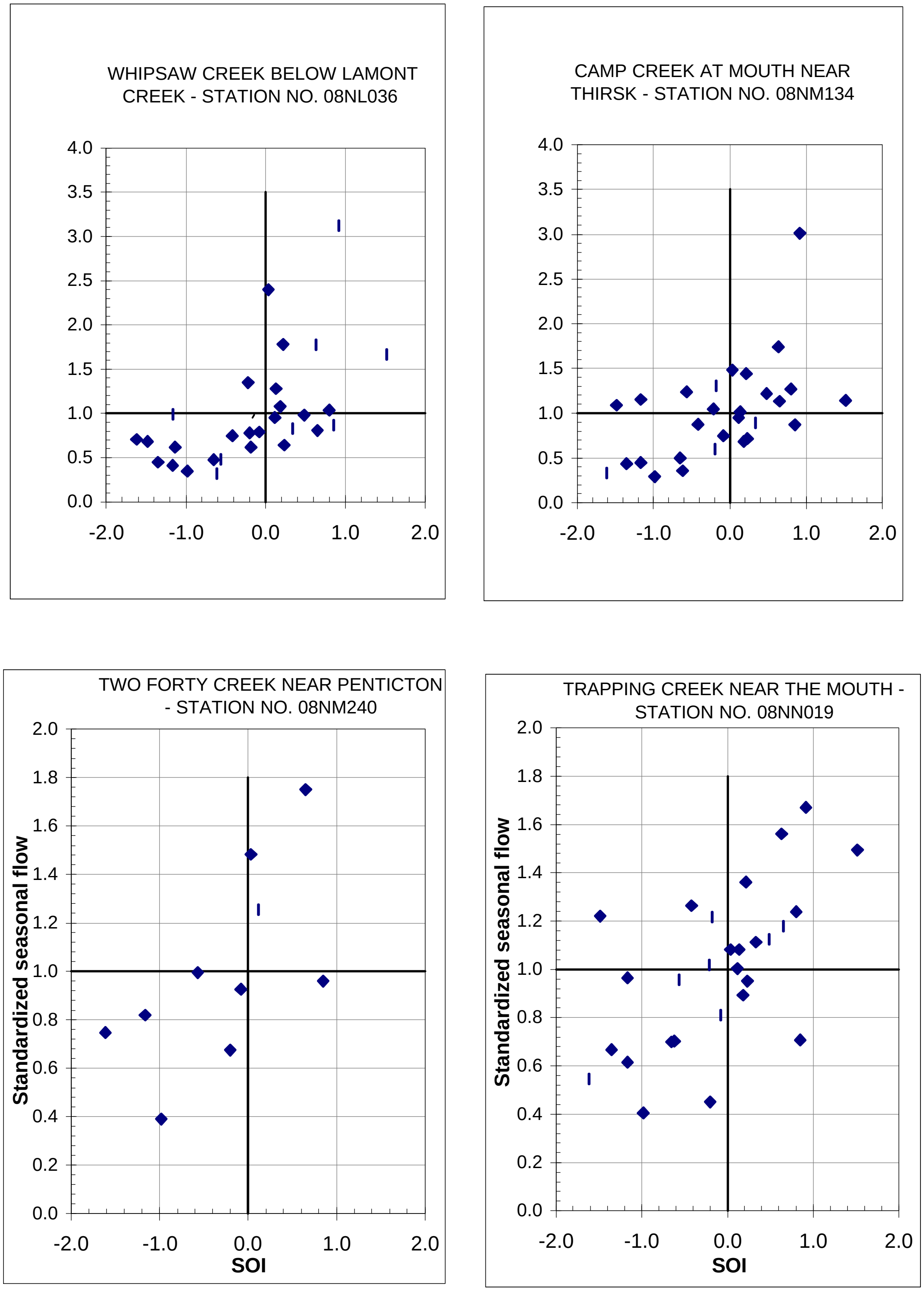


FIGURE 6. LOCATION MAP OF GAUGING STATIONS USED IN CORRELATION ANALYSIS BETWEEN SOI AND STREAM FLOW.



WHIPSAW CREEK BELOW LAMONT CREEK - STATION NO. 08NL036

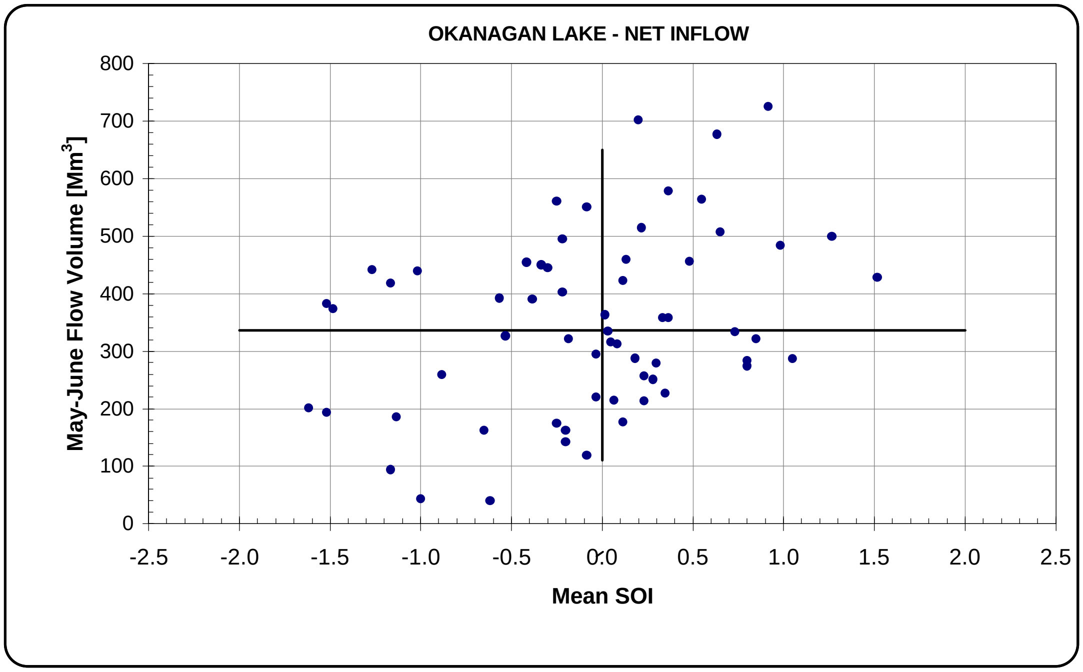
CAMP CREEK AT MOUTH NEAR THIRSK - STATION NO. 08NM134

TWO FORTY CREEK NEAR PENTICTON - STATION NO. 08NM240

TRAPPING CREEK NEAR THE MOUTH - STATION NO. 08NN019

FIGURE 7: SNOW MELT RUNOFF CORRELATION, SELECTED BASINS

APRIL-SEPTEMBER SOUTHERN OSCILLATION INDEX AND FOLLOWING YEAR VALUES FOR MAY/JUNE FLOWS



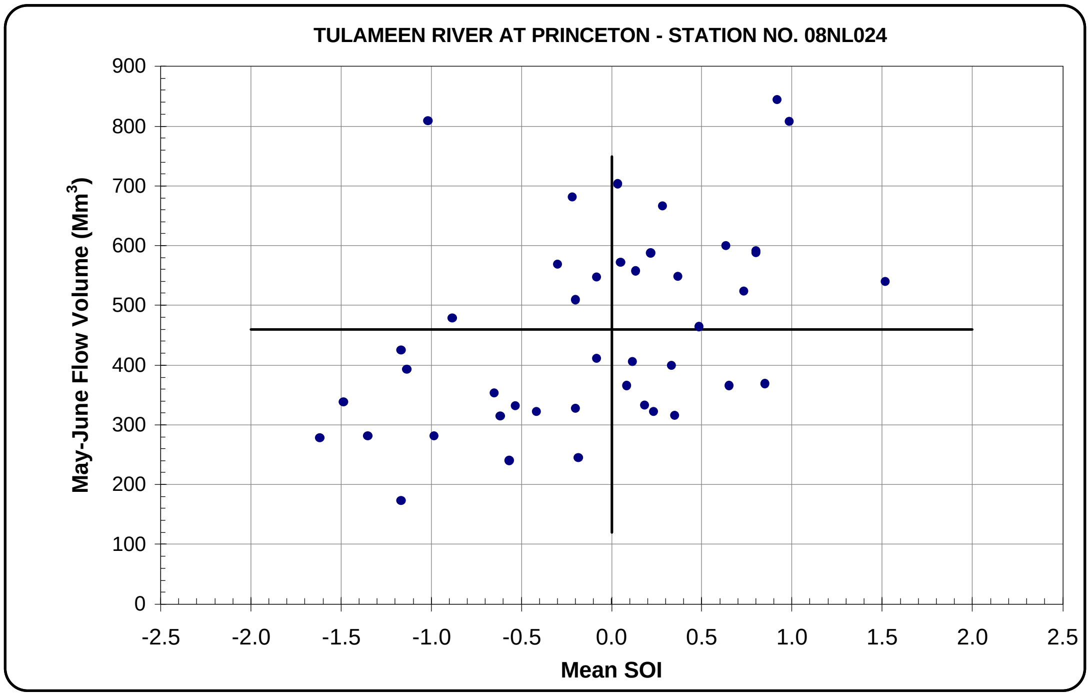


FIGURE 8: SNOW MELT RUNOFF CORRELATION, OKANAGAN AND TULAMEEN BASINS

APRIL-SEPTEMBER SOI AND FOLLOWING YEAR VALUES FOR MAY/JUNE FLOWS ADJUSTED FOR STORAGE

Appendix A. Hydrological data Okanagan Lake.

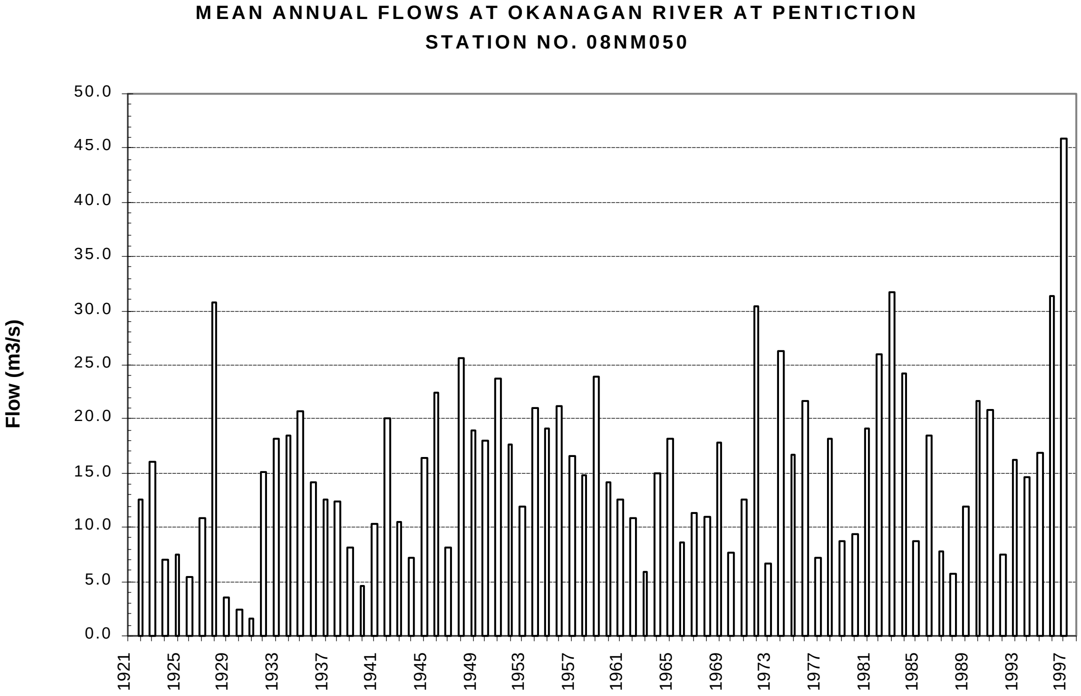


Figure A1.

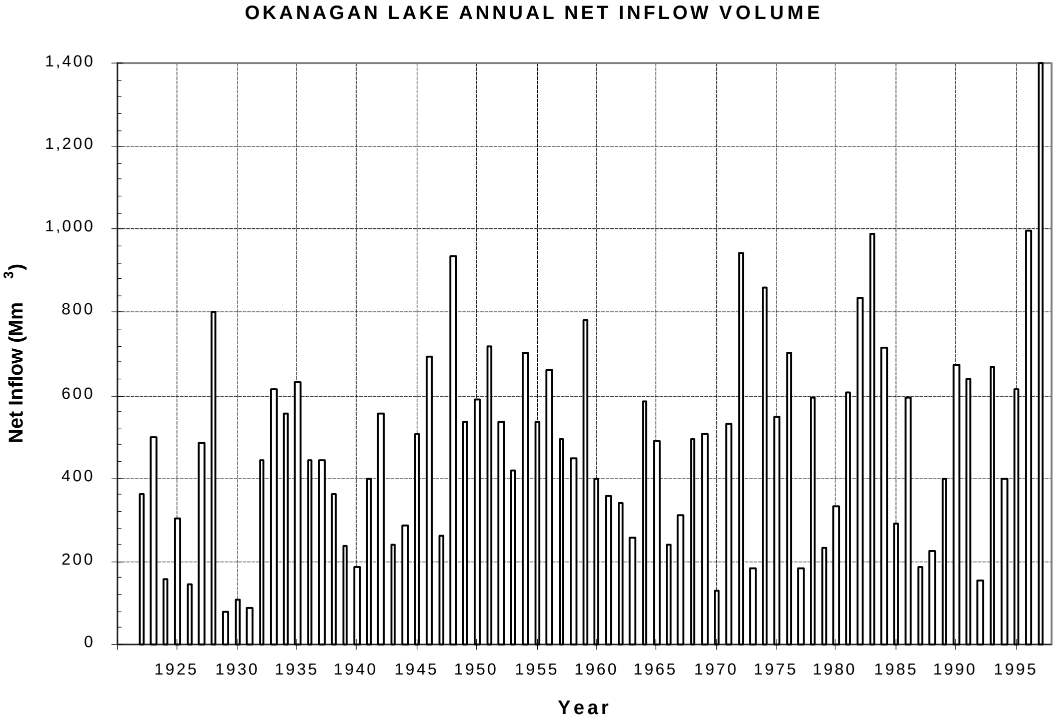


Figure A2.

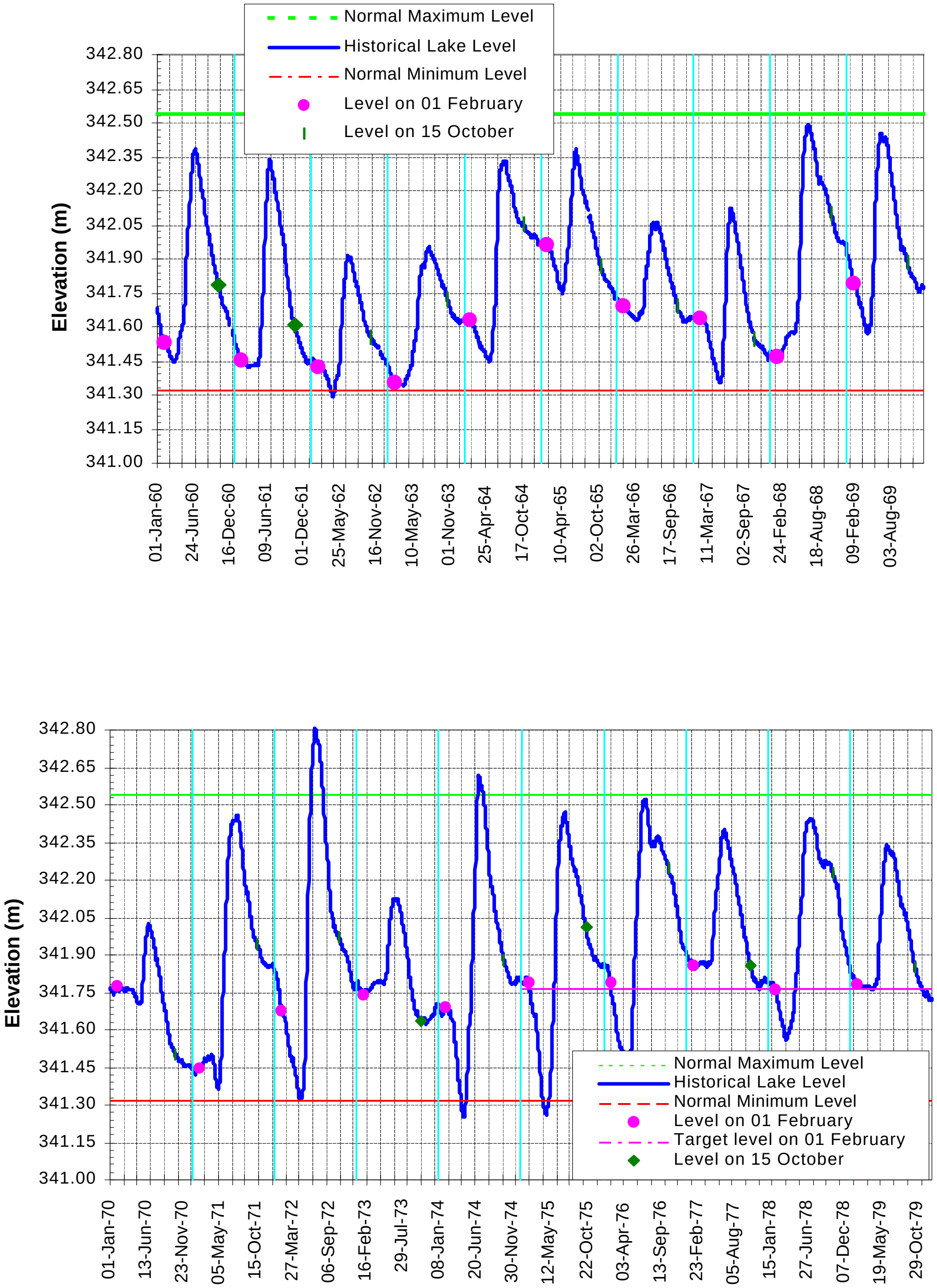


Figure A3. Okanagan Lake historical water levels for all years from1960 to 1990.

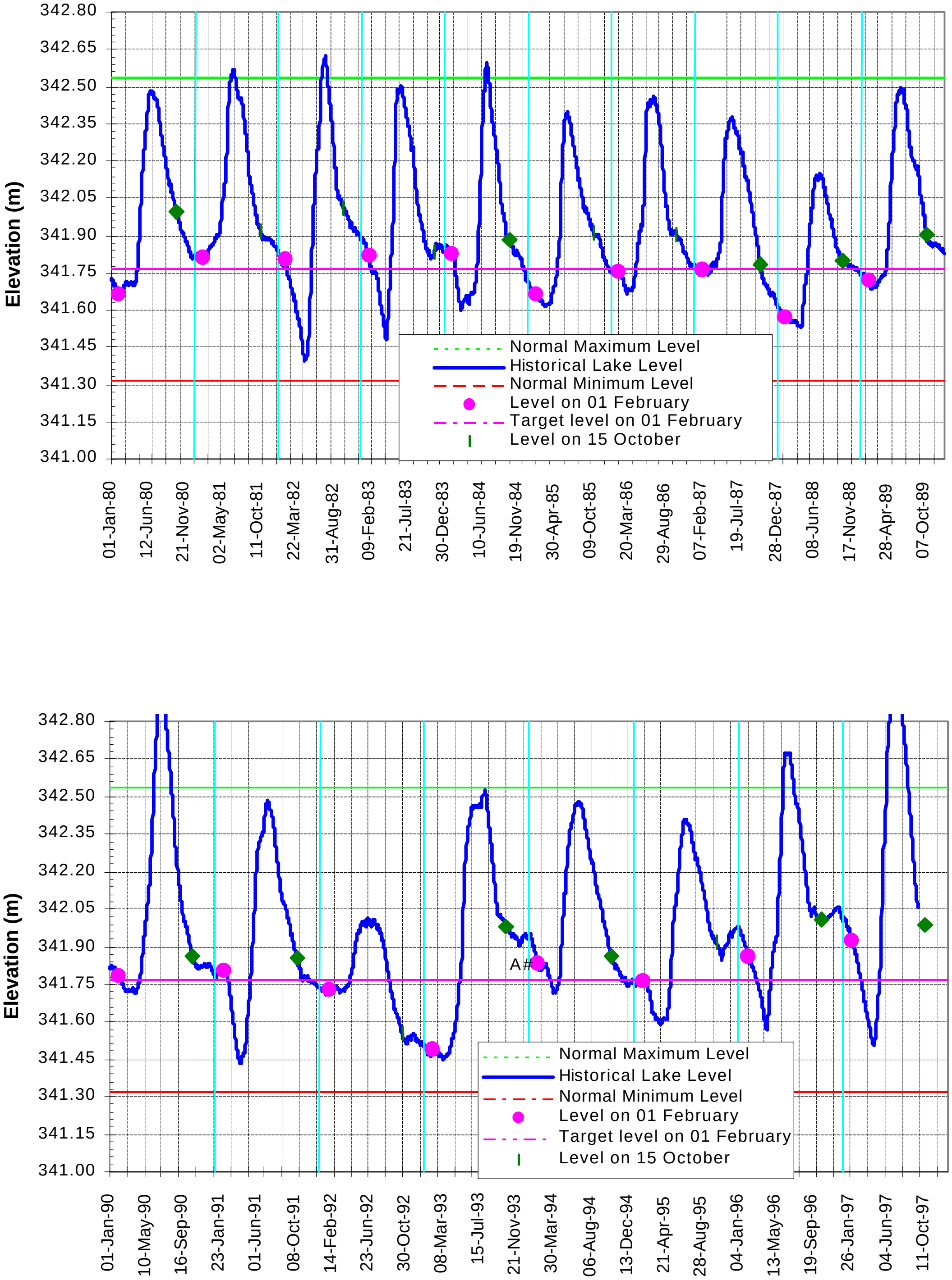


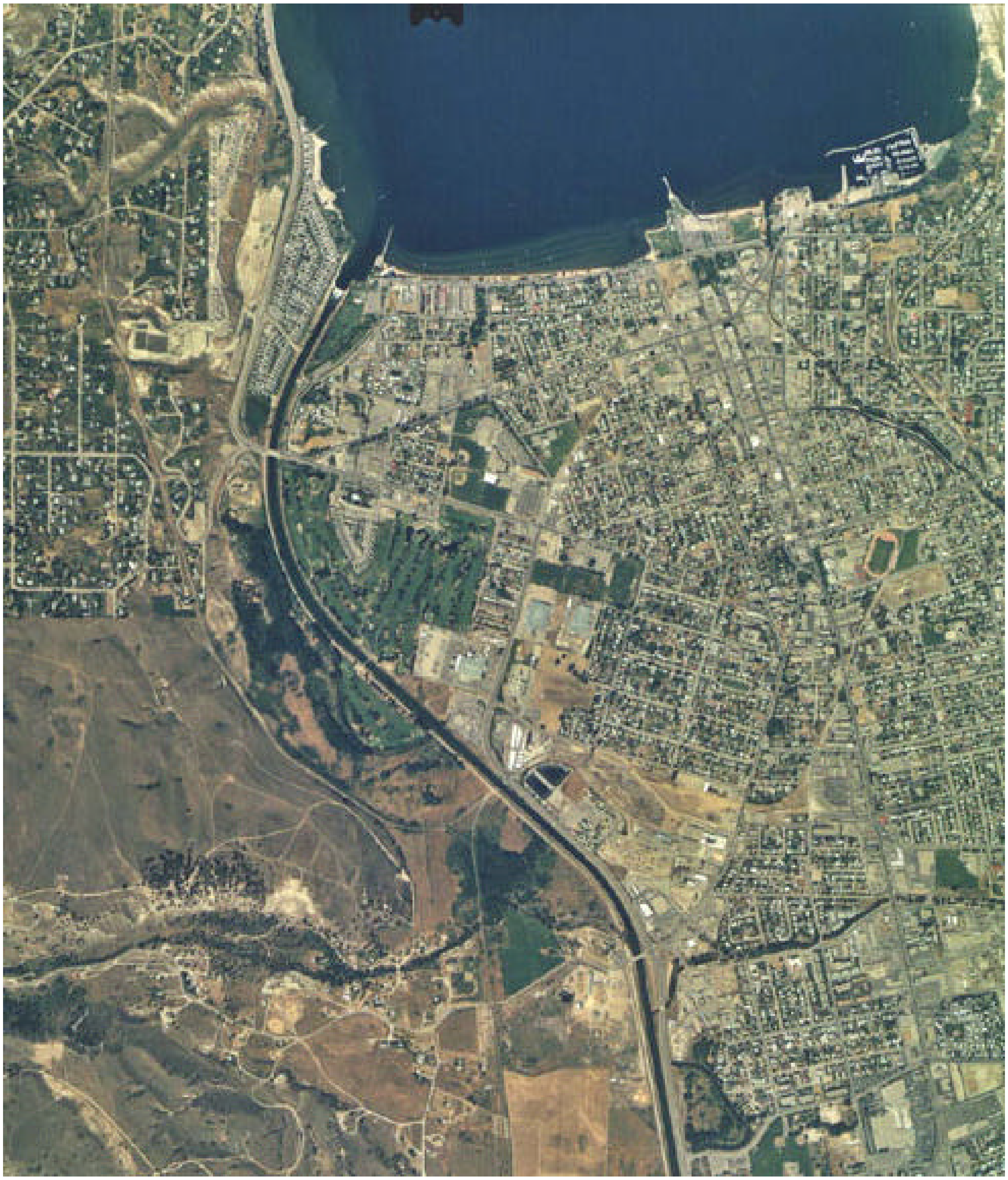
Figure A3 con't. Okanagan Lake historical water levels for all years from1960 to 1990.

Appendix B. Historical air photos Okanagan Lake at the outlet.

1938 Photo
Approximate scale 1:15,000

1955 Photo
Approximate scale 1:5,000

1977 Photo
Approximate scale 1:12,000



1996 Photo
Approximate scale 1:15,000

Key spawning streams have been identified for protection and some have been identified for possible restoration. The following reports outline some encouraging possibilities either being implemented or being considered under the provincial government's Forest Renewal BC (FRBC) Watershed Restoration Program (WRP).

TROUT CREEK BANK AND CHANNEL STABILIZATION

PROGRESS REPORT

by

M. Zimmerman and P. Epp

INTRODUCTION

This report provides the background and objectives for a WRP on Trout Creek and preliminary details of restoration work. The Corporation of the District of Summerland has been the proponent of this restoration project.

Location of the Trout Creek Watershed

Trout Creek flows from west to east on the lee side of the Cascade Mountains and enters Okanagan Lake just south of the town of Summerland, BC (Map 1). The watershed area is approximately 74,000 hectares with an elevation range from 342 m at Okanagan Lake to over 1,920 m in the headwaters. The watershed is designated as a community watershed and is used as a domestic and irrigation water supply by the District of Summerland. Numerous water storage reservoirs are in place on Trout Creek and its tributaries.

Fish

Historically, kokanee spawned and incubated in gravel shoals either in the lower reaches of the mainstem of Trout Creek or in one of the now defunct side channels. Spawning occurs in the fall (September to October), hatching usually occurs in March and emergence and migration to the lake generally occurs no later than May. Typically, adults will inhabit Okanagan Lake for four years before returning to spawn and die. Due to loss of habitat, very few kokanee now return to spawn in Trout Creek (<10 per year).

Resident rainbow trout occur throughout most of the watershed with Eastern brook trout in some lakes and reaches. Kokanee spawn in the lower reach adjacent to Okanagan Lake with resident and potentially adfluvial rainbow trout spawning in the lower to mid reaches of Trout Creek.

Due to the loss of in-stream habitat structures few resident rainbow trout are present in the lower reach of Trout Creek. Recent changes to the hydrologic regime of the watershed may also reduce the adfluvial rainbow populations from migrating through this area to spawn in the mid and upper reaches (see J. den Dulk *in:* Ashley et al. 1998).

BACKGROUND

A good summary of the history of the Trout Creek watershed and impacts on Creek Stream can be found in J. den Dulk (*in:* Ashley et al. 1998) and is worth repeating:

"The Trout Creek watershed has undergone extensive changes as a result of human activities since the early 1900s. Timber harvesting has been carried out for at least 60 years; grazing is practised on much of the crown forest; several headwater lakes have been dammed for the community water system; extensive clearing for agriculture has occurred in the lower portions of the watershed; the lowest reach has been channelized and straightened to deal with flooding problems. The watershed hydrology has been altered by forest harvesting and domestic water storage and use while the habitat in the lower reach has been essentially been eliminated due to channelization.

Results of the Interior Watershed Assessment carried out in 1996 as part of the WRP indicate that effective clear-cut area (ECA) of the watershed is approximately 17% with road densities of 1.8 km/km^2. There are associated moderate to high peak flow hazards and typically high erosion hazards. Riparian buffer hazards and landslide hazards were low in all sub-basins.

There is also a long history of water storage and water withdrawal from Trout Creek by the District of Summerland. Major reservoirs include Isintok Lake, the Headwaters Lakes, Thirsk Lake, Darke Lake, Whitehead Lake and Crescent Lake. Water is stored in these lakes during the spring freshet and then released into Trout Creek to augment summer low flows above the Summerland water intake. During the summer months, the District largely controls the flow in Trout Creek by balancing releases from storage with water withdrawals at their water intake. During extended dry periods, virtually all of the flow at the intake is directed into the community water system leading to extreme low flows in the lowest reach below the canyon. Currently, the intake is unscreened and emigrating rainbow trout are diverted into the irrigation intake and lost to the Trout Creek system. The diversion intake is expected to be screened in 1999.

In the 1970s the lower two kilometres of the channel were channelized and dyked to protect the alluvial fan from flooding. This has resulted in loss of channel length and sinuosity. The gradient has increased slightly. A maintenance regime (dredging) is required periodically to manage the bedload deposition east of Highway 97. In addition to channel maintenance, extensive vegetation removal has been promoted as a means of maintaining the integrity of the dyke. The lack of riparian vegetation combined with the low summer flows leads to wide variations in the thermal regime resulting in summer maximum temperatures well in excess of lethal limits for rainbow trout.

Also of concern is a “perpetual slide” along the north bank of the stream approximately five kilometres upstream from the lake. Initiation and cause of this slide is unclear yet a substantial amount of sediment enters Trout Creek at this point. Some research was conducted in the mid 1970s but no definitive mitigation was developed or implemented.

These changes to the watershed, as exhibited in its geomorphology, hydrology and water quality, have resulted in the complete loss of all spawning, rearing and staging habitat in the lower reach of Trout Creek. This system no longer maintains natural channel bed forms (such as riffle-pool sequences), in-stream large woody debris structures (such as jams), side and over-flow channels (due to straightening), or a seasonally inundated floodplain (due to dyking). In short, all usable fish habitat has been removed from the lower two kilometres of Trout Creek.”

Project Objectives

The primary objective of this project was to reduce sediment transport in Trout Creek for improved water quality by reducing stream bank erosion and stabilizing gravel bars. A secondary objective was to screen the District of Summerland's domestic and irrigation water intake to reduce the loss of emigrating rainbow trout.

METHODS

Materials and Supplies

Equipment used included:
- Hitachi EX100 Excavator
- Rock Truck
- Farm Tractor/Loader
- 4 X 4 Pick-up truck
- Chainsaw, rock drill, wood drill, hammers, cable cutters

Material used included:
- 190 m of 3/8” Steel-rope cable
- 3/8” Crosby Clamps
- 10 tubes of HILTI HY150 epoxy
- 1100 6” and 8” spikes

Raw materials used at the eight sites included:
- 68 large wood pieces with root wads attached
- 552 thinned pine and fir trees
- 24 root wads
- 21 deadman logs
- 110 boulders
- 135 m^3 rip-rap
- 1456 willow stakes

RESULTS

a) Assessments and Prescriptions

Level 1 fish habitat assessments (Slaney P. A. and D. Zaldokas 1997) and present functioning condition assessments were previously completed for Trout Creek and it's major tributaries (see details in J. den Dulk *in:* Ashley et al. 1998). Various impacts were identified relating to eroding stream banks, poor riparian vegetation and limited fish habitat. A number of reaches within the Trout Creek watershed were identified as high priority for restoration.

Reach 7 was identified in the assessments as a significant sediment source with several kilometers of stream bank logged and cleared for agriculture. There is poor riparian vegetation, particularly in unfenced areas, with actively eroding stream banks and a recent channel avulsion. Restoration potential was high due to easy access and willing participation from the current landowner. A land owner, Mr. Redicop, has recently changed grazing management practices in Reach 7 by fencing to reduce cattle access to many areas as well as reducing overall herd size. Slow natural recovery of riparian areas has begun.

Reach 7 was surveyed during the prescription phase to identify and delineate specific problem sites. Typical sites had eroding banks of fine alluvium on outside bends and expansive unvegetated bars on the inside points. The greatest impacts were associated with the avulsion and the immediate downstream area.

b) Rehabilitation Work

Eroding banks were stabilized at eight sites within an 1,800 m section of the stream and point bars were planted at two sites within this section.

- Bankside river spur structures were constructed at six of the sites. Structures were comprised of large wood, thinned trees, root wads and boulders). Anchoring of structures was by boulders, cables using epoxy, or by buried deadman logs and cables. A blanket layer of thinned pine and fir trees was placed against the eroding bank. Large wood debris with root wads attached was placed on top of the brush layer. Large wood pieces were spaced out along the subject bank at 6 to 8 m intervals, with root wads facing upstream. Thinned trees were then positioned on top of the structures. All thinned trees were secured to the LWD with spikes.

- Deadman logs were used to anchor the structures at two sites. T-trenches were excavated 2.5 to 3.0 m back from the eroding bank to just below stream bed elevation. Cable was cinched and clamped around large woody debris (LWD) pieces against the bank so the cable was as low to the water as possible. The other end of the cable was wrapped around the deadman log and secured with clamps. The excavator was used to pull on the deadman to tighten the cable (Fig. 3). The deadman was then lowered into the T-trench when the cable was as tight as possible and the LWD against the bank was tight. The cables were attached and tightened in order to resist both buoyant and vector forces during high flow evens. The T-trench was then infilled and compacted. Trench scars and exposed soil (Fig. 1) was also planted with willow stakes to promote riparian recovery.

- The remaining four river spur structures were anchored by boulders and the HILTI epoxy and cable system.
- At the remaining two bank protection sites, subject banks were pulled back to a more natural configuration and alignment and armored with graded rip-rap to above the bankfull height. The banks were further stabilized with supplemental planting of willow stakes to promote the establishment of riparian vegetation (Fig. 4).
- Willow stakes were also planted on two large point bars using the excavator. The excavator was used to dig a vertical walled pit up to 1 m deep. Three or four willow stakes were placed into each pit and then infilled (Fig. 5).

The ground crew for all restoration components of this project were members of the Penticton Indian Band arranged through the First Nations of the Okanagan Similkameen Environmental Protections Society (FNOSEPS). The Penticton Indian Band has a special interest in land management within the Trout Creek watershed as this area falls within their traditional lands. Band members actively participated in this restoration process by providing local knowledge and restoration ideas.

c) Water Intake Screening

With the cooperation of the District of Summerland, MELP, and the WRP a fish screening device will be placed in the District's water intake in 1999. The screen is expected to divert thousands of rainbow trout, consisting of all age classes, back into Trout Creek. Formerly, these fish were eliminated from the Trout Creek ecosystem.

Production Estimates

The primary purpose of this project was to stabilize eroding banks and revegetate gravel bars to reduce sediment movement in the stream, thereby improving water quality. Fish production estimates are not available, but the features installed are expected to create more complex habitat for resident rainbow trout and improve water quality in the lower portions of the watershed.

Monitoring / Future Work

All sites will be monitored post freshet in 1999 to determine functionality and stability of structures. Willow plantings will also be monitored to determine success rate. Sites not addressed in 1998 may be prioritized for work in 1999 pending directives of the principle proponent.

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Slaney P. A. and D. Zaldokas. 1997. Fish Habitat Rehabilitation Procedures Watershed Restoration Technical Circular No. 9. Watershed Restoration Program. Ministry of Environment, Lands and Parks and Ministry of Forests, BC Government.

Figure 1. Typical river spur structure using large wood pieces, thinned trees, root wads and boulders; supplemented by planting willow stakes.

Figure 2. Typical river spur on outside bend. Note: large wood pieces, thinned trees and extensive bar planting with willow stakes.

Figure 3. Excavator used to tighten and place deadman logs into T-trenches.

Figure 4. Channel manipulation using graded rip-rap and supplemented with planting willow stakes.

Figure 5. Bar planting using excavator 3 to 4 willow stakes were planted per bucket, up to 1 m deep.

MISSION CREEK RAINBOW TROUT REARING CHANNEL CONCEPTUAL DESIGN AND TECHNICAL DETAILS

by

H. Andrusak

INTRODUCTION

The deterioration of Okanagan Lake spawning streams has been well documented by Galbraith and Taylor (1969, MS), Wightman and Sebastian (1979, MS) and Tredger (1988, 1989a, 1989b, MS). More than ninety percent of the potential kokanee stream habitat (Galbraith and Taylor 1969, MS) has been impaired due to cumulative impacts of urbanization, flood control and severe water demand for irrigation. Several restoration efforts have been made over the last two decades to improve kokanee stream habitat including construction of a 900 m spawning channel on Mission Creek in the early 1990s.

The problems associated with Okanagan Lake kokanee are more complex than simply attributing the entire decline to loss of shore or stream spawning and rearing habitat. Reduction in lake rearing capacity and *mysis* shrimp competition have been primary reasons why the lakes' kokanee population has declined so dramatically (Ashley et al. 1998).

Most of the focus on stream habitat restoration has been directed at kokanee. However, a series of technical assessments of Mission Creek habitat capability was conducted (Wightman and Sebastian 1979, MS; Wightman 1980, MS; and Wightman and Yaworski 1982, MS) to determine the feasibility of improving rainbow trout rearing habitat. The focus of this earlier work was on in-stream improvements to increase over winter rearing by means of habitat complexing such as boulder cluster placement and reverse gravel platforms (Wightman and Sebastian 1979, MS). Construction of off channel rearing habitat was not considered although Wightman and Sebastian (1979, MS) recognized the value of a hatchery rearing pond located adjacent to Mission Creek on the Hasse property operated by the MELP Fish Culture Section during the late 1970s. This report is focussed on feasibility of developing an off channel for over wintering Mission Creek rainbow trout and possibly providing some kokanee spawning habitat.

SITE DESCRIPTION

Mission Creek is the largest tributary to Okanagan Lake with a watershed encompassing approximately 880 km^2 that drains east to west from the Midway Mountains of the Monashee range to Okanagan Lake (Fig. 1). A more detailed description of Mission Creek can be found in Wightman and Sebastian (1979, MS). The lower 12 km of Mission Creek flow through the City of Kelowna and have been severely channelized on numerous occasions for flood protection purposes. This has resulted in loss of channel length and sinuosity. As well, a network of irrigation channels can be found in the mid-reach area (5 to12 km) utilizing a significant amount of the main stream water. A kokanee spawning is located within Sutherland Regional Park approximately 8 km upstream from Okanagan Lake (Fig. 1).

Some 19 km upstream from the lake are Gallagher's Falls that represents a total barrier to any migrating fish. Kokanee and rainbow trout are known to ascend to the base of these falls (Wightman and Sebastian 1979, MS). The stream below the falls runs through a steep canyon area for some 7 km before breaking out to the valley floor adjacent to Okanagan Lake and the City of Kelowna. This 7 km section of stream is relatively pristine and supports the majority of remaining rainbow trout rearing habitat (Wightman and Sebastian 1979, MS).

Located approximately 12 km upstream of the lake and only 4 km from the spawning channel (Fig. 1) at the upper extent of channelized stream is a key piece of property adjacent to Mission Creek known as the Hasse property. This property was originally privately owned and in the 1970s MELP-Fisheries held a lease on it for the purposes of rearing hatchery raised rainbow trout. This rearing pond operation ceased in 1984 and was abandoned (D. Peterson, Victoria, Ministry of Fisheries, pers. comm.). In 1995 the Regional District of Central Okanagan (RDCO) purchased the property with contributions from the Okanagan Region Heritage Fund Society, Ministry of Environment, Lands and Parks (MELP) and the Habitat Conservation Trust Fund (HCTF).

The Hasse property is owned by the Regional District of Central Okanagan with a restrictive covenant held by the Okanagan Region Heritage Fund Society for purposes of parks and conservation and preservation of fish and wildlife values. The property is on Lot 5, Section 14, Township 26, Osoyoos Division of Yale District, Plan 1751 except Plans 21761 and KAP44196. The western boundary of the property borders Mission Creek.

The Hasse property is 9.21 acres in size. Immediately south and adjacent to Mission Creek and the Hasse property is a parcel of Crown Land approximately 6 acres in size[1]. Of particular importance is the fact that these properties have several groundwater springs. The Fisheries Branch holds five water licences (Table 1) on the Hasse property. In addition two licences are assigned to the property that need to be converted to the Regional District. The City of Kelowna also holds a water licence on nearby Belgo spring that may be available for the proposed rearing channel. Consolidation of all groundwater-licensed water associated with the property is required.

Habitat attributes that make this a high priority project include secure land including riparian habitat and a water supply adjacent to Mission Creek that is the single most important spawning and rearing stream on Okanagan Lake. The property includes approximately 900 m of riparian habitat adjacent to Mission Creek, which at that location supports rearing rainbow trout and kokanee spawning habitat (Wightman and Sebastian 1979, MS).

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[1] Note: herein this report reference to "property" means the combination of Crown Land and Hasse parcels.

Table 1. Relevant water licenses associated with the Hasse property.

Licence Number	Use	Source Name	Quantity	Licensee	Priority Date
CO51804	Conservation	Nicholas Springs	0.25 cfs	Fisheries Branch	1978/06/14
FO12611	Domestic	Nicholas Springs	500GPD	Hasse, A[1]	1939/01/19
FO12611	Irrigation	Nicholas Springs	9 AF	Hasse, A[1]	1939/01/19
CO51803	Conservation	Craggs Brook	0.25 CFS	Fisheries Branch	1978/06/14
CO60399	Conservation	Houston Springs #1	0.25 CFS	Fisheries Branch	1978/08/29
CO60399	Conservation	Houston Springs #2	0.25 CFS	Fisheries Branch	1978/08/29
CO51805	Conservation	Tuthill Spring	0.25 CFS	Fisheries Branch	1978/06/14
FO12612	Irrigation	Belgo Spring	5 AF	City of Kelowna	1939/01/25

[1] Licenses that need to be converted for conservation purposes.

Water Quality

The fact that MELP-Fisheries successfully operated a year round rainbow trout rearing pond at this site in the 1970s indicates that the spring water supply sources had very good water quality.

Rainbow Trout Rearing

Sebastian (1979, MS) determined from extensive scale analysis of mature and juvenile fish that most Mission Creek rainbow trout rear in the stream for 1 to 2 years. Rainbow fry migrating directly to the lake did not appear to survive to adult age fish. Sebastian (1979, MS) found that a minimum size of 75 to 80 mm was critical for survival at lake entry. Wightman and Sebastian (1979, MS) confirmed the presence of older juveniles (ages 1 to 3) rearing in the canyon area (stream km 10 to 19). Trout populations estimates, densities and biomass densities for each age group and major habitat types were reported by Wightman and Sebastian (1979, MS). Irvine (1978) has conducted a similar assessment of Gerrard rainbow trout rearing habitat requirements and these fish have an identical life history to Mission Creek rainbow trout. An updated analysis of this information and that available in the literature is required.

Slaney and Zaldokas (1997) describe the current known bio-standards for stream rearing rainbow trout. Surprisingly few studies have been conducted on rearing rainbow trout requirements but Slaney and Zaldokas (1997) suggest a 2.7 fold increase of all rainbow juveniles and a 1.3 fold increase of trout >15 cm can be achieved by development of complex habitat using known bio-standards. Aside from suitable water temperature and water quality, a flow of 2 to 5 cfs at 15 to 30 cm per second is required. Most important is development of complex habitat using a pool:riffle ratio of 1:1 (P. Slaney, Watershed Restoration Program Biologist, UBC, Vancouver, pers. comm.). A mix of coarse gravel-cobble and boulders is essential for over wintering juveniles much as described by Wightman and Sebastian (1979, MS).

Kokanee Spawning Habitat

Spawning habitat requirements for kokanee are well documented since the province has six kokanee channels currently in operation (Andrusak 1999, MS). This project is primarily directed at development of rainbow trout rearing habitat. However, some low gradient sections (0.1 to 0.5%) of the proposed channel would be ideal for spawning kokanee and some suitable gravel can easily be placed in 1 to 2 sections in the event kokanee enter the channel to spawn.

Conceptual Project Plan

According to water licenses (Table 1) spring groundwater supply may provide up to 1.5 cfs of water. It is proposed that a spring water collector pond be developed on the property to capture as much spring water as is possible. A small channel (about 1 m wide, 15 cm deep) would carry the spring water approximately 200 m to a head pond located at the southern end of the property. Grade survey data confirms this is feasible. From the head pond a meandering channel would be excavated to intercept stream groundwater. The channel would be 2 to 3 m wide and approximately 700 m long, exiting at the north end of the property.

Conceptually the project design will include a groundwater channel having a depth of 30 cm and grade of 0.2 to 1.0% to accommodate over-wintering rainbow trout juveniles. The channel would be lined with 10 to 20 cm sized rocks preferred by juvenile rainbow trout. It will be designed for a velocity of 18 cm per second and final channel width will be determined on the basis spring water and how much groundwater is intercepted. In the unlikely event that groundwater is insufficient surface water could be utilized but this is not the preferred option. Adequate setback banks (from the active channel) will be incorporated and at one location a small protective dyke may be required.

In-stream habitat features will include some rock clusters, over hanging vegetation, floating debris and log placements all designed to encourage over-wintering of trout. Rock weirs may be employed to increase flows at specific sites and spawning gravel for kokanee will be placed at the headpond outlet. The rearing channel will be designed after some steelhead channels constructed on the coast and two successful groundwater channels located on the Deadman Creek (I. McGregor, Kamloops, BC, pers. comm.). Evaluation design will be based on Johnston and Slaney (1996) and input from WRP habitat biologists and engineers.

A small section (approximately 30 to 50 m) of the channel will be designed to accommodate some spawning kokanee. Rainbow trout spawning is not anticipated but if spawning trout did enter the channel it could easily be modified to accommodate them. It is known that Mission Creek rainbow trout spawn upstream of the proposed channel.

The RDCO and Friends of Mission Creek have expressed support for this project and are particularly interested in extending the Greenway trail system in the lower reaches of Mission Creek onto the property. Development of a walkway can easily be incorporated during channel construction and would be a very positive attribute for public enjoyment and education.

Expected Rearing Production1[1]

Using data summarized by Slaney and Zaldokas (1997) a crude estimate of potential numbers of rearing rainbow trout can be determined (Table 2). It is expected that if the channel is built to meet rearing rainbow trout juvenile biostandards a range of 13,580 to 29,100 trout of all sizes could potentially utilize a 700 to 1,000 m long channel. Clearly most of these fish would be fry; an estimated 224 to 480 age 1 to 3 fish are estimated to rear in the same sized channel. A review of the literature is required to determine a more accurate estimate.

Table 2. Estimate of potential numbers of juvenile trout produced in the proposed channel.

Species	**Channel**		**Total Fish**	**Age 1-3**
	Length	**Width**		
rainbow trout	700 m	2 m	13,580	224
	1,000 m	3 m	29,100	480

This proposed project will evolve over the next 1 to 2 years. Using the adaptive management approach will undoubtedly result in a very productive rainbow trout rearing channel and possibly some kokanee spawning habitat.

RECOMMENDATIONS

- Meet with RDOC staff to outline project proposal and understand RDCO requirements such as trail development on the site location.
- Meet with Okanagan Heritage Fund Society and other public groups such as the Friends of Mission Creek to ensure support for project.
- Conduct a literature review and analysis of rainbow trout rearing densities to more accurately predict expected benefits of rearing channel construction.
- Consolidate all water licenses for fish conservation purposes.
- Provide some spawning habitat for kokanee.
- Develop channel in stages and modify based on assessments and observations.
- Establish an assessment program in consultation with WRP biologists and engineers.

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[1] Estimates are based on Slaney and Zaldokas (1997 pages 3-4) that are not entirely comparable since they summarized main channel rearing not off channel rearing habitat.

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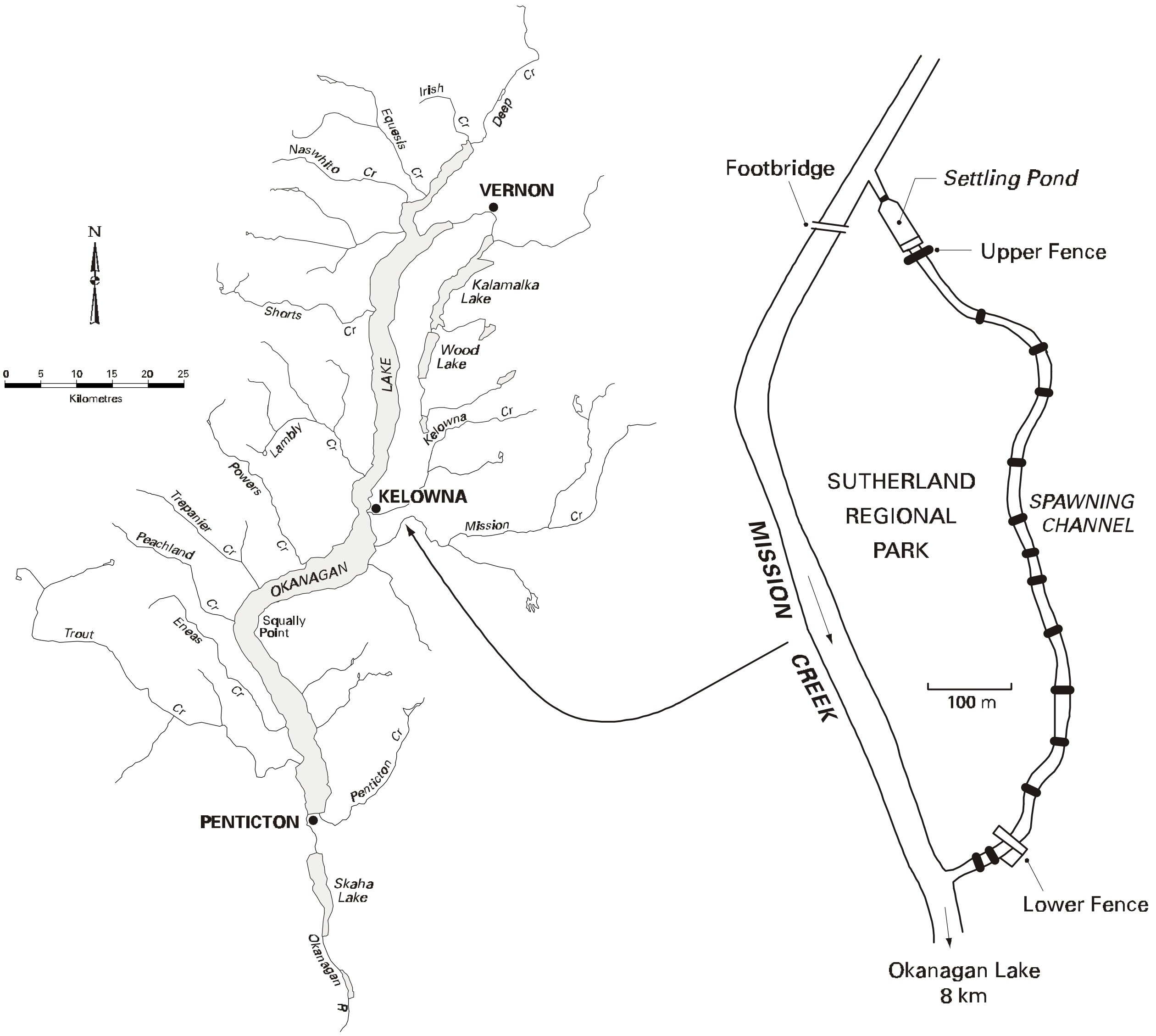

Figure 1. Okanagan Lake and Location of Mission Creek and Mission Creek Spawning Channel.

CHAPTER 2

MONITORING PROGRAM

This component of the Action Plan involves routine data collection of annual limnological and fisheries information. It involves work that should be conducted an on-going basis to ensure a long term data base is maintained to follow trends in water chemistry, plankton, mysids, kokanee and rainbow trout in Okanagan Lake. Emphasis has been placed on standardizing and collection of zooplankton, in-lake kokanee abundance estimates and shore and stream spawner counts.

OKANAGAN LAKE KOKANEE ABUNDANCE, SIZE AND AGE STRUCTURE BASED ON TRAWL AND ACOUSTIC SURVEYS

1988 to 1998

by

D. C. Sebastian[1] and G. Scholten[1]

INTRODUCTION

Okanagan Lake is a large lake (351 km^2) located in southern BC, which supports a sizeable kokanee (*Oncorhynchus nerka*) population that recently has undergone a significant decline. In response to the decline a monitoring program was initiated in 1988 to determine the status of the population. Hydroacoustic and trawl net surveys have been conducted annually in the fall months since 1988. Establishment of a continuous data set over a period of time is invaluable for determining trends in the population. Calculations of in-lake abundance indices from the trawl and hydroacoustic data should complement annual shore and stream counts, and provide greater insight into stock status. This report provides an update of Sebastian et al. (1995, MS) and Sebastian and Scholten in Ashley et al. (1998). This report summarizes acoustic and trawl data collected during 1996 to 1998 under the Okanagan Action Plan and makes comparisons with data collected since 1988.

METHODS

a) Hydroacoustic Sampling

A complete night time survey of the limnetic habitat in Okanagan Lake was conducted during October 8 to 10, 1996, October 1 to 4, 1997, and September 20 to 21, 1998, concurrent with the annual trawl surveys. Acoustic surveys each consisted of 18 transects evenly spaced from the south to the north end of Okanagan Lake (see Map 2) using the standard survey design in Sebastian et al. (1995, MS). The 1997 survey also included 6 transects on Kalamalka Lake.

All surveys were conducted using a Simrad model EY200P operating at 70 kHz. The transducer was towed on a planer along side the boat at a depth of 1.5 m and data was collected continuously along survey lines at 1 to 2 $\text{pings}\cdot\text{s}^{-1}$ while cruising at 2 $\text{m}\cdot\text{s}^{-1}$. The data was converted to digital format and stored both on a PC computer and backed-up on Sony Digital Audio Tape (DAT). Navigation was by radar and a 1:50,000 Canadian Hydrographic Services chart. The sounder was field calibrated at depths of 15 to 40 m using a standard -39.1 dB copper calibration sphere.

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[1] Ministry of Fisheries, Fisheries Management Branch, Victoria, BC

The Simrad survey data were digitized and then analyzed using the Hydroacoustic Data Acquisition System (HADAS) program version 3.98 by Lindem (1991). The HADAS statistical analysis performed a function similar to manual counting to determine the number of targets per unit area by depth stratum. In addition, the HADAS estimated the fish size distribution using a statistical de-convolution algorithm based on Craig and Forbes (1969). The resulting bimodal acoustic size distribution was used to proportion the fish population into two size classes representing age 0 fish and age 1 to 3 fish, respectively.

Fork lengths of trawl caught fish were converted to the same acoustic scale using Love's (1977) empirical relation and compared to acoustic size distributions in order to verify the age cut-off for the two size groups. Since it was not possible to distinguish between age 1 to 3 fish using acoustic data, the proportions of these age groups were based on trawl catches. Kokanee abundance estimates and age 0 proportions were derived from acoustic data while abundance estimates of age 1 and age 2 fish relied on both trawl and acoustic results.

b) Trawl Sampling

Trawl gear consisted of a 5 x 5 m beam trawl, holding a 15 m long net of graduated mesh size (0.6-10.0 cm stretched), towed at 0.65-0.85 $m \cdot s^{-1}$. Net depth was estimated by the cable angle and the length of cable deployed. In addition, a Global Positioning System (GPS) was used in 1997 to 1998 to verify the distances traveled by the trawl net, and to fine-tune estimates of sample volumes.

A standard trawl survey of the limnetic habitat (>20 depth) in Okanagan Lake was completed during October 6 to 9, 1996, October 2 to 11, 1997, and September 15 to 22, 1998. The survey design and sampling techniques were consistent with the kokanee stock monitoring that has been conducted annually on Okanagan Lake since 1988 (Sebastian et al. 1995, MS). The survey consisted of 24 standardized trawls with 3 replicates at each of 8 evenly spaced stations from the south to the north end of the lake (Map 2). Stepped-oblique trawls ensured a representative sample of fish was attained from each depth strata where fish were observed on the echosounder. The net was fished for 8 minutes at each consecutive 5 m depth layer from beneath the observed fish layer to a few meters above the layer. Captured fish were kept on ice until processed the following morning at the Okanagan College laboratory. The species, fork length, weight, distinguishing marks (e.g., fin clips), scale code and stage of maturity were recorded and samples were then preserved in 10% formalin for long-term storage. Scales were taken from fish >75 mm for aging, and in 1997, otoliths were taken as a second method of age determination.

Trawl surveys provide the following information: species verification for the acoustic survey, an indices of kokanee abundance, age structure, size-at-age and the proportion of mature fish in the catch. Abundance indices were calculated based on a standardized volume of water filtered, representing the upper 55 m of the water column, which produced estimates of density in numbers per million litres or megalitres (ML) of water filtered. The sample volumes in 1998 ranged from 85,000 to 112,000 liters per trawl depending on the boat speed. Fish lengths were adjusted to a standardized survey date of October 1 to enable growth comparisons with previous fall surveys (Sebastian et al. 1995, MS).

RESULTS AND DISCUSSION

Fish Distribution

Trawl catches during standard fall surveys indicated that the large majority (98 to 100%) of fish occupying the limnetic habitat below the thermocline at night were kokanee. Number of fish caught per survey ranged from 226 (1998) to 1,014 (1988) and the number of trawls per survey ranged from 21 to 26 (Table 1). The average distribution of fish by age for the eight trawl stations based on ten years of data (1988 to 1997) showed the greatest abundance of age 0 fish at Cameron Point (station 8) followed by Squally Point (station 3), Gelately (station 4) and Trout Creek (station 1) (Fig. 1). Largest numbers of age 1 fish often occurred at the same locations as the largest numbers of fry, indicating a similarity in their preference for local habitat conditions. Age 2 fish tended to be more uniformly distributed over the lake except for near the ends of the lake (e.g., Cameron Point and Trout Creek), where their numbers were typically low.

Table 1. Summary of kokanee catches in Okanagan Lake standard trawl surveys, 1988 to 1998.

Survey	Survey	No. of	No. of	Number of Kokanee Caught					
Year	**Period**	**Stations**	**Trawls**	**Age 0**	**Age 1**	**Age 2**	**Age 3**	**Mature**	**Total**
1988	Oct 6-18	8	23	754	206	54	0	3	1014
1989	Sep 28 - Oct 5	8	24	362	111	69	0	6	542
1990	Oct 16-20	7	21	395	117	62	0	1	574
1991	Oct 4 - 8	8	24	258	110	170	21	29	559
1992	Sep 27 - Oct 1	8	24	349	118	130	1	21	598
1993	Oct 13-19	8	24	191	108	54	6	11	359
1994	Oct 4-8	8	24	167	69	79	1	18	316
1995	Sep 22-28	9	26	331	109	161	21	57	622
1996	Oct 8 - 11	8	23	441	49	31	14	13	535
1997	Oct 2 - 11	8	24	293	97	41	6	13	437
1998	Sep 15-22	8	24	104	86	30	2	11	222

In 1997, the trawl age distribution and abundance was fairly similar to the 10 year average at all except stations 1 and 2 (Trout Creek and Summerland) where catches of all ages were low (Fig. 2). In 1998, there was an obvious lack of age 0 fish at stations 3, 5 and 8, which typically supported high numbers. When compared to acoustic survey results, it appears that some age 0 fish were missed by the trawl sampling, either as a result of the depth of sampling (slightly too deep to catch the top of the fish layer) or of the particular site locations chosen. To reduce the potential for a near shore bias, in 1998 there was a deliberate emphasis on sampling 3 replicates at each of the trawl stations toward the center of the lake. The GPS indicated that some of the replicates were done toward the low density side of the lake, and would therefore underestimate the true numbers of fish present. In retrospect, spreading the trawls out across the lake as done in previous years did tend to produce a more reliable index of overall fish abundance, particularly for age 0 fish. It is recommended that replicates be spread out across the lake and GPS “way points” be selected for trawling start points. It should be noted that trawl catch per unit effort (CPUEs) reported by Figures 2, 3 and 4 on page 72 of Ashley et al. (1998) were in error. These figures have been corrected as Figures 1, 2 and 3 in this report by dividing the CPUE estimates by 1,000.

Abundance

Estimates of kokanee abundance in the limnetic zone of Okanagan Lake have ranged from 5 to 14 million fish over the last eleven years. Abundance was estimated at 8.2 million fish in 1996, 5.1 million in 1997, and 5.3 million in 1998. The total number of fish declined by 45% from 1991 to 1994, increased slightly in 1996, and then declined a further 17% to 5.1 million in 1997 (Fig. 4). The 95% confidence limits on these estimates suggest these observed declines during 1991 to 1994 and again in 1997 were statistically significant. According to acoustic size distributions, the proportion of fall fry (age 0 fish) in Okanagan Lake ranged from 56 to 71% of the total population. Fry abundance has declined 68% from nearly 9.0 to 2.9 million from 1990 to 1997 (i.e., spawning years 1989 to 1996). The large decrease in fry abundance in 1997 followed a low shore spawner estimate in 1996 and an extreme lake drawdown during the spring of 1997. Fry numbers increased slightly in 1998 but remained fairly low.

From 1990 to 1995 estimates of age 1 fish have declined by 50% from 3.0 to 1.5 million and have since increased slightly (Fig. 5). Trends in age 2 fish abundance were generally more variable but also showed some overall decline during the 1991 to 1998 survey years, corresponding to the 1988 to 1995 spawning years.

Age Structure and Sampling Techniques

A combination of trawl and acoustic results was used to estimate the age structure of kokanee in the lake (Fig. 5). Acoustic results were preferred over trawling results for estimating total abundance and proportion of age 0 fish, since the sample coverage was greater and the variability in estimates was lower (e.g., more stable). The tendency for fry to congregate in high densities immediately below the thermocline makes them somewhat difficult to sample using a stepped oblique trawl method. The depth of the “fry layer” and the thermocline can vary along the lake. These variations in fish depth do not present a problem for acoustic counting, which analyzes each 5 m depth layer separately. Unfortunately, the ability to distinguish size differences using the single beam de-convolution method is limited to large size differences, so this technique is not suitable for separating age 1, 2 and 3 fish into different size groups. The proportions of age 1, 2 and 3 fish from the trawl were applied to the total acoustic abundance of age 1 to 3 fish to proportion the population into these age groups (Fig. 5).

Similarity in estimated numbers of age 1 and 2 fish for the same spawning years indicates there may be some problems in using the trawl proportions for estimating age 1 abundance. Three potential sources of error associated with trawl netting are: 1) location and intensity of sampling relative to where the fish are: 2) estimating the volume of water sampled in each trawl, and 3) relative efficiency of the net for capturing different sized fish as a result of the mesh size and tow speed.

The confidence intervals on age 1 trawl catches were similar or tighter than on age 2 catches, indicating that patchiness of age 1 fish or insufficient number of sample sites were not likely to be the cause of low age 1 catches. The GPS coordinates of trawl start and end points recorded in 1997 and 1998 indicated that average boat speed was 15% less than previously estimated. However, this error would likely apply similar bias to all age groups, and have minimal effect on age proportions in the catch. Field observations from the Kootenay Lake fertilization study suggest that there is a greater loss of age 1 than age 2 fish through the large mesh at the head end of the trawl net (D. Miller, contractor Nelson BC pers. comm., 1996). It was concluded that relative catch efficiency due to large head-end mesh size was the most likely reason that numbers of age 1 fish remain relatively low and similar in numbers to age 2 fish in the trawl. With this problem in mind, trends in abundance within a specific age group should still be valid. Size (age) specific expansion factors for age 0 and 1 fish would have to be developed in order to estimate and track survivals of cohort groups through the population using current sampling methods. The abundance of age 1 fish originating from the 1996 spawning year were expected to decline as a result of a 50% reduction in the 1997 fry population over the previous year. However, a slight increase in age 1 numbers suggests that fry-to-yearling survival improved last year.

Mature fish and shore spawner distribution

Trawl surveys during 1988 to 1997 occurred after the peak of stream spawning activity and before the peak of shore spawning between September 22nd and October 20th. During this period the number of mature fish caught in the trawl ranged from 1 to 57 fish. It was anticipated that distribution and abundance of mature fish caught in the trawl would be useful in predicting distribution and relative abundance of shore spawners 2 to 3 weeks later. Numbers in the trawl were too low to predict abundance but there appeared to be a reasonable correlation between the distribution of mature fish from trawls and the location of observed shore spawning. The largest numbers of mature fish were caught in the vicinity of Squally Point and Okanagan Resort, two areas known to have high spawner concentrations. Lower numbers at Cameron Point, Gelately and Whiskey Island also correlate to fewer numbers of observed spawners (Fig. 6). The 1996 trawl suggested that Squally Point would be the most important area with less spawning near Okanagan Resort and Whiskey Island. This data agreed with the observed distribution in 1996, although the numbers of mature fish did not reflect the apparent low abundance of spawners suggested by the shoreline observations.

The 1997 trawl results suggested higher than average numbers of potential spawners just south of Kelowna, and little if any spawning activity for Squally Point and southward (Fig. 6). These results agree with shore spawner count distributions if it is assumed that fish caught off Mission Creek (where there is no suitable shore spawning habitat) moved immediately north of Kelowna to spawn where highest numbers were observed. Lack of shore spawning activity at Squally Point parallels the trawl results. The 1998 trawling data predicted a slightly lower than average number of spawners but spread over the entire lake, so did not agree with the total lack of shore spawning observed by fixed wing surveys in October 1999. It may be that spawner numbers have declined below a threshold number that are required to use shoreline observations as an index of abundance.

Growth

Kokanee mean size-at-age during 1985 to 1996 were 59 ± 2 mm for age 0, 131 ± 6 mm for age 1, 214 ± 2 mm for age 2 and 237 ± 4 mm for age 3 fish adjusted to an October 1 standard (Fig. 7). Only slight adjustments to raw fish lengths were made to age 0 fish during 1996 and 1997, as no preservative corrections were required and surveys occurred within a few days of October 1. The mean size of 58, 126, 213 and 245 mm for age 0, 1, 2 and 3 fish, respectively, in 1996 showed no significant difference in fish size from the 85 to 96 averages (Fig. 7). In 1997, however, the mean sizes of 56,119,190 and 226 mm for ages 0 to 3 respectively, all showed decreases in size compared to the previous year and the 12-year average. In 1998, the means sizes were again lower than the 12-year average and were similar to 1997 sizes.

The decline in 1997 to 1998 size was most noticeable in the age 2 and 3 fish, with age 2 size statistically the lowest on record for its age group. The low numbers of age 3 fish result in wide confidence limits on the means. Except for the age 3 fish, it appears that there has been a gradual downward trend in kokanee size since about 1990 in Okanagan Lake. This downward trend in size is remarkably similar to what occurred to Kootenay Lake kokanee in the 1980s (Ashley et al. 1997). Trends in kokanee length-at-age showed no evidence of density dependence. In fact, simultaneous declines in both size and density of kokanee support the current theory of declining lake capacity. From a preliminary trawl survey in 1997, mean size-at-age of kokanee in Kalamalka Lake appeared to be smaller than in Okanagan Lake (Fig. 7).

Mature fish caught by trawl-net averaged 233 ± 5 mm from 1988 to 1996. This was consistent with the mean size of 237 ± 2 mm for a sample of 104 shore spawners collected at Squally Point and Okanagan Lake Resort during 1994 (Pollard and Taylor, 1997). Pollard and Taylor (1997) reported that all their samples were age 2+. A small sample of mature fish from the 1996 trawl (n=13) suggested that 70% of the fish were age 3s, with a mean size of 247 ± 4 mm. A similar sized sample in 1997 suggested 70% age 2s with a mean length of only 205 mm. Mature fish in 1998 also appeared to be mainly age 2 with a mean length of about 200 mm. Clearly, there is a need to clarify the age of maturation for these fish. A better data set has been collected from the fall 1997 shore spawners and age will be determined using otoliths.

Spawner Abundance and Fry Recruitment

An initial comparison of spawner estimates to in-lake fry abundance estimates the following year was made using data from the 1987 to 1997 spawning years (Fig. 8). Separate correlations of stream and shore spawners to the number of fry in the lake suggested that the shore component had the most influence over fry abundance. In order to combine the indices of stream and shore spawner abundance, they were each adjusted to represent the total numbers of spawners. The stream peak count was expanded by 1.5 times as suggested in Andrusak (1999, in this report) and has been revised downward from the 2.3 factor used previously for Okanagan stream spawners (Ashley et al. 1998). Because of difficulties in enumerating shore spawners (e.g., less coloration, wave action, depth of spawning) with a shorter residence time and lower frequency of shore surveys (e.g., lower probability of encountering the peak of spawning), it was concluded that the expansion factor for shore spawners would have to be greater than the 1.5 used for stream spawners.

A number of iterations were applied using different expansion factors to the shore counts and then compared to the combined spawner estimates and resultant fry numbers. Using an expansion factor of 4 resulted in a good correlation between the total combined spawner estimates and the resulting fry population in 9 of the 10 years of record (Fig. 8). This technique provides supporting evidence that the shore spawner indices of abundance may be reliable.

The extremely low shore counts reported in October 1998 predict a sharp decline in the total numbers of kokanee fry in Okanagan Lake next year (fall 1999). If this does not occur, it will support the notion that numbers have fallen below a threshold level whereby shore spawners abundance can no longer be represented by visual counts along the shoreline. We are currently developing an indirect enumeration technique through use of genetic markers to differentiate between the stream and shore spawning stocks from samples of fish taken at any life stage (see Taylor et al. 1999, in this report).

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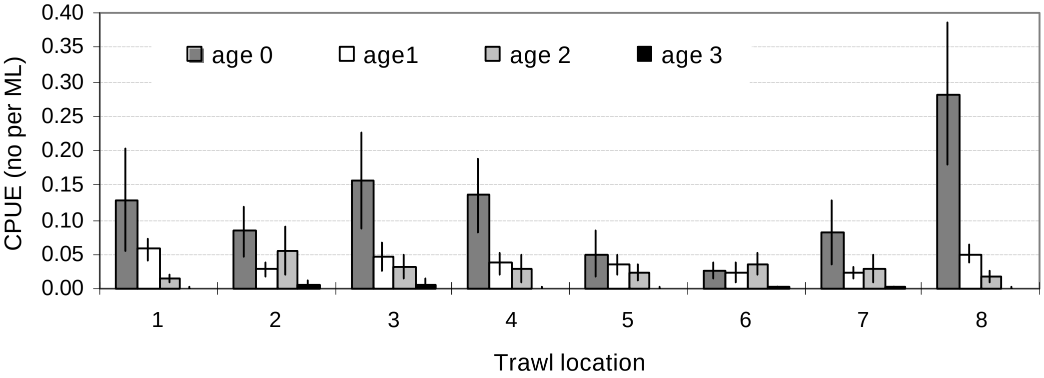

Figure 1. Kokanee distribution by age in Okanagan Lake based on trawl surveys, 1988 to 1997. Error bars denote 95% confidence limits on means.

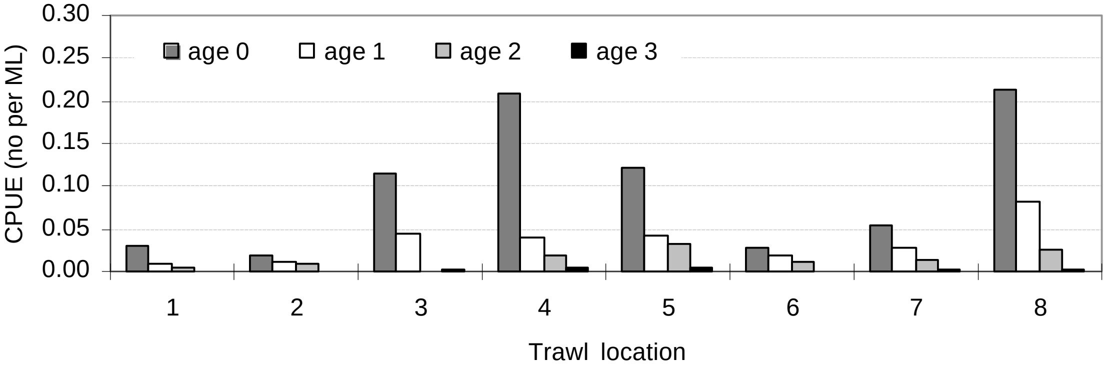

Figure 2. Kokanee distribution by age during fall 1997 based on trawl survey.

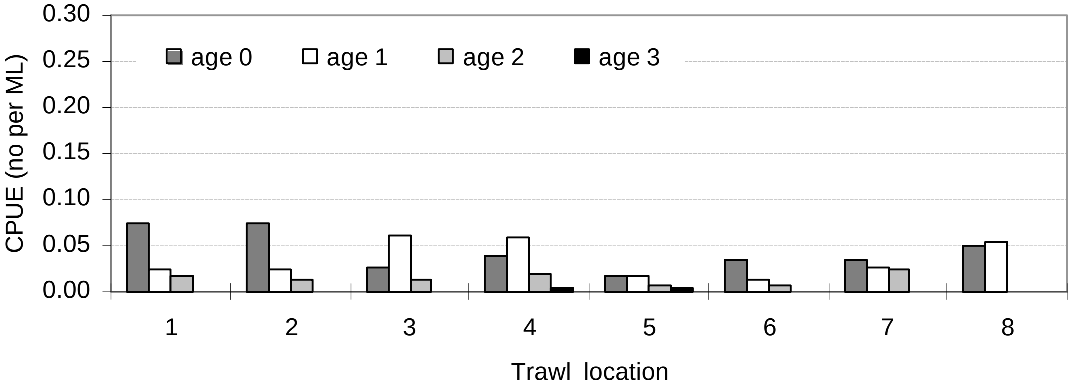

Figure 3. Kokanee distribution by age during fall 1998 based on trawl survey.

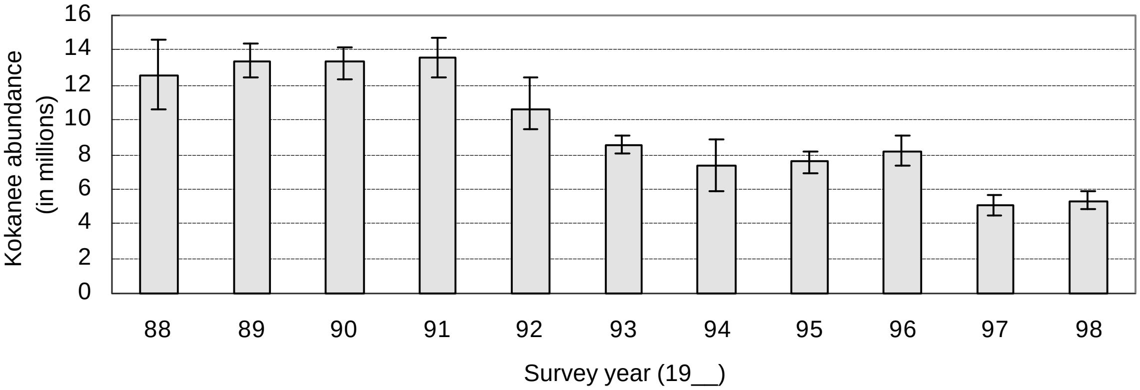

Figure 4. Kokanee abundance in Okanagan Lake based on fall acoustic surveys, 1988 to 1998. Error bars represent 95% confidence limits.

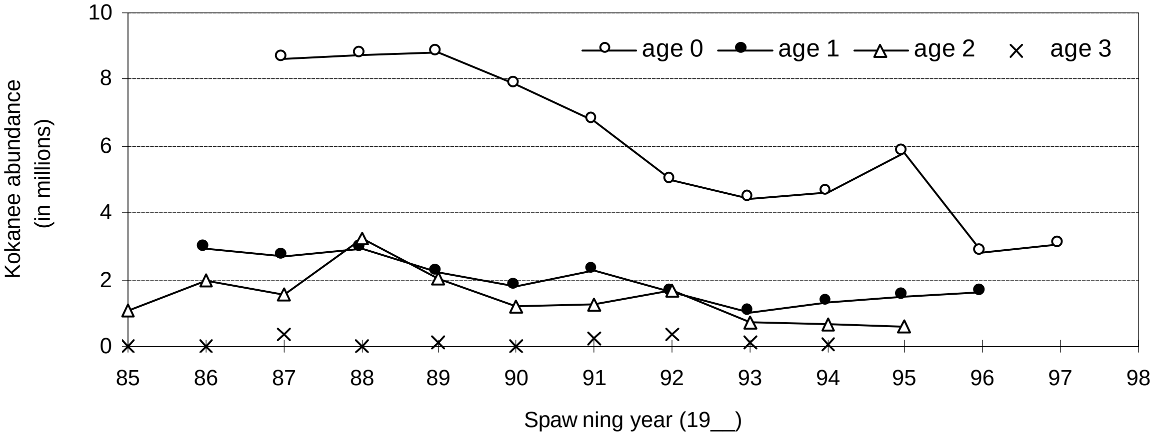

Figure 5. Trends in kokanee abundance by age and spawning year based on acoustic and trawl surveys conducted in 1988 to 1998. Note: data presented by spawning years.

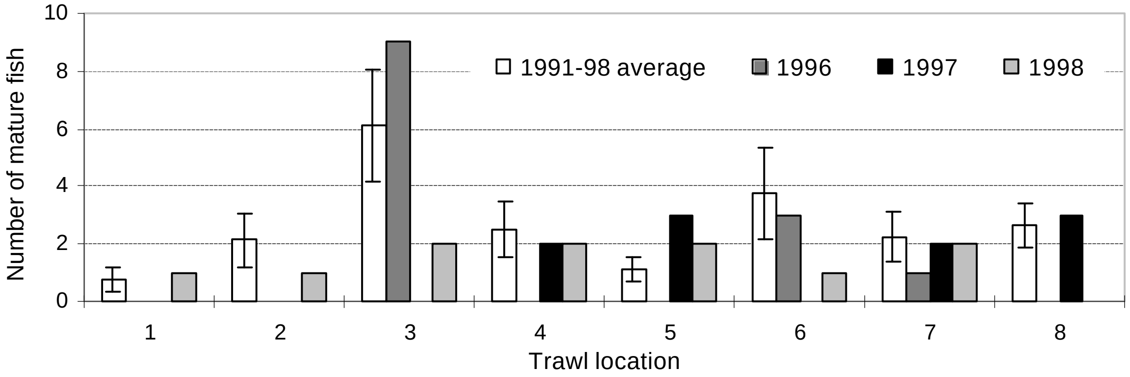

Figure 6. Distribution of mature fish in Okanagan Lake prior to shore spawning in 1996 to 1998 compared with the last eight years.

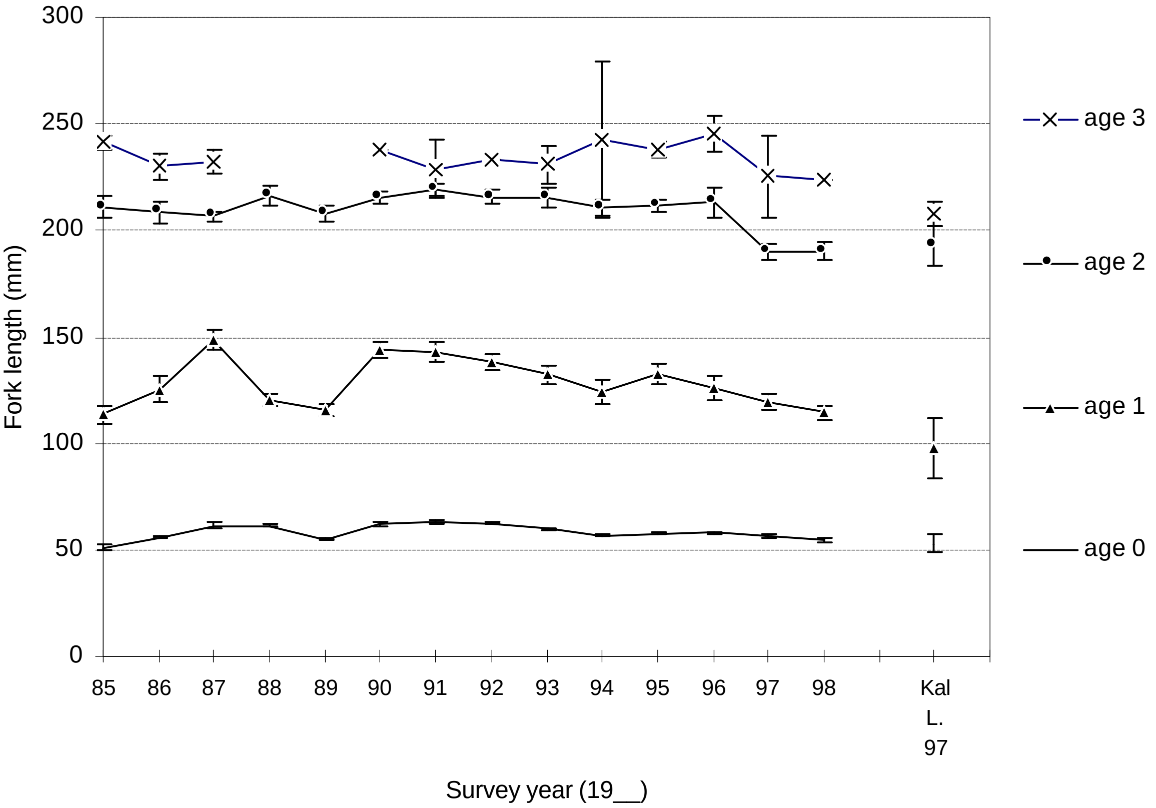

Figure 7. Kokanee mean fork length-at-age for Okanagan Lake adjusted to October 1 based on trawl sampling, 1985 to 1998. Note: limited length-at-age results for Kalamalka Lake in 1997 are also included.

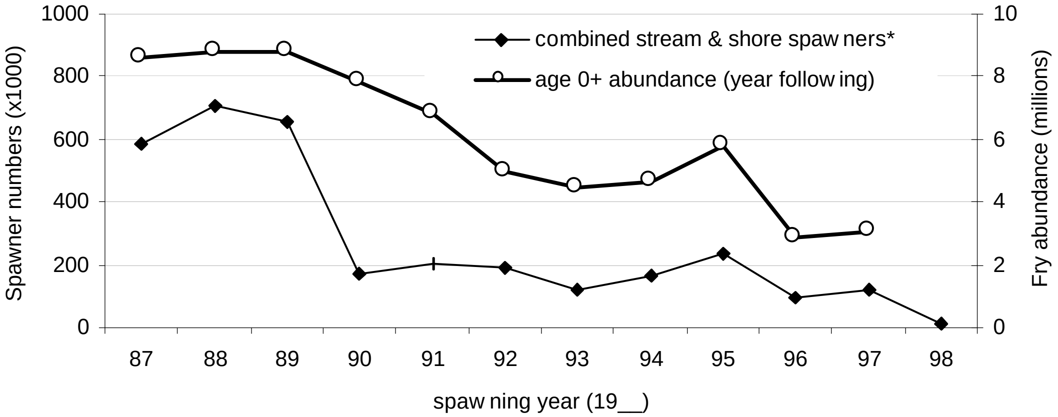

Figure 8. Trends in spawner returns and following year fry populations in Okanagan Lake based on spawner counts and acoustic surveys, 1987 to 1998.

OKANAGAN LAKE KOKANEE SHORE AND STREAM ESCAPEMENTS

1998

by

Steven Matthews and Bruce Shepherd

INTRODUCTION

Routine monitoring of kokanee shore and stream spawning escapements in Okanagan Lake and its tributaries began in the early 1970s as part of the Federal-Provincial Okanagan Basin Agreement studies. Results were reported up to 1994 in Ashley and Shepherd (1996). The trends shown by these escapement data indicated that the kokanee populations declined significantly in this system since the 1960s and early 1970s. Establishment of the Okanagan Lake Action Plan (OLAP) was due primarily to this observed decline in kokanee spawner numbers (Ashley and Shepherd 1996). Kokanee escapements are based on visual estimates therefore their accuracy is subject to several errors due to weather, water clarity, frequency of counts, water temperature variation, etc. (see Thompson, *in:* Ashley et al. 1998). Despite these limitations, the data set remains valuable as an index of population trends over time.

This paper presents escapement information obtained in 1998, and compares these results to previous years.

METHODS

Except where identified otherwise, the following survey procedures have been used since the 1970s (described by Shepherd *in:* Ashley et al. 1998).

Shore Spawner Surveys

Due to the very low abundance of shore spawners, the 1998 surveys deviated considerably from the routine procedures outlined by Shepherd (*in:* Ashley et al. 1998). A local resident was contracted to conduct daily land-based shore spawner counts in the vicinity of Bertram Creek Park from October 6 to November 15, 1998. From 1100 to 1300 hrs PST on October 13, the Fisheries Program research vessel was used to survey Reaches 2-11, 19 and 22a in the southeast quadrant (Commando Bay to Bertram Creek Park; see Map 2). During mid-day of October 27, the limnological sampling crew opportunistically checked for spawning in Reaches 1-12 of the southeast quadrant. Reaches that supported spawning in recent years in all quadrants of the lake were surveyed using fixed-wing aircraft on October 18, 23, and 28; and November 2, 9 and 17.

Stream Spawner Surveys

In 1998, the numbers of live and dead kokanee were counted in 13 known spawning tributaries to Okanagan Lake. All of these tributaries have been part of an ongoing annual monitoring program with the exception of Trout Creek, which had not been enumerated for several years due to low flow problems and resulting low escapement. This creek was included in 1998 due to anecdotal reports of significant number of kokanee observed in 1998. Three North Arm streams located on Indian Reserve lands (Equisis, Whiteman and Nashwito creeks) have been surveyed sporadically in the past, but were not attempted this year due to access difficulties.

Counts began on September 17 and extended to October 12 in 1998. Visual counts were made from the stream bank and recorded on a reach specific basis. Reach breaks were established according to obvious land marks (not changes in habitat) and have remained relatively consistent over the years (see Shepherd *in:* Ashley et al. 1998). Reach specific counts were then summed to form a total count for that day for each stream. All count data were entered to the Fisheries Program KO_ENUM data base (on file, Penticton Office).

The enumeration schedule used in recent years was modified in order to provide more intensive coverage of the higher use tributaries and reduced coverage on the lower use streams. More specifically, Mission, Powers, Peachland, Penticton, Trepanier and Kelowna creeks were counted every three days through the historical moderate and high use spawning periods. In past years, counts were conducted on five day intervals, but concerns were raised the migration peak may be missed. Counts during the lower use spawning periods (early and late in migration) were not conducted in 1998 since the data is not necessary for determining spawner numbers provided the peak count is obtained. The remaining tributaries, which support less than 5% of the total escapement, were counted only once, at the predicted peak based on run timing in other area tributaries.

Peak live count for each stream was expanded by 1.5 based on recent analysis of peak vs. total counts at Mission Creek (Andrusak 1999, in this report).

Water temperatures were recorded for all streams at the time of each count using a pocket thermometer (± 0.5° C). Up to 50 fresh carcasses or moribund fish (where available) were collected from Mission, Powers, Penticton and Peachland creeks and analyzed for nose fork length, sex, maturity, age (otolith), fecundity and egg retention. All data collected in 1998 along with data from previous years has been entered to the fisheries OKFISHP database (on file, Penticton Office).

RESULTS AND DISCUSSION

Shore Spawners

At the time of the October 13 boat survey, water temperatures were unusually high (16.2-16.7^{o}C) and no fish, predators or other evidence of spawning were observed. The first (and only) kokanee seen by the Bertram Creek observer was a group of 55 fish that arrived late in the morning of

October 15, and left the area by early afternoon of the same day. Visibility conditions were moderate to excellent on all fixed-wing aerial surveys, but the only kokanee located were 20 adults, seen in shallow waters about 3 km south of the Hiram Walker Intake (Reach 31). On the flights done October 28 and later, small areas of the shallows in the Paul's Tomb area (Reach 24) were noted to have been "cleaned" in a manner characteristic of kokanee shore spawning, but no spawners were ever observed in the area. The October 27 boat inspection revealed no sign of fish or previous spawning activity in the Squally Point area. Monitoring was extended at Bertram Creek Park due to the continuation of unusually high water temperatures that might have delayed the onset of spawning. However, temperatures had declined to 10.0°C by November 15 at Bertram Creek Park with no further sign of spawning activity.

As escapement estimates were rounded in past years to the nearest thousand fish for shore spawners, the 1998 index estimate was therefore set at an all-time low of <1,000 fish for the entire Okanagan Lake shore spawning event (Fig. 1). Given the lack of spawners, no biological sampling was attempted.

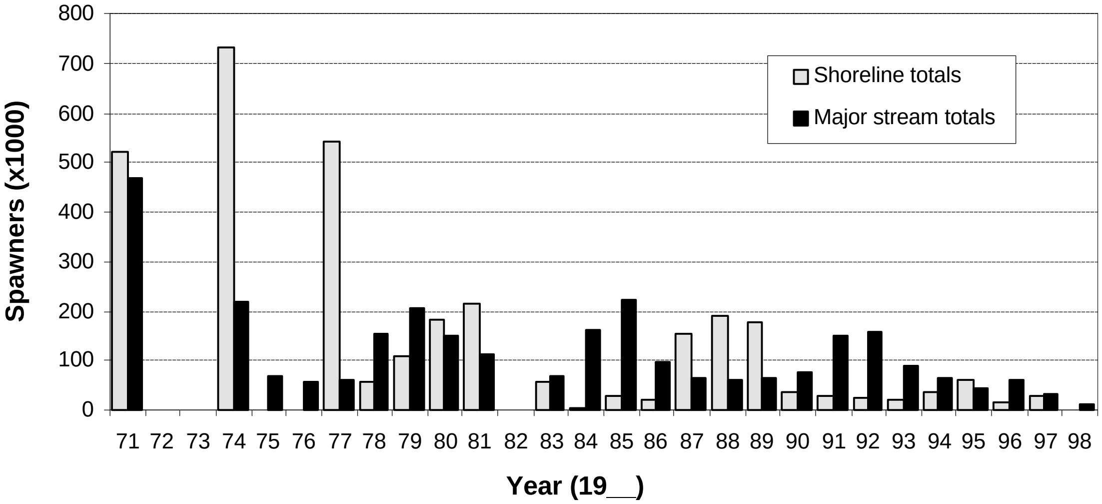

Figure 1. Kokanee Stream Escapement and Indices of Kokanee Shore Spawners.

Stream Spawners

Estimated total escapement to the 13 streams surveyed in 1998 was 12,300. This is a 39% decline from the all time low of 31,000 kokanee in 1997, a far cry from the runs of the 1970s that reached as high as 470,000 kokanee. This decline was reflected in the majority of tributaries, but was most evident in Mission Creek and Powers Creek which have typically supported over 70% of all kokanee stream production. Kokanee numbers in these creeks were down 87% and 74% respectively from 1997, and their combined totals for 1998 represent only 30% of the total stream escapement. Penticton and Vernon creeks were the only monitored streams where an increase in spawner numbers was recorded.

Timing of the spawning peak was earlier than usual in all of the tributaries in 1998 even though water temperatures were high. In addition, run duration was shorter than usual bringing into question the validity of the 1.5 factor for calculating total spawner numbers from the peak count in 1998.

Time series information on stream escapement estimates is invaluable for tracking trends in kokanee populations. Ashley et al. (1997) demonstrated the dramatic decline of Kootenay Lake kokanee stocks and their subsequent recovery due to lake fertilization, using the long time series information available from Meadow Creek. The 1998 counts on Okanagan Lake are valuable even though the numbers are at historical lows.

It should be noted that live stream counts on Kootenay and Arrow lakes are expanded by a factor of 1.5 for total count determination based on several actual fence counts (B. Lindsay, Nelson Fisheries, pers. comm.). Using more intensive sampling and analyses, Dill (1991 to 1993, and 1996, MS; Dill and Larsen 1995, MS; Dill and Reilly 1994, MS; Taylor and Dill 1997, MS) generated independent estimates of the number of spawners using the Mission Creek spawning channel. These researchers determined the expansion factor was 1.5, which is in line with the Kootenay results. Andrusak (1999, MS) has confirmed from Mission Creek data that the conversion factor is 1.5.

Trend indices from annual hydroacoustic and trawl data conducted on Okanagan Lake suggests the current juvenile population is not going to result in increased numbers of spawners in the next 2 to 3 years unless in-lake survival rates improve. Sebastian (*in:* Ashley et al. 1998) discusses these trend data in greater detail elsewhere in this report.

Analysis of 1998 sampling data, including length frequencies and age determination was not available for inclusion in this report. A brief summary of sampling data analysis to 1997 can be found in Ashley et al. (1998).

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TRENDS IN ABUNDANCE OF *MYSIS RELICTA* OVER THE PAST DECADE IN OKANAGAN LAKE; IMPLICATIONS OF SEASONAL VARIATION IN ARMSTRONG ARM

by

Laurie McEachern[1]

INTRODUCTION

In an attempt to improve the kokanee fishery of Okanagan Lake *Mysis relicta* were introduced in 1966 (Shepherd 1990, MS). These macrozooplanktors have since been implicated in the serious decline of kokanee not only in Okanagan Lake (Ashley et al. 1998), but also in Kootenay Lake (Ashley et al. 1997, MS; Lasenby 1991) and elsewhere (Martinez and Bergersen 1991). Mysids are known to be direct competitors with kokanee fry for preferred cladocerans (*Daphnia*) and copepods (*Diaptomus*) (Ashley et al. 1997, MS; Martinez and Bergersen 1991; Richards et al. 1991; Rieman and Meyers 1992).

To understand the role and status of *Mysis relicta* in Okanagan Lake and as part of the Okanagan Lake Action Plan (OLAP), monthly monitoring for *Mysis relicta* was implemented in August 1996 and continues to the present time. This report summarizes mysid abundance data through 1998 and makes some comparisons with previous years information.

The purpose of this report is to examine trends in mysid abundance over the past ten years in Okanagan Lake.

METHODS

From 1989 through 1995, inclusive, *Mysis relicta* were sampled only once per year (with the exception of 1989 where samples were taken in both May and September), around the period of the new moon in late September or early October. Vertical hauls were taken at night using a circular net of 0.96 m diameter and variable mesh size ranging from 1,000 µm to less than 500 µm.

Commencing in August 1996, monthly sampling began with vertical hauls taken at night, around the period of the new moon, using a new 1 m square net with mesh size 1,000 µm at the top, 210 µm in the terminal cone and 438 µm in the collecting bucket.

In order to compare current data with previous years' data it was necessary to determine whether mysid numbers captured by the "old" net were equivalent to numbers captured by the "new" net.

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In other words, it was essential to ensure that any differences in abundance over the years were real and not attributable to differences in performance between the two nets. To this end, a side-by-side comparison of the two nets was carried out on November 11, 1997. Using a boat with a dual-boom, a series of 90-meter vertical hauls were taken at night. Both nets were lowered and raised simultaneously, one on either side of the boat. All mysids were preserved in ethanol. As in previous years, the mysids were separated into three size classes: <10 mm, 10 to 15 mm and >15 mm in length, and counted.

Only current stations which corresponded spatially with past stations were used for this analysis (see Maps 1 and 2).

RESULTS AND DISCUSSION

For purposes of evaluation of the old and new nets, a total of six side-by-side vertical hauls were completed within a three-hour period at an average haul rate of 0.28 m/sec (Table 1).

Table 1. Time, rate and number of mysids captured in side-by-side vertical net hauls conducted November 11, 1997, on Okanagan Lake near Vernon, BC.

			"New" Net				"Old" Net			
Haul No.	Time	Haul Rate (m/sec)	# captured (per haul)				# captured (per haul)			
			<10mm	10-15mm	>15mm	Total	<10mm	10-15mm	>15mm	Total
1	18:00	0.21	26	357	131	514	49	129	58	236
2	18:25	0.24	15	307	129	451	49	82	47	178
3	18:48	0.31	23	201	109	333	49	129	70	248
4	19:06	0.30	38	216	87	341	31	66	52	149
5	19:25	0.30	21	165	108	294	25	101	60	186
6	20:31	0.32	35	206	101	342	58	78	33	169

Numbers captured by the “old” net were converted to number per square meter (Table 2) and the ratio of mysids captured in the “new” net to numbers captured in the “old” net was determined (Table 3).

Table 2. Numbers of mysids captured per square meter in the “new” and “old” nets.

	"New" Net				"Old" Net			
Haul No.	# captured (per square meter)				# captured (per square meter)			
	<10mm	10-15mm	>15mm	Total	<10mm	10-15mm	>15mm	Total
1	26	357	131	514	68	179	81	328
2	15	307	129	451	68	114	65	247
3	23	201	109	333	68	179	97	344
4	38	216	87	341	43	92	72	207
5	21	165	108	294	35	140	83	258
6	35	206	101	342	81	108	46	235

Table 3. Ratio of numbers of mysids captured (“new”/“old”) for each size class.

	Size Class			
Haul No.	**<10mm**	**10-15mm**	**>15mm**	**Total**
1	0.38	1.99	1.62	1.57
2	0.22	2.69	1.98	1.83
3	0.34	1.12	1.12	0.97
4	0.88	2.35	1.21	1.65
5	0.60	1.18	1.30	1.14
7	0.43	1.91	2.20	1.46
Average	0.48	1.87	1.57	1.43

From Table 3, it is evident that there were differences in capture efficiency between the two nets, and that these differences varied among size classes. For the smallest size class (<10 mm), the “new” net captured approximately half as many as the “old” net; for the other two size classes the “new” net captured more than 1.5 times as many as the “old” net. Reasons for these differences are not apparent, although it is possible that variation in bow wave or filtration efficiency might affect the smaller mysids more than the larger ones. This possibility would contradict research of Chipps and Bennett (1996) who found that abundance and length-frequency distributions were similar for both coarse (1,000 µm) and finer meshed (333 µm) nets at haul rates of up to 0.44 m^{-1}. The haul rates for the Okanagan Lake net comparison fell well below that maximum rate (Table 1). However, the nets used by Chipps and Bennett (1996) were of the same material as the “new” mysid net (flat nitex mesh), while the “old” net is of unknown material that is more three-dimensional in nature.

Overall, the “new” net captured 1.43 times as many mysids per square meter as the “old” net. It is this factor which was used to convert numbers captured per square meter in the “old” net for the years 1989 through 1995 (data on file at Penticton office, #40.3902), inclusive, in order to compare the abundance for all years sampled.

Mysid Abundance

Mysids were sampled only once per year from 1990 to 1995, in late September or early October. Of the seven stations sampled from 1996 to 1998, five corresponded spatially to those sampled from 1989 to 1995, inclusive. Data from these stations were summarized and compared with the pre-1996 data.

Average mysid densities ranged from a high of 446 · m^2 in 1989 to a low of 154 · m^2 in 1996 (Fig. 1). While annual fluctuations were evident, there appears to have been a slight decline in mysid abundance over the past ten years (Fig. 1). High variability is not unusual as mysid populations are often characterized by extreme changes in density. For example, the average density of *Mysis relicta* in the North Arm of Kootenay Lake, British Columbia, ranged from around 425 · m^2 in 1978 to over 1,400 · m^2 in 1979 to around 100 · m^2 in 1980 (Ashley et al. 1997).

Actual densities were highest at OK7 (Cameron Point) for eight of the ten years, ranging from 914 · m^2 in 1989 to 245 · m^2 in 1996. Densities were lowest at OK4 (Mission Creek) for six of the eight years for which data is available, ranging from 66 · m^2 in 1994 to 230 · m^2 in 1989 (Fig. 1). Variation in horizontal distribution is also common (Ashley et al. 1997, Lasenby 1991, Beattie and Clancey 1991) and has been attributed to factors such as the stage of maturity of the mysids, basin morphometry, temperature, light conditions, turbidity and prey availability (Lasenby 1991, Beattie and Clancey 1991).

Implications of Seasonal Variation in Armstrong Arm

As depicted in Figure 1 there has been a slight decline in mysid abundance over the last ten years. With such a decline it might be expected that the impact on zooplankton would be abated. Trend in mysid abundance compared to both numbers of kokanee spawners (Shepherd *in:* Ashley et al. 1998) and kokanee abundance (Sebastian and Scholten 1998 *in:* Ashley et al. 1998) from hydroacoustic surveys in Okanagan Lake show remarkable similarity (Fig. 2 and Fig. 3). Therefore, declining kokanee numbers cannot be attributed solely to mysids, as mysid numbers are also declining.

There is little question that mysids can have a significant impact on zooplankton populations. Many lakes where they have been introduced have demonstrated changes in zooplankton abundance, species composition and size distribution. The literature certainly points to decreased zooplankton abundance, including decreased size of some zooplankters and the disappearance of some species altogether, with mysid introductions (Lasenby et al. 1986, Richards et al. 1991, Beattie and Clancey 1991, Martinez and Bergersen 1991, Koksvik et al. 1991, Langeland et al. 1991).

For each of the past three years during October, mysid numbers in Armstrong Arm have dropped dramatically, a trend that is not reflected in the rest of the lake (Fig. 4). This is most likely attributable to a combination of the low oxygen concentrations and warm water temperatures in Armstrong Arm. For example, oxygen concentrations were less than 1 mg·L^{-1} at a depth of 44 m by October of each of the past three years (Fig. 5). Research by Sherman et al. (1987) demonstrated that at 6°C the 16-hour LC$_{50}$ for *Mysis relicta* was 1.0 mg·L^{-1}. Mysids are sensitive to low oxygen concentrations (Sandeman and Lasenby 1981, Lasenby 1971) and are able to detect and avoid areas of low dissolved oxygen concentrations (Sherman et al. 1987). Distributions of mysids have also been found to be limited by gradients of temperature and or light (Nero 1981, Smith 1970) which would restrict them to the deeper water.

A plausible explanation of the Armstrong Arm mysid data is that as the oxygen concentration decreases in the sediments and the hypolimnial water, the mysids are forced higher in the water column where they encounter warmer water temperatures. For example, if the "zone of tolerance" can be defined for *Mysis relicta* as being >1.5 mg·L^{-1} and <10°C (Sherman et al. 1987, Bowles et al. 1991), then Armstrong Arm would probably have been intolerable for mysids by October 1996. Mysids would have been restricted to the 18 to 32 m stratum by October 1997 and the upper 24 m by November 1997. They would have been restricted to the 18 to 36 m stratum by September 1998 and to a narrow 20 to 28 m stratum by October of 1998 (Fig. 6).

Armstrong Arm was ice-covered from December 1996 until May 1997, by which time mysid numbers had increased from 10 · m^{2} in November 1996 to 603 · m^{2} in May 1997; it was ice-covered for January and February of 1998 by which time numbers of mysids had risen from 4 · m^{2} in December 1997 to 90 · m^{2} by March 1998.

Possible hypotheses for the virtual absence of mysids from Armstrong Arm in the fall include unusual mortality and or horizontal migration. The former is unlikely as oxygen in the upper levels of the water column was not at lethal concentrations, but it is possible that as the mysids were forced higher in the water that they would be more susceptible to fish predation (e.g., Bowles et al. 1991). In Lake Granby, Colorado, the mysid population initially remained suspended off the bottom as dissolved oxygen decreased to < 2 mg·L^{-1} at depths > 40 m, then moved horizontally in the reservoir as dissolved oxygen fell below 2 mg·L^{-1} at depths > 20 m (Martinez and Bergersen 1991). The "zone of tolerance" described earlier applies to conditions in the deepest part of Armstrong Arm, but movement to the shallows would not provide a refuge for the mysids. As they moved away from the center of the basin they would quickly encounter higher light conditions and intolerably warm water. The data suggests that virtually all mysids move horizontally out of Armstrong Arm for the fall period.

Regardless of the mechanism responsible for the absence of mysids, the response of the zooplankton community suggests that they may have been controlling cladoceran abundance. While cladoceran densities declined in the rest of the lake during the summer and fall months, densities in Armstrong Arm increased dramatically as the numbers of mysids declined (Fig. 7). In fact, numbers of cladocerans in October 1996 and from October through December 1997 were higher than at any other time of year (Fig. 8). In contrast, the highest densities of cladocerans were present in July and August in the main body of Okanagan Lake for all three years (Fig. 9).

While there are numerous examples of the impacts of mysid introductions on lake zooplankton populations, there are no known examples of lakes where a mysid population, once established, has been eliminated (Northcote 1991). Okanagan Lake may present a unique opportunity to investigate implications of mysid removal as a result of proposed experimental harvest (Ashley et al. 1998).

Assuming that mysid harvesting will increase the available food supply for kokanee, specifically by increasing cladoceran densities, the obvious question is "How many mysids must be removed before there will be an appreciable impact?" The baseline data collected for this report were not designed to address such a question but the data from Armstrong Arm provide some informative insight. Evidently a large percentage decline (probably due to outmigration) in mysid numbers occurred in Armstrong Arm before there was any measurable increase in cladoceran numbers (Table 4.).

Table 4. Percentage change in cladoceran densities following sharp declines in mysid densities in Armstrong Arm (OK 8) compared to changes in the main body (OK1-7) of Okanagan Lake, BC.

		***Mysis* Density** **$(\cdot\ m^{2})$**			**Cladoceran Density (#/L)**								
					Daphnia			***Diaphanosoma***			***Bosmina***		
		Sept.	Oct.	%	Sept.	Oct.	%	Sept.	Oct.	%	Sept.	Oct.	%
1996	OK8	479	46	-90	0.13	0.66	+80	0.1	0.26	+62	0.28	0.14	-50
	OK1-7	201	156	-22	0.32	0.13	-59	0.13	0.04	-69	0.08	0.19	+58
1997	OK8	1079	63	-94	0.04	0.47	+91	0.23	0.17	-26	0.04	0.61	+93
	OK1-7	327	277	-15	0.01	0	-100	0.3	0.16	-47	0.11	0.57	+81
1998	*OK8	432	34	-92	0.01	0.21	+95	0.09	0.08	-11	0.04	0.24	+83
	**OK1-4	192	189	-2	0	0	0	0.06	0.03	-50	0.03	0.03	0

* Mysid density from August sampling as no samples were taken in September 1998.

** No mysid samples taken at OK5, 6 or 7 in September 1998.

Of the three groups of cladocerans, only *Daphnia* were positively affected in all three years. A quick examination of the changes that took place between August and September reveals that although mysid densities decreased by 53% in 1996 and 36% in 1997, *Daphnia* numbers also declined by 7% and 92%, respectively. This emphasizes the point that probably only drastic reductions in mysid numbers would have a positive impact on cladoceran densities.

Based on the data in this report, it is impossible to attribute the changes in the zooplankton community in Armstrong Arm solely to changes in mysid density. Nevertheless, evidence that similar changes did not take place in the main body of Okanagan Lake gives weight to the theory that mysid do exert a strong influence. If this is any indication of the changes that may be effected by means of mysid harvesting, then clearly this practice should be encouraged. However, given the large percentage change in mysid density that seemingly is required for a positive response by the cladoceran population, harvesting alone may not be enough to significantly increase this preferred kokanee food item.

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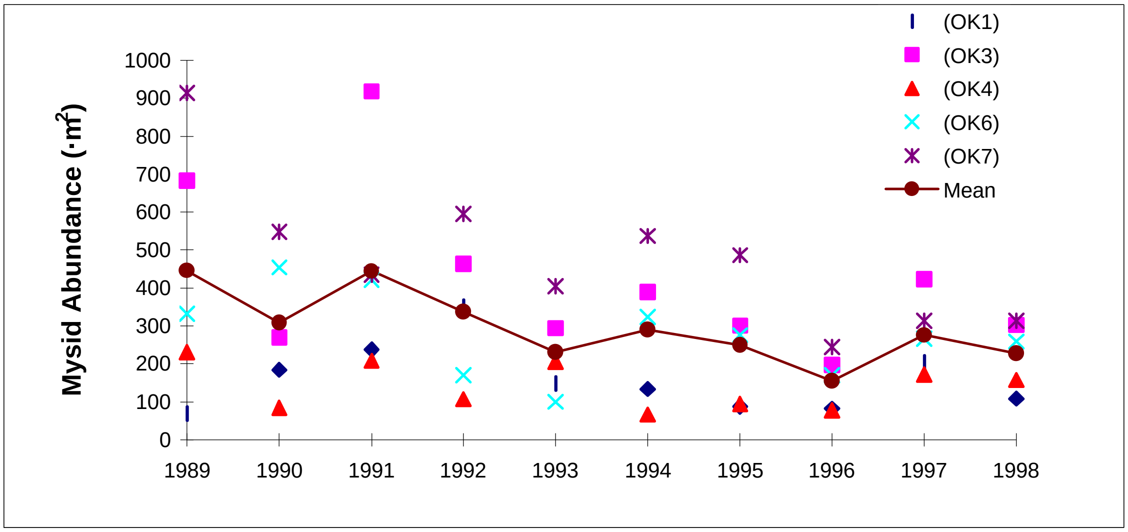


Figure 1. Abundance of *Mysis relicta* in Okanagan Lake from 1989 through 1998 inclusive; vertical hauls from September and October only.

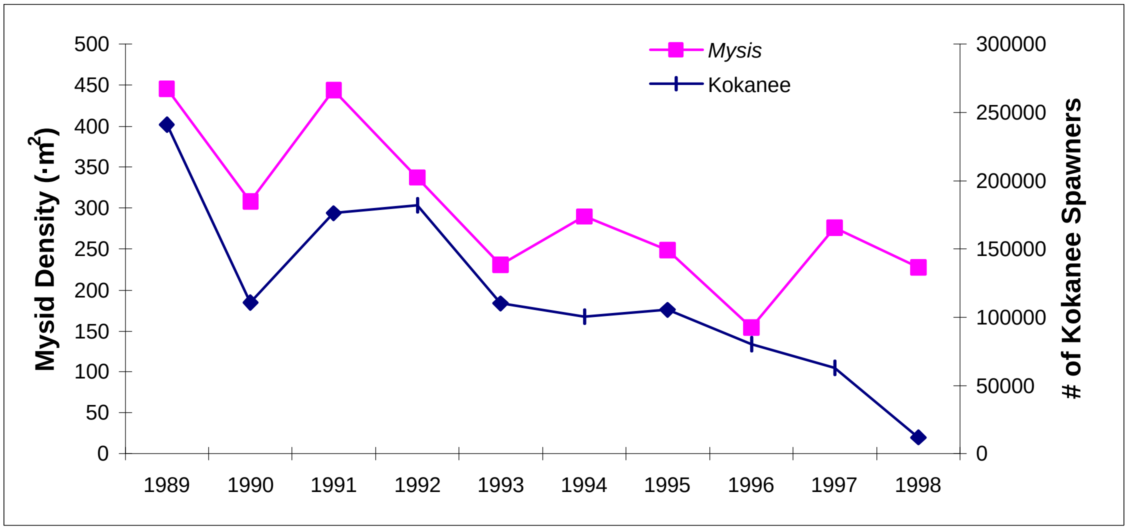


Figure 2. Trends in fall mysid abundance (vertical hauls) compared with trends in numbers of kokanee spawners (fall counts) from 1989 through 1998 inclusive, in Okanagan Lake.

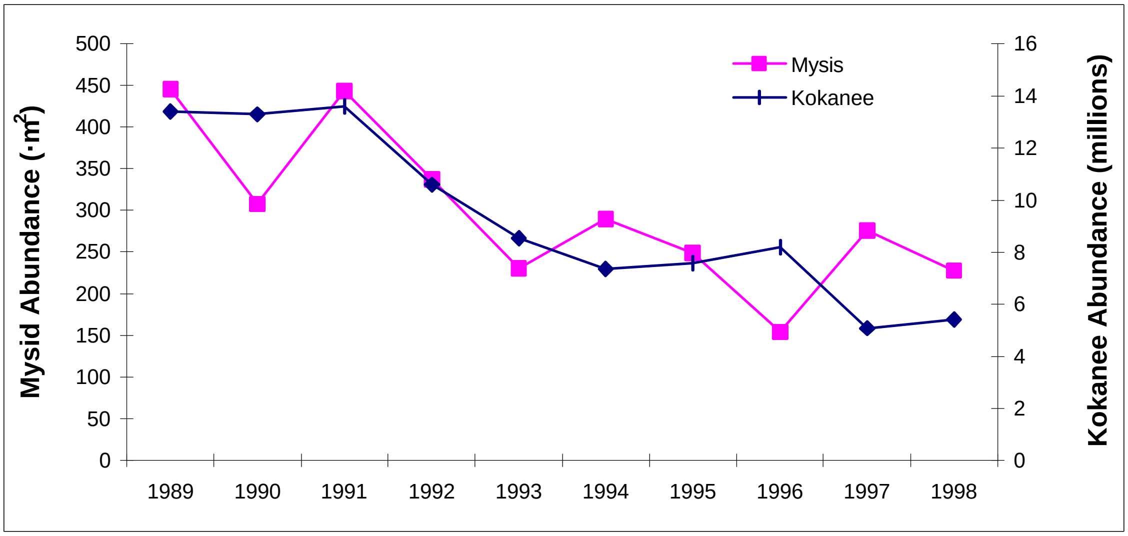


Figure 3. Trends in fall mysid abundance (vertical hauls) compared with trends in kokanee abundance (hydroacoustic surveys) from 1989 through 1998 inclusive, in Okanagan Lake.

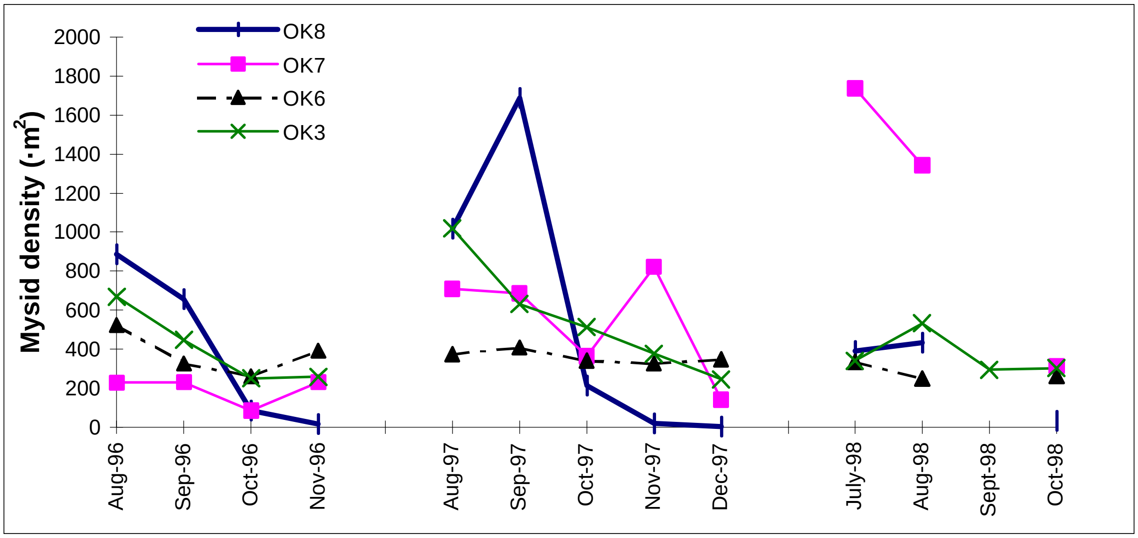
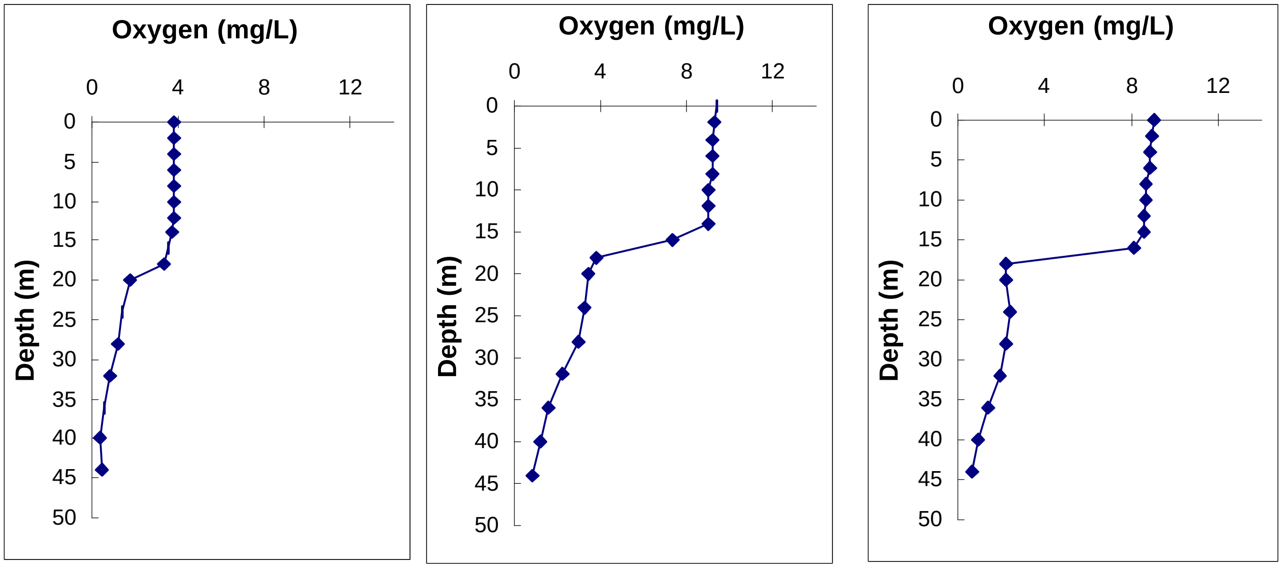


Figure 4. Summer/fall variation in mysid abundance in Armstrong Arm (OK8) compared to variation at three representative sites in the main body of Okanagan Lake.



a. b. c.

Figure 5. October profiles of dissolved oxygen concentration at depth for Okanagan Lake at Armstrong Arm (OK8) in a) 1996, b) 1997 and c) 1998.

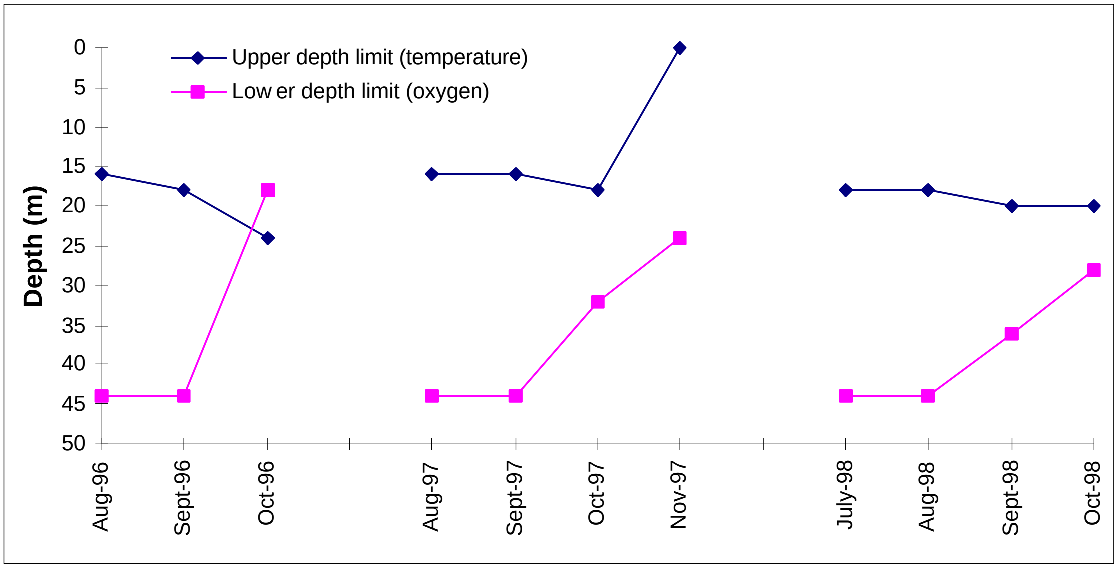


Figure 6. “Zone of tolerance” for *Mysis relicta* as delimited from above by temperature (<10ºC) and below by dissolved oxygen concentration (>1.5 $mg \cdot L^{-1}$).

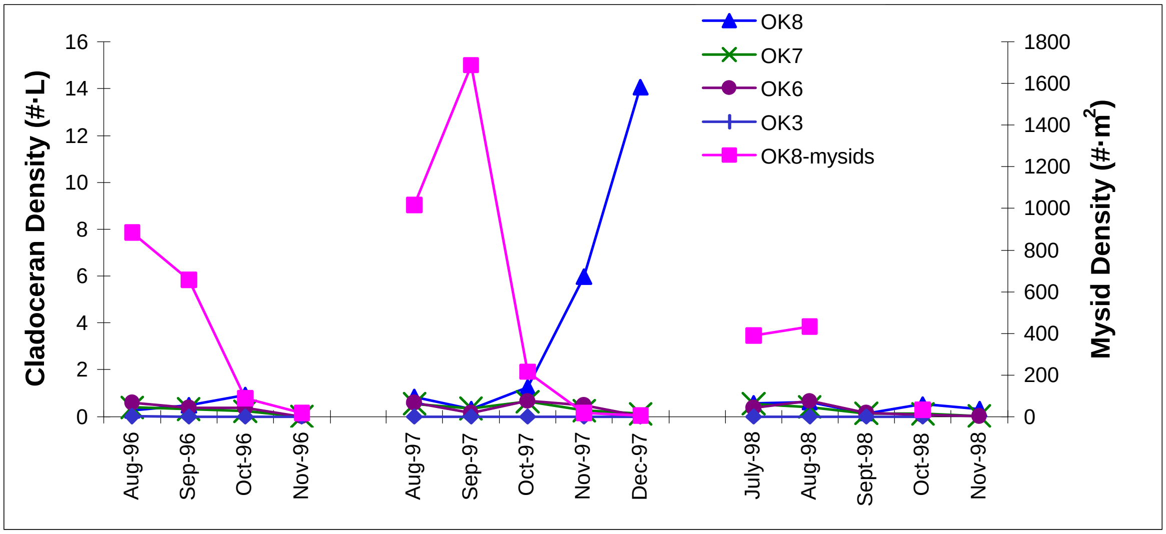


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Figure 7. Summer/fall variations in cladoceran density at three representative sites in the main body of Okanagan Lake (OK3, OK6 and OK7) compared to variations in cladoceran density and mysid density in Armstrong Arm (OK8).

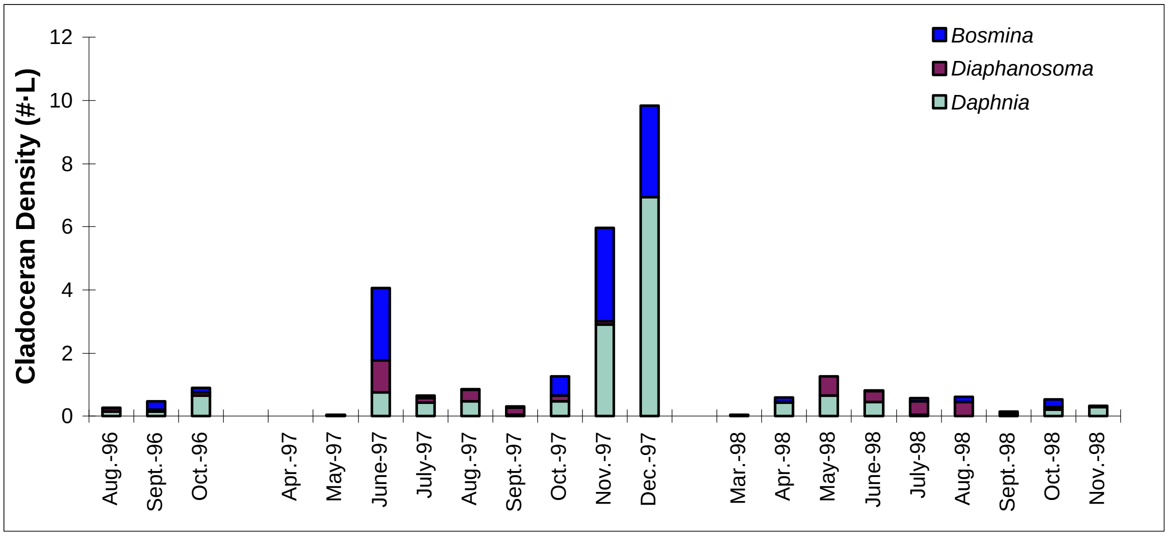

Figure 8. Seasonal variation in density of *Daphnia*, *Diaphanosoma* and *Bosmina* in Okanagan Lake at Armstrong Arm (OK8).

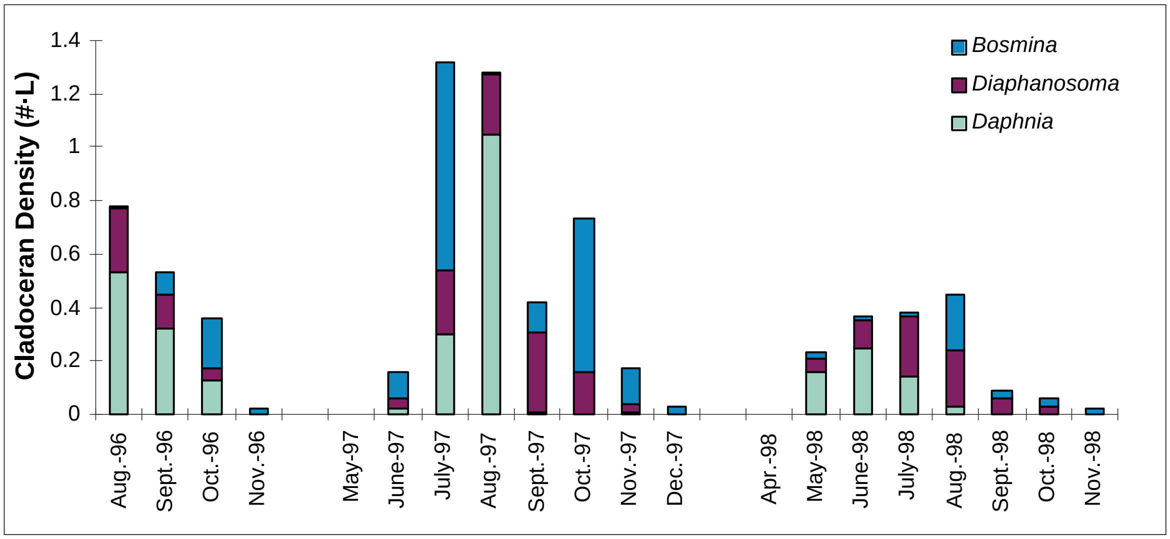

Figure 9. Seasonal variation in density of *Daphnia*, *Diaphanosoma* and *Bosmina* for all sites in Okanagan Lake, excluding Armstrong Arm.

TRENDS IN PHYSICAL AND CHEMICAL LIMNOLOGY - SEASONAL VARIATION IN ZOOPLANKTON COMMUNITIES OF OKANAGAN LAKE AND KALAMALKA LAKE - 1996 THROUGH 1998

by

Laurie McEachern[1]

INTRODUCTION

Dramatically reduced numbers of kokanee (*Oncorhynchus nerka*) in Okanagan Lake during the last two decades has recently led to a multidisciplinary task group being formed to address the problem. Known as the Okanagan Lake Action Plan (OLAP), Ashley and Shepherd (1996) described the background rationale and formation of the working group and Ashley et al. (1998) have reported on the preliminary findings.

The main goal of the OLAP is to “rebuild and maintain the biodiversity of kokanee stocks (and other indigenous fish species) in Okanagan Lake” (Ashley and Shepherd 1996). A major strategy currently under development is that of mysid harvesting; the purpose of this strategy is to reduce the population of *Mysis relicta* in order to decrease the competition with kokanee fry for their common food source, zooplankton (Ashley and Shepherd 1996).

At present there are no known methods of controlling mysid populations (Northcote 1991), but basic measurements of life history parameters and research on pheromones and behavioural cues identified in Ashley et al. (1998) may produce some practical solutions. To aid in this research, baseline limnological sampling began in 1996 and the once-per-year mysid sampling was expanded to a monthly sampling regimen. In 1996, Kalamalka Lake was also added to the sampling program for comparative purposes, as it supports mysids but has a relatively healthy kokanee population. The limnological sampling program has also been expanded to match the mysid sampling schedule.

Limnological data collected in these initial years will provide valuable baseline information for use in planning decisions, and be a major determinant of the direction of the OLAP.

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METHODS

The OLAP limnological sampling stations (Table 1; see Map 2) for mysids, plankton and water chemistry correspond closely to those previously established on Okanagan and Kalamalka lakes. As of April 1998, KA3 and OK2 were dropped from the mysid sampling program; KA1, OK2, OK4 and OK5 were dropped from the monthly limnological sampling (OK4 was sampled in August and November only, after April 1998).

Table 1. Names and depths of sampling sites.

Site Designation[1]	Site Number	Site Name	Maximum Depth (m)
KA1	0500246	Kalamalka Lake South End	80
KA2	0500847	Kalamalka Lake Deep Basin	150
KA3	0500247	Kalamalka Lake Opposite Rattlesnake Point	135
OK1	0500454	Okanagan Lake South Prairie Creek	90
OK2	0500729	Okanagan Lake South Squally Point	115
OK3	E223295	Okanagan Lake Opposite Rattlesnake Island	140
OK4	0500236	Okanagan Lake DNS Kelowna STP	90
OK5	0500456	Okanagan Lake UPS Kelowna STP	146
OK6	0500730	Okanagan Lake N. Ok. Centre	225
OK7	E206611	Okanagan Lake @ Vernon Outfall	90
OK8	0500239	Okanagan Lake Central Armstrong Arm	55

[1] See Map 2.

Physical Limnology

Vertical profiles of temperature and dissolved oxygen were obtained on a monthly basis at the stations on Okanagan and Kalamalka lakes. A YSI Oxygen Meter was used to measure dissolved oxygen and temperature at 2 m intervals from 0-20 m, then at 4 m intervals from 24-44 m, inclusive. Secchi disk transparency was measured at each site.

Water Chemistry

At each site on a monthly basis, a Van Dorn water bottle was used to obtain discrete samples at 45 m and 20 m, and an integrated sample from 1 to 10 m. These samples were placed in coolers with ice, and shipped to Environment Canada Laboratories, Pacific Environmental Science Centre (PESC), North Vancouver, BC, where they were analyzed for major nutrients (nitrogen - ammonia, nitrite, nitrite+nitrate, total; phosphorus - total dissolved, total, and reactive silica). (Data on SEAM file, Penticton Fisheries Office.)

Phytoplankton

At each site on a monthly basis, a Van Dorn water bottle was used to obtain integrated samples at 1 to 10 m depth. Samples to be used for phytotaxonomy were preserved with Lugol’s iodine solution. Selected samples were sent to Fraser Environmental Services, Surrey, BC where dominant species were identified to species and non-dominant species to genus.

Samples to be used for chlorophyll *a* analysis were placed immediately in brown bottles, and placed in coolers with ice. In the Penticton lab, these samples were filtered (at least 500 ml each) with the addition of a couple of drops of $MgCO_3$, sealed in plastic bottles with a small amount of silica gel, and shipped with the water samples in coolers with ice, to PESC for analysis.

Zooplankton

From August 1996 through May 1997, two 45 m vertical hauls were taken at each site using a 0.5 m diameter plankton net of mesh size of 153 μm. Starting in June 1997 and following recommendations of Thompson (*in:* Ashley et al. 1998), this procedure was changed to three 45 m hauls taken at each site. One sample was taken at mid-lake, and the other two at approximately 500 m to each side, east and west, in order to account for possible effects of Langmuir spirals (Appendix 1). The samples were preserved in 70% ethanol; each sample was also back-filtered to eliminate dilution of the preservative.

In the lab, the samples were split using a two-chambered Folsom plankton wheel and counted in a square gridded dish using a dissecting microscope at 10X magnification. Cladocerans and copepods were identified to genus.

Mysids

Mysid samples were collected on a monthly basis, at night, around the period of the new moon. The mysid net used was 1 m square, with mesh size 1,000 μm at the top, 210 μm in the terminal cone and 438 μm in the bucket. From August to October 1996, inclusive, two vertical hauls were taken mid-lake at each sampling station to within two meters of the bottom, and an additional two vertical hauls were taken near shore (either east or west) at a depth of around 40 meters. This procedure was changed in November of 1996 to two replicate hauls mid-lake plus one vertical haul on each of the east and west shores at a depth of around 40 meters. A hydraulic winch was used for all hauls. The speed of the winch was approximately 1 m· 3s. Samples were preserved with 100% denatured alcohol (85% ethanol, 15% methanol) and shipped to Dr. D. Lasenby at Trent University in Peterborough, Ontario for analysis.

This sampling regimen and the equipment used is modeled on the techniques developed for the Kootenay Lake fertilization experiment (Ashley et al. 1997) and will allow comparison of results between these two large lake projects.

RESULTS AND DISCUSSION

Physical Limnology[1]

Okanagan and Kalamalka lakes reached maximum thermal stratification in late July, early August in each of the past three years, with surface temperatures of around 20ºC (Fig. 1). The upper

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[1] Data on file, MELP Penticton Office.

hypolimnion was around 20 m in Okanagan Lake (Fig. 1a-f) and slightly higher in Kalamalka Lake (Fig. 1g-i) at approximately 15 m. Epilimnetic temperatures were highest in 1998, with surface temperatures >25ºC (Fig. 1). Both lakes underwent mixing after late October (Fig. 2) and remained isothermal into April (Fig. 3).

In general, both lakes exhibited orthograde dissolved oxygen profiles typical of oligotrophic lakes in mid-summer (Wetzel 1975), with dissolved oxygen concentrations lowest at the surface and highest in the hypolimnion (Fig. 4). The lower surface concentrations are probably a result of warmer temperatures, as the solubility of oxygen in water decreases with increasing temperature (Wetzel 1975). In contrast, Armstrong Arm (OK8) exhibited a clinograde profile typical of eutrophic lakes (Wetzel 1975), where the hypolimnetic dissolved oxygen concentrations were less than 1 $mg^{.} L^{-1}$ by mid-October (Fig. 5). Armstrong Arm is relatively shallow, with a maximum depth of 54 m, and thus is greatly affected by the oxygen uptake during oxidation of organic matter, which is particularly high at the sediment-water interface (Wetzel 1975).

Secchi disc transparencies in Okanagan Lake were generally lower at the north end sites (OK5-7) than at the south end sites (OK1-4), and lowest in Armstrong Arm (OK8) for all three years (Fig. 6). Water clarity in Kalamalka Lake (KA1-2) was higher than in Armstrong Arm, but secchi disc transparencies were lower than at the north end sites in Okanagan Lake (Fig. 6).

Differences in oxygen levels and water clarity between Armstrong Arm and the other sampling stations is indicative of differing levels of productivity. Armstrong Arm has been categorized as mesotrophic, while Kalamalka Lake and the main basin of Okanagan Lake have been categorized as oligotrophic (Bryan 1990, MS). Indicators of trophic status include levels of the major nutrients (i.e., nitrogen and phosphorus), chlorophyll a concentrations, water clarity and hypolimnetic oxygen depletion (Wetzel 1975).

Water Chemistry

Total nitrogen concentrations in the main body of Okanagan Lake (OK1-4 and OK5-7) remained relatively stable at average concentrations of around 0.20 $mg^{.} L^{-1}$ (Fig. 7). Kalamalka Lake (KA1-2) and Armstrong Arm (OK8) had higher nitrogen concentrations than the main body of Okanagan Lake, but also exhibited greater variability, ranging from around 0.3 $mg^{.} L^{-1}$ to over 0.65 $mg^{.} L^{-1}$ (Fig. 7).

Nitrate nitrogen showed strong seasonal variability (Fig. 8), with the highest levels present in spring when dissolved organic nitrogen is added to the lake through runoff. Epilimnetic concentrations dropped to undetectable levels at all stations by early summer (Fig. 8a) probably due to biological uptake. Both total nitrogen and spring nitrate nitrogen have shown a slight increase over the past 25 years in Okanagan and Kalamalka lakes. However, these levels are still low relative to other oligotrophic lakes with comparable spring phosphorus levels (Jensen 1999, in this report).

Levels of ammonia and nitrite nitrogen were extremely low to undetectable over the three-year sampling period (data on file Penticton Fisheries Branch).

Concentrations of both total phosphorus TP (Fig. 9) and total dissolved phosphorus TDP (Fig. 10) displayed seasonal variability over the sampling period. Spring phosphorus levels were highest in Armstrong Arm (OK8, Fig. 9), a trend that has been consistent over the past 25 years (Jensen 1999 in this report). Year-to-year variation was also evident, as phosphorus levels (both TP and TDP) were lower in 1998 than either 1997 or 1996 (Figs. 9, 10). Such variation is not uncommon, as there is increased phosphorus loading from the watershed during years of higher runoff (Jensen 1999, in this report).

Algae and aquatic macrophytes require both nitrogen (N) and phosphorus (P) for growth, and lake productivity is often limited by the relative availability of these nutrients (Wetzel 1975). An N:P ratio of $\leq$10 is indicative of nitrogen limitation, a ratio of $\geq$17 is indicative of phosphorus limitation and an N:P ratio between 10 and 17 is generally indicative of no limiting nutrients (Smith 1982). Ratios of N:P calculated for both Okanagan and Kalamalka lakes in spring, summer and fall indicate phosphorus limitation (Fig. 11). Only Armstrong Arm (OK8) appears to have no nutrient limitations for 1996 and 1997, but phosphorus limitation in 1998 (Fig. 11).

Although TN:TP ratios did not indicate nitrogen limitation, the fact that nitrate nitrogen (the biologically available form of nitrogen) drops to undetectable levels in the summer (Fig. 8) suggests that these lakes are most likely nitrogen-limited as well, at least for part of the year.

Concentrations of reactive silica showed little variation in the main body of Okanagan Lake (OK1-4 and OK5-7) ranging from around 5 $mg \cdot L^{-1}$ to $7 mg \cdot L^{-1}$ (Fig. 12). In contrast, reactive silica in Kalamalka Lake (KA1-2) ranged from greater than 7.5 $mg \cdot L^{-1}$ in the spring to less than 5 $mg \cdot L^{-1}$ in the summer (Fig. 12). Levels in Armstrong Arm (OK8) tended to be higher than at the other sites (Fig. 12). Silica is critical for the growth of diatomaceous algae and can be another limiting factor in lake productivity (Wetzel 1975). However, the relatively high levels in both lakes indicate that silica limitation is unlikely.

Chlorophyll *a* levels were relatively stable throughout the 1996 and 1997 sampling periods, with the highest concentrations found in Armstrong Arm (OK8, Fig. 13). In 1998 however, levels fluctuated widely, with peaks occurring in March (8 $\mu g \cdot L^{-1}$ at OK5-7) and August (13 $\mu g \cdot L^{-1}$ at OK8); the lowest levels occurred in November in the southern part of Okanagan Lake (OK1-4) where concentrations were less than 0.4 $\mu g \cdot L^{-1}$ (Fig. 13).

Zooplankton

Distribution and abundance

Over the three year sampling period, the average annual densities of zooplankton (cladocerans and copepods) ranged from a low of 1.19 $individuals \cdot L^{-1}$ in the main basin of Okanagan Lake (OK1-7) in 1998, to a high of 6.82 $individuals \cdot L^{-1}$ in Armstrong Arm (OK8) in 1997 (Table 4). Average annual densities were lowest in 1998 for both lakes (Table 4). With average annual densities <3 $individuals \cdot L^{-1}$ in both Kalamalka Lake and the main basin of Okanagan Lake, they appear to be unproductive compared to the Arrow Lakes with 7 individuals·L^{-1} in 1997 (Pieters et al. 1999) and Kootenay Lake with 19 individuals·L^{-1} in 1997 (Ashley et al. 1997).

Peak densities usually occurred in July in 1997 and 1998 (no samples available for July 1996) and ranged from a low of 7.75 individuals·L^{-1} in the main basin of Okanagan Lake (OK1-7) in 1998 to a high of 85.2 individuals·L^{-1} in Armstrong Arm (OK8) in 1997 (Table2).

Table 2. Average and peak densities of zooplankton in the main basin of Okanagan Lake (OK1-7), Armstrong Arm (OK8) and Kalamalka Lake (KA1-3) over the three-year sampling period.

	Okanagan Lake (OK1-7)			**Armstrong Arm (OK8)**			**Kalamalka Lake (KA1-3)**		
	Density	**Peak**		**Density**	**Peak**		**Density**	**Peak**	
	Ave. (#/L)	Peak (#/L)	Month	Ave. (#/L)	Peak (#/L)	Month	Ave. (#/L)	Peak (#/L)	Month
1996*	2.77	15.63	Aug.	4.73	31.69	Aug.	2.16	12.73	Oct.
1997	2.43	23.09	July	6.82	85.20	July	2.16	19.07	July
1998	1.19	7.75	July	2.09	17.58	May	1.33	11.15	July

* samples from Aug. through Oct. (OK1-4, OK8 and KA1-2) and Aug. through Nov. (OK5-7) only.

From August 1996 through November 1998, copepods (*Diaptomus*, *Cyclops* and *Epischura*) were the dominant zooplankters in both Okanagan and Kalamalka lakes, at all stations and for all dates (Fig. 14a-c). Copepods constituted 97% (by number) of the zooplankton in the main basin of Okanagan Lake for all three years, ranged from 93% to 98% in Armstrong Arm and from 92% to 96% in Kalamalka Lake.

Except for the months of February, March and April when calanoid copepods (primarily *Diaptomus*) were more abundant, cyclopoid copepods (i.e., *Cyclops*) were the dominant zooplankter in both Okanagan Lake (Fig. 14a-b) and Kalamalka Lake (Fig. 14c). The switch in dominance between calanoids and cyclopoids may be a function of their changing food supply. Calanoids are herbivorous filter feeders while cyclopoids are carnivorous, preying on microcrustaceans, dipteran larvae and oligochaetes (Wetzel 1975). Some phytoplankton growth as measured by chlorophyll *a* concentrations was evident from February to April (Fig. 13) while cladocerans were not present in the zooplankton during those months (Fig. 14a-c).

Trends in cladoceran (*Daphnia*, *Diaphanosoma* and *Bosmina*) abundance in the main body of Okanagan Lake (Fig. 15a) and in Armstrong Arm (Fig. 15b) mirrored overall zooplankton abundance in that densities were highest in 1997 and lowest in 1998. Cladoceran abundance in Kalamalka Lake in 1998 was only slightly less than in 1996 and 1997 (Fig. 15c). Cladocerans constituted only 3% (by number) of the zooplankton in the main body of Okanagan Lake (OK1-7) for all three years, ranged from 2 to 7% in Armstrong Arm (OK8) and from 4 to 8% in Kalamalka Lake (KA1-3). Again, these values are low in comparison to the Arrow Lakes with 21% cladocerans in 1997 (Pieters et al. 1999) and with Kootenay Lake at an average of over 8% cladocerans over the past six years (Ashley et al. 1997).

Daphnia were detectable in the main basin of Okanagan Lake (OK1-7) from August to October of 1996 at densities of < 0.60 individuals·L^{-1}, from June to September in 1997 with a peak density of 1.05 individuals·L^{-1} in August and from May to August in 1998 with densities of <0.30 individuals·L^{-1} (Fig. 15a). In Armstrong Arm (OK8) *Daphnia* were detectable from August to October of 1996 with a peak density of 0.66 individuals·L^{-1} in October, from June to December of 1997 with a peak density of 6.95 individuals·L^{-1} in December and from April to June and October to November in 1998 with a peak density of 0.66 individuals·L^{-1} in May (Fig. 15b). *Daphnia* were detectable in Kalamalka Lake (KA1-3) from August to October of 1996 at densities <0.15 individuals·L^{-1} , from June to September of 1997 with a peak density of 0.77 individuals·L^{-1} in July, and from May to July of 1998 with densities of <0.25 individuals·L^{-1} (Fig. 15c).

The cladoceran populations in Okanagan and Kalamalka lakes were mainly comprised of *Daphnia, Diaphanosoma* and *Bosmina*. Also occasionally present in the samples, but in numbers too low for enumeration purposes, was the cladoceran *Leptodora kindtii*. It is interesting to note that although *Leptodora* was observed in mid-summer samples in 1996 and 1997, none were captured in the net hauls in 1998 (Data on file Penticton Fisheries Branch). As well, none were captured in the net hauls in Kalamalka Lake during the sampling period, although *Leptodora* were present in 1951 and 1971 as noted in the Okanagan Basin Agreement studies (data on file Penticton Fisheries Branch office).

Historical comparison

Okanagan and Kalamalka lakes have been sampled on a regular basis for zooplankton, but only in early spring and late fall when cladoceran numbers were reduced or absent altogether (Fig. 14a-c). Occasionally samples were taken in late August or early September and these have been used for comparison. Based solely on % cladocerans, Okanagan Lake had the highest % (by number) cladocerans from 1978 through 1980 (Fig. 16). Interestingly, percentages from 1996 through 1998 were higher than percentages from 1971 and higher than percentages observed in the early 1990s (Fig. 16).

Based on actual densities, and again using only late August or early September samples for comparison, the 1998 zooplankton density in Okanagan Lake was the lowest on record (Fig. 17a). The highest densities occurred in the late 1970s (Fig. 17a). In Armstrong Arm (Fig. 17b) and Kalamalka Lake (Fig. 17c), the 1998 densities were also low, but densities in 1996 and 1997 were similar to those in 1979 and 1980. Actual densities of *Daphnia* were highly variable, ranging from a low of 0 individuals·L^{-1} in 1991 and 1992 to a high of 1.21 individuals·L^{-1} in 1980 (Table 3).

Table 3. Average density of *Daphnia* in Okanagan Lake from 1969 through 1998 (late August or early September samples only).

Daphnia Density (#/L)									
1969	1971	1979	1980	1991	1992	1993	1996	1997	1998
0.42	0.48	0.46	1.21	0	0	0.39	0.53	1.05	0.03

Overall, there does not appear to have been any dramatic change in zooplankton density over the past 27 years.

ACKNOWLEDGEMENTS

This project would not have been possible without funding from the British Columbia Conservation Foundation. Thanks to all those people at the Ministry of Environment, Lands and Parks, Penticton, for their support, and especially to Vic Jensen for his patience and invaluable advice concerning the chemical limnology. Thanks also to Lisa Thompson and the other knowledgeable people for their input regarding the zooplankton sampling methods and analysis. And finally, my special thanks to Graham Young and Nick Ipatowicz for their invaluable assistance in the field under frequently adverse conditions.

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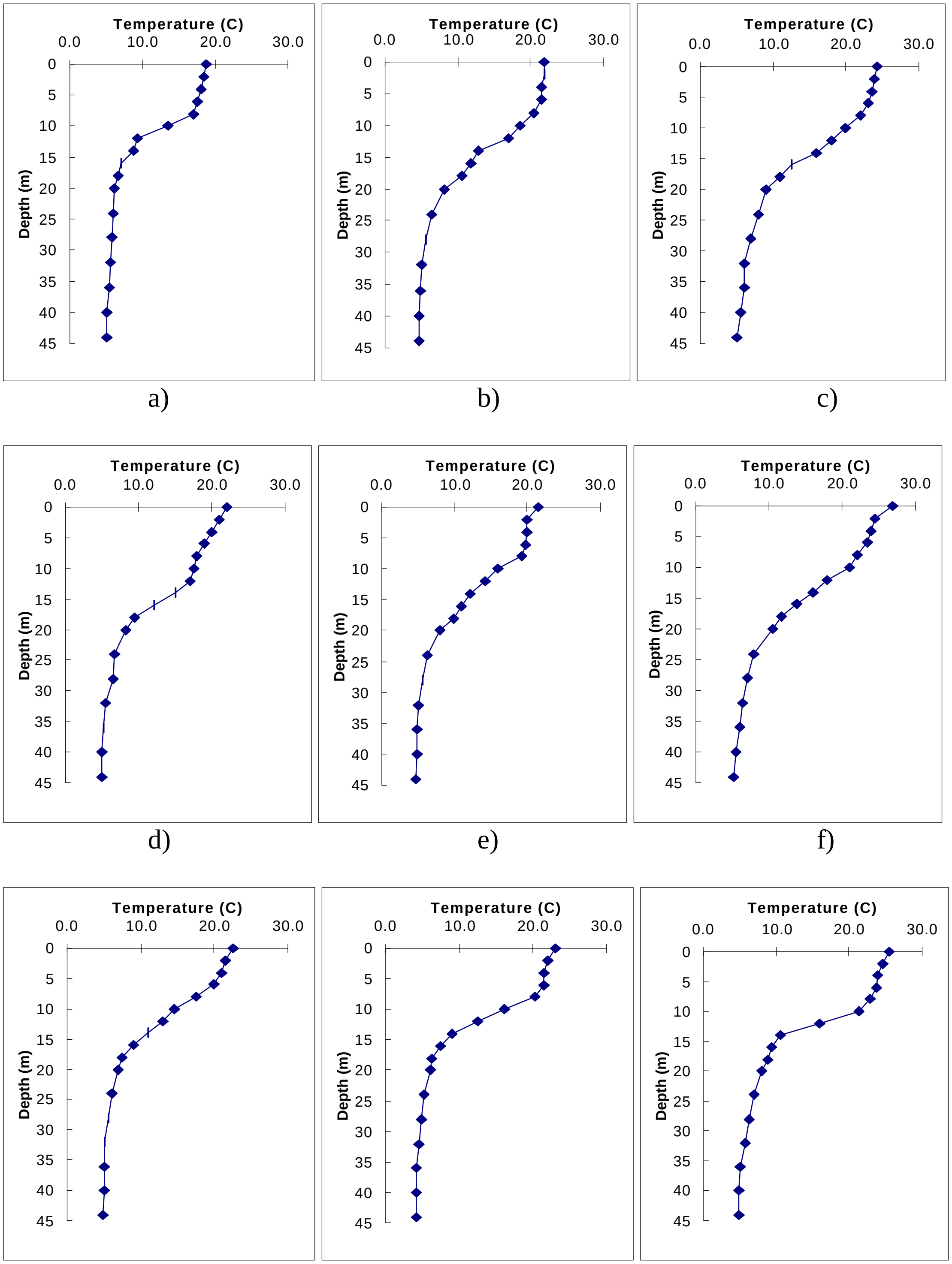
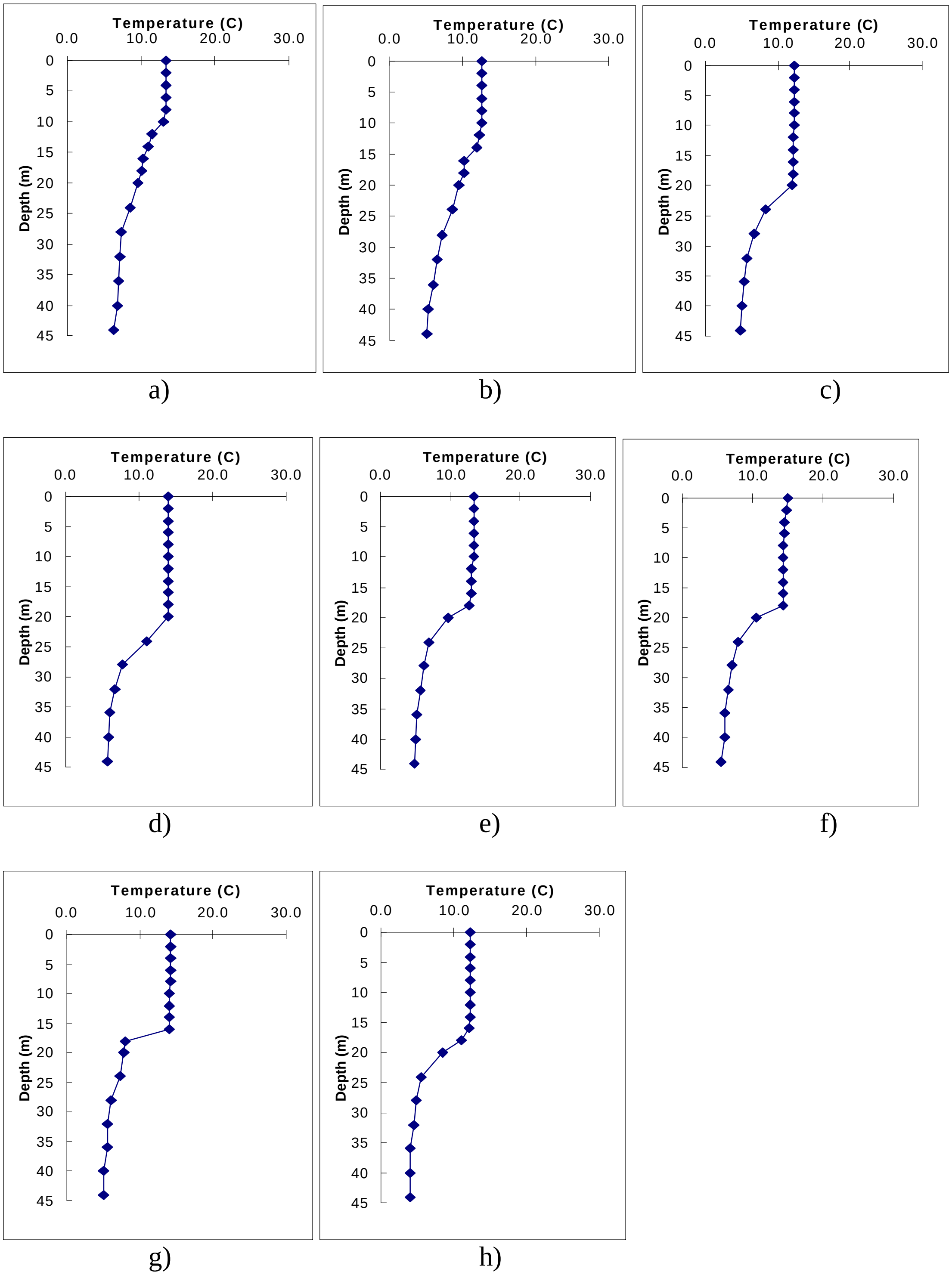


a) b) c)

d) e) f)

g) h) i)

Figure 1. Summer temperature profiles at OK3 in a) 1996, b) 1997 and c) 1998; at OK6 in d) 1996, e) 1997 and f) 1998; and at KA2 in g) 1996, h) 1997 and i) 1998.

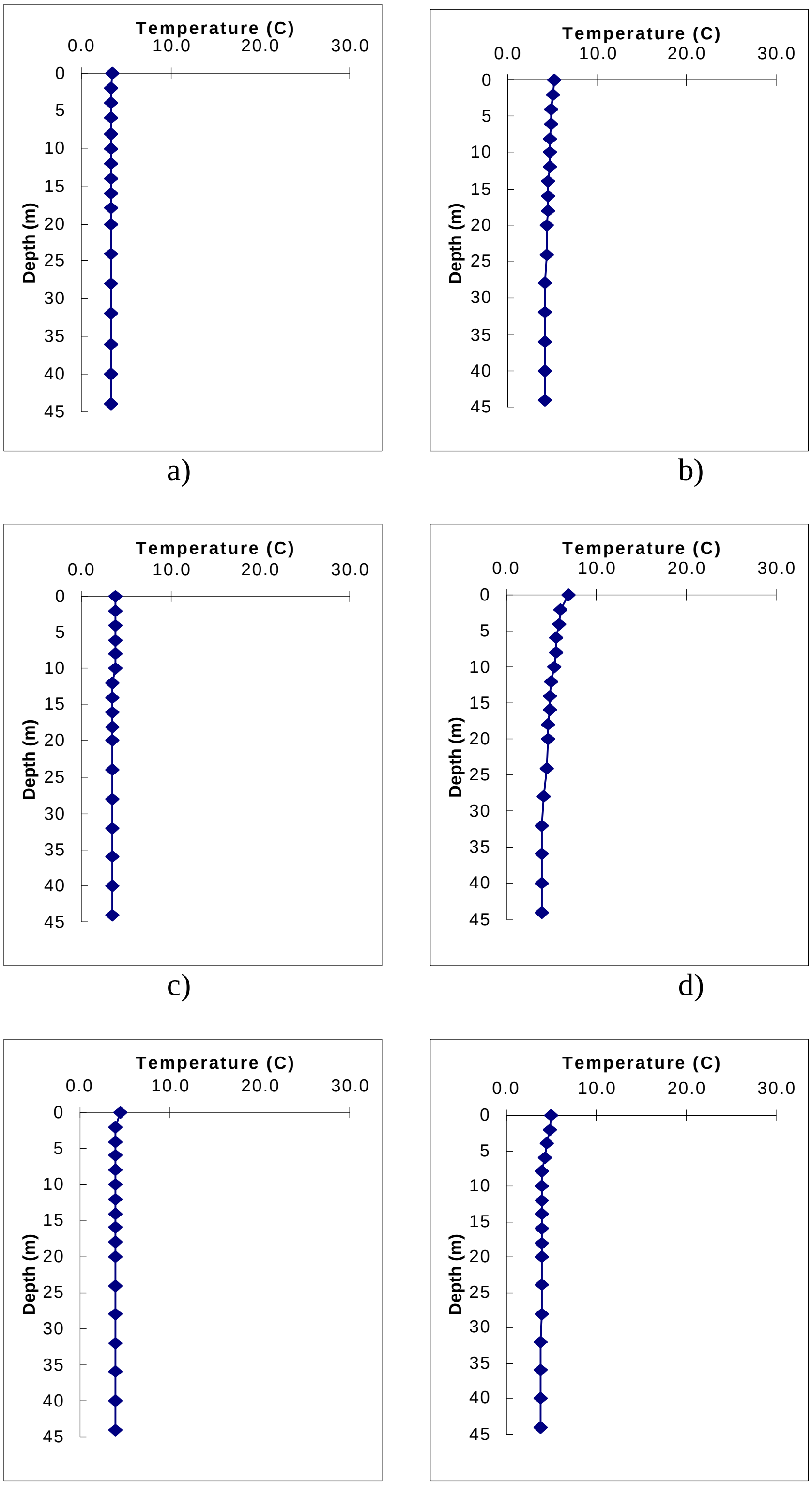


a) b) c)

d) e) f)

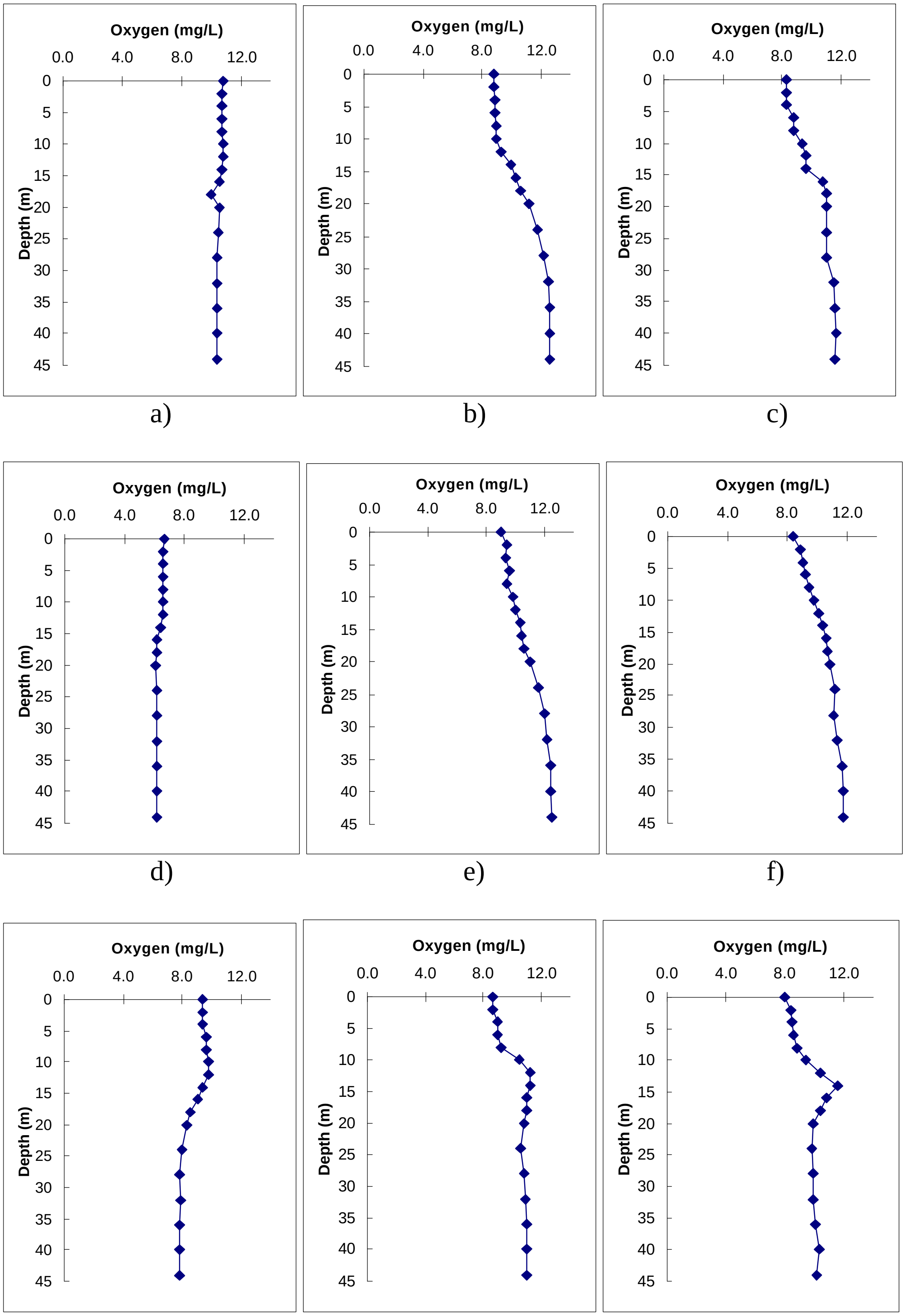
g) h)

Figure 2. Fall temperature profiles at OK3 in a) 1996, b) 1997 and c) 1998; at OK6 in d) 1996, e) 1997 and f) 1998; and at KA2 in g) 1996 and h) 1997.



a) b) c) d) e) f)

Figure 3. Spring temperature profiles at OK3 in a) 1997 and b) 1998; at OK6 in c) 1997 and d) 1998; and at KA2 in e) 1997 and f) 1998.



a) b) c)

d) e) f)

g) h) i)

Figure 4. Summer oxygen profiles at OK3 in a) 1996, b) 1997 and c) 1998; at OK6 in d) 1996, e) 1997 and f) 1998 and at KA2 in g) 1996, h) 1997 and i) 1998.

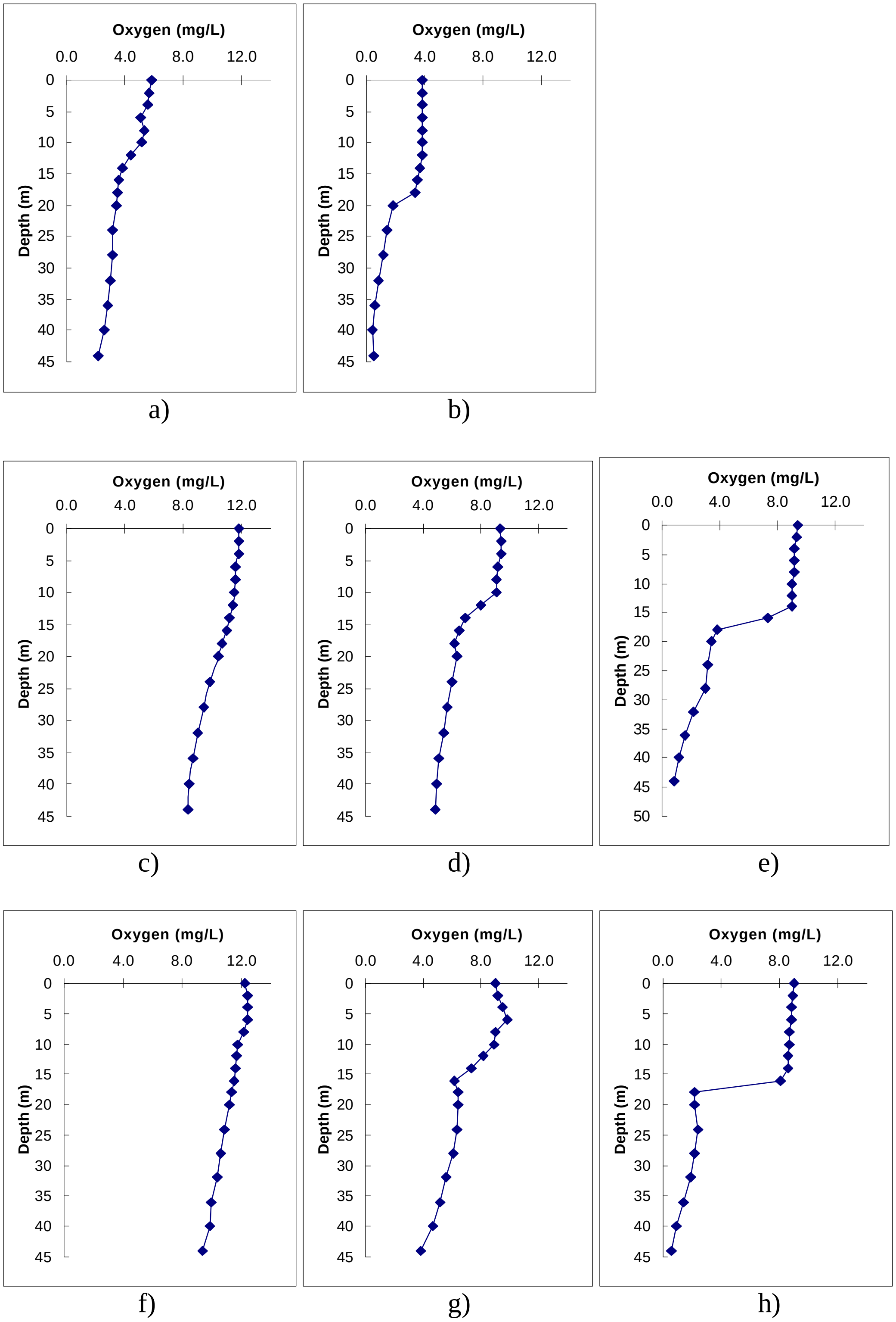


Figure 5. Oxygen profiles at OK8 in a) July 1996, b) October 1996, c) April 1997 d) August 1997, e) October 1997, f) April 1998, g) July 1998 and h) October 1998.

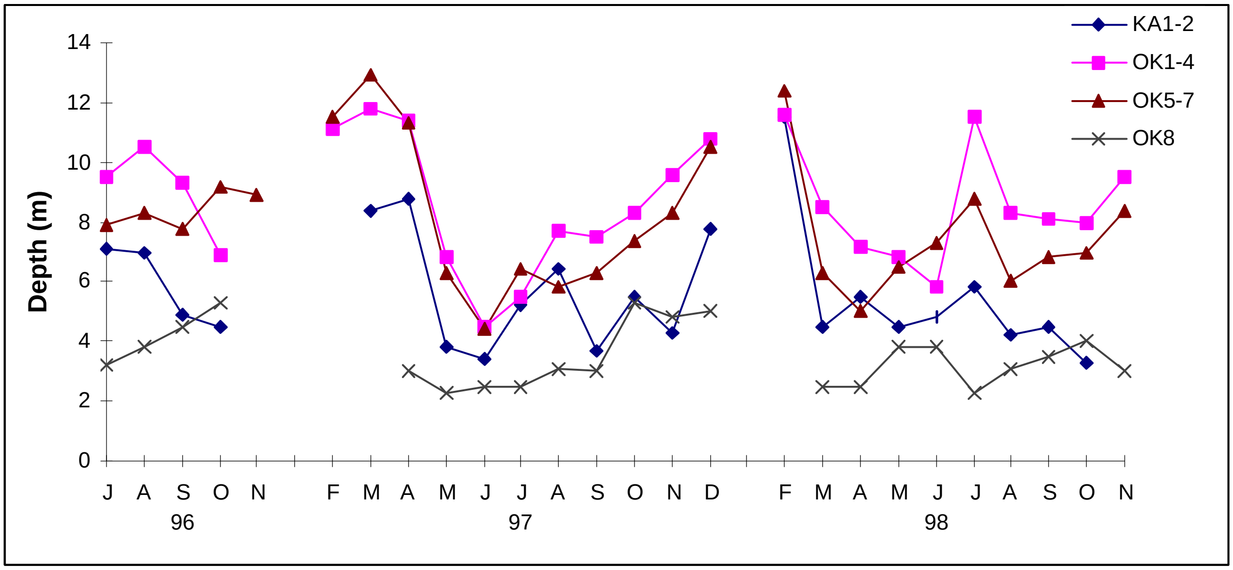
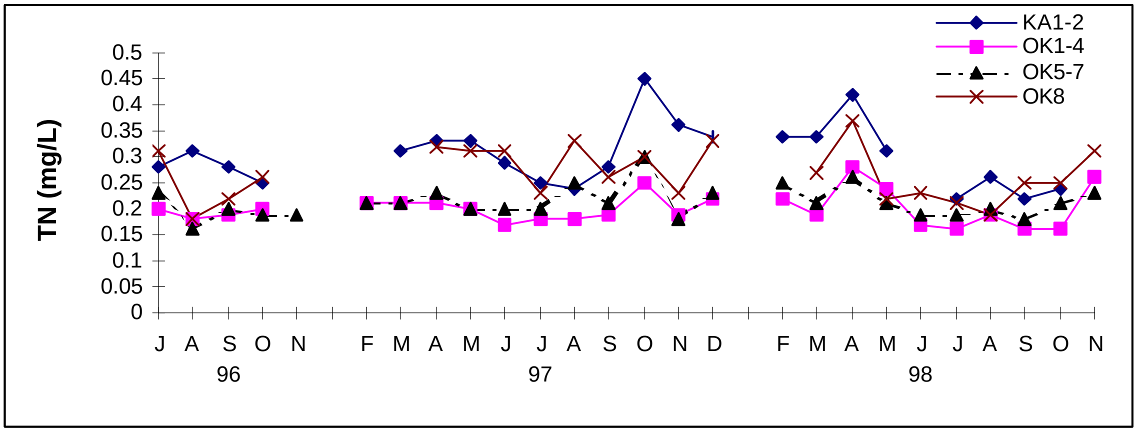


Figure 6. Secchi disk transparencies in Okanagan Lake at the south end sites (OK1-4), the north end sites (OK5-7), in Armstrong Arm (OK8) and in Kalamalka Lake (KA1-2).



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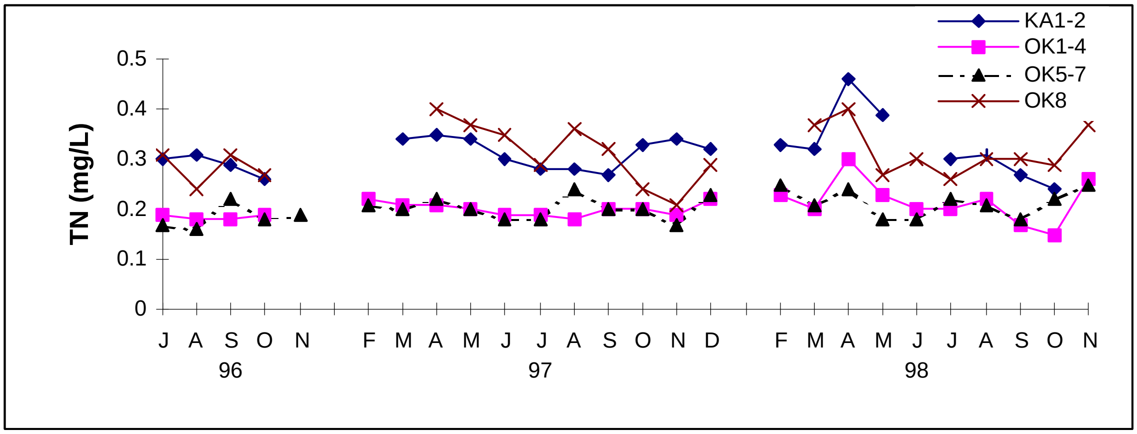

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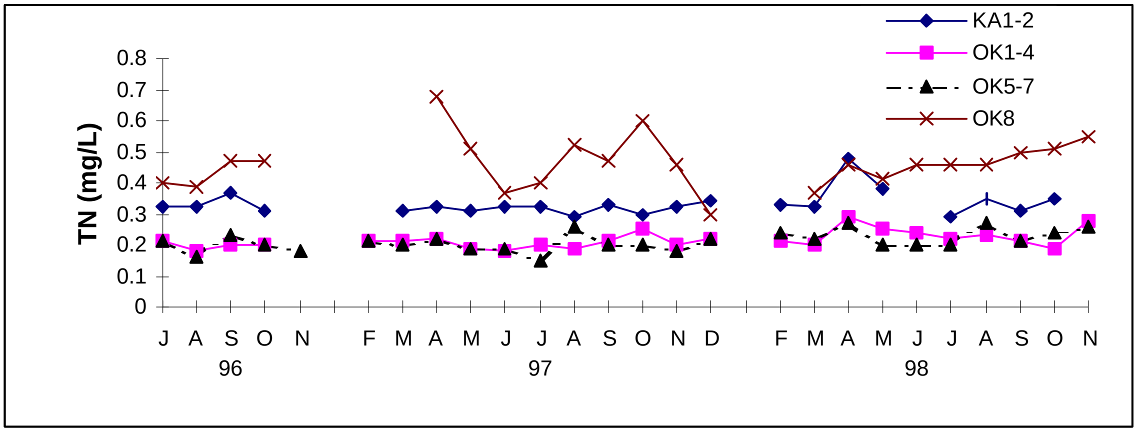
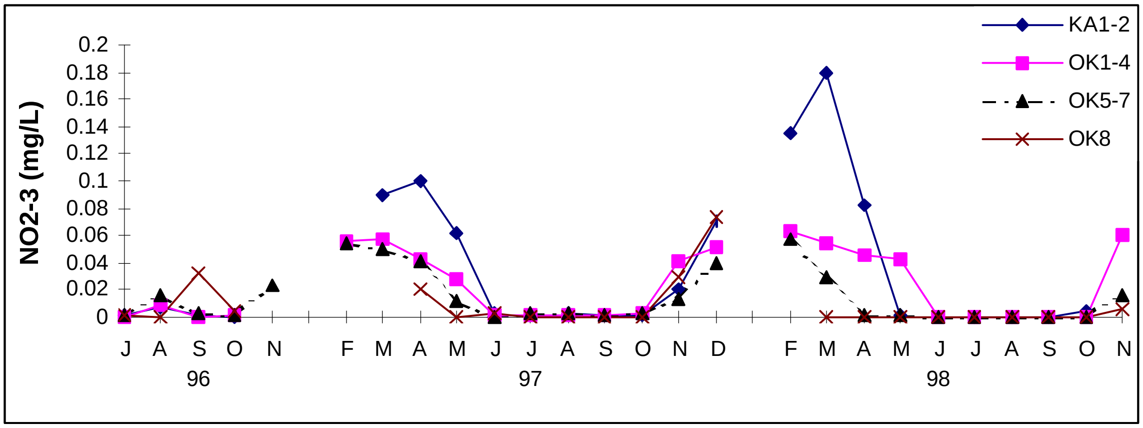


c)

Figure 7. Concentrations of total nitrogen (TN) in Okanagan Lake at the south end sites (OK1-4), the north end sites (OK5-7), Armstrong Arm (OK8) and in Kalamalka Lake (KA1-2) in a) 1-10 m, at b) 20 m and at c) 45 m.



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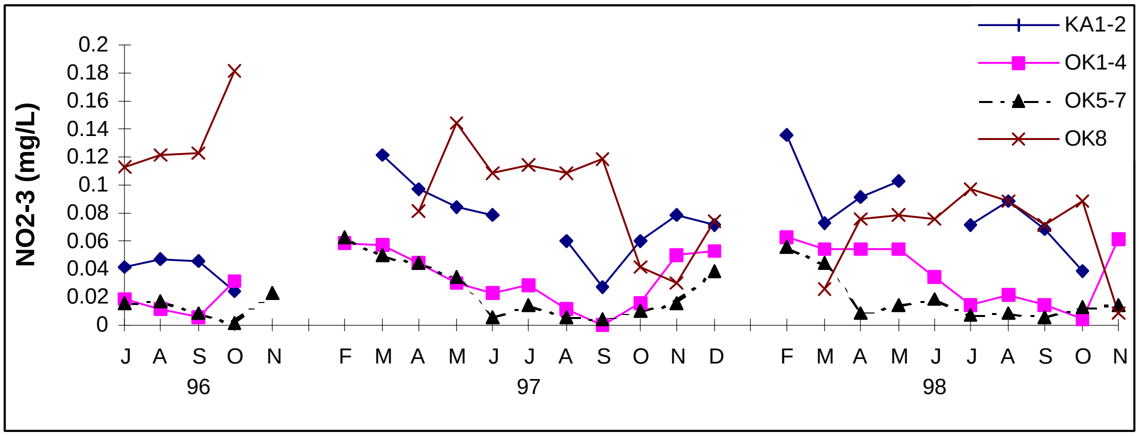

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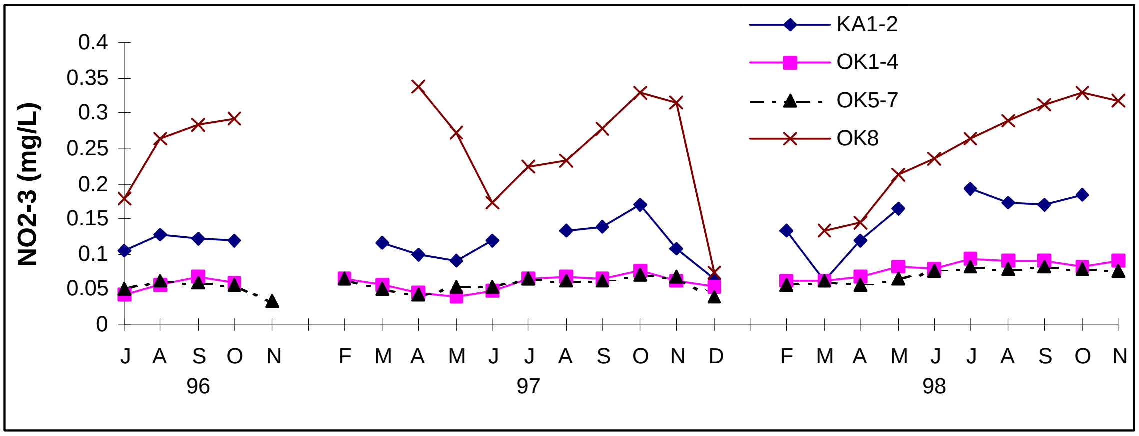
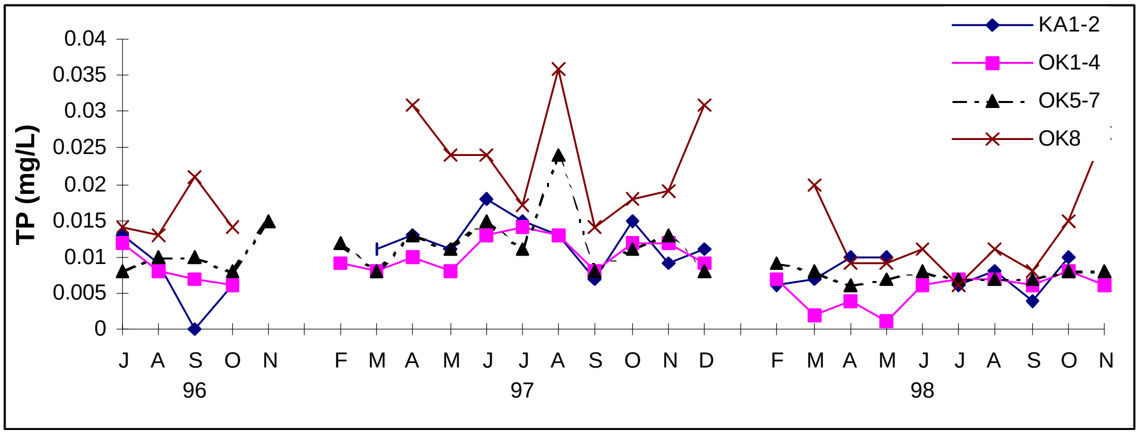


c)

Figure 8. Concentrations of nitrite+nitrate nitrogen (NO2-3) in Okanagan Lake at the south end sites (OK1-4), the north end sites (OK5-7), Armstrong Arm (OK8) and in Kalamalka Lake (KA1-2) in a) 1-10 m, at b) 20 m and at c) 45 m.



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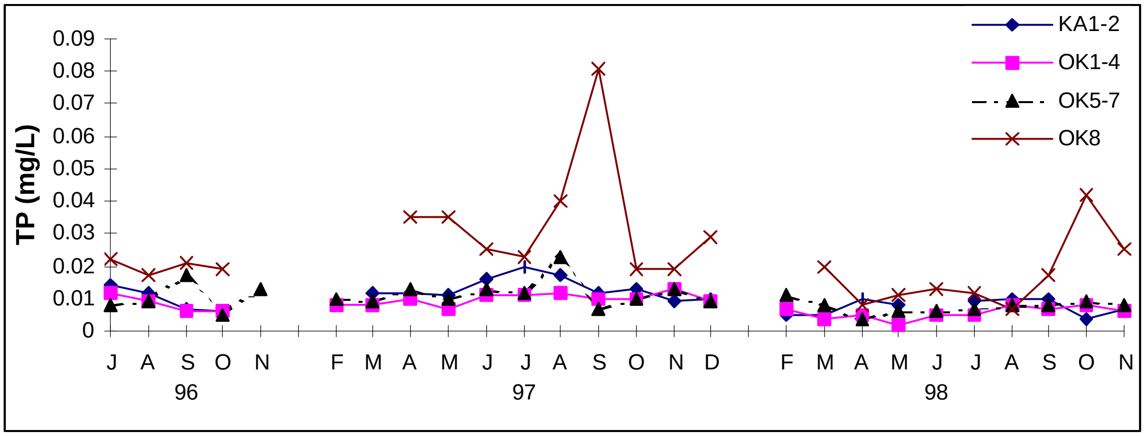

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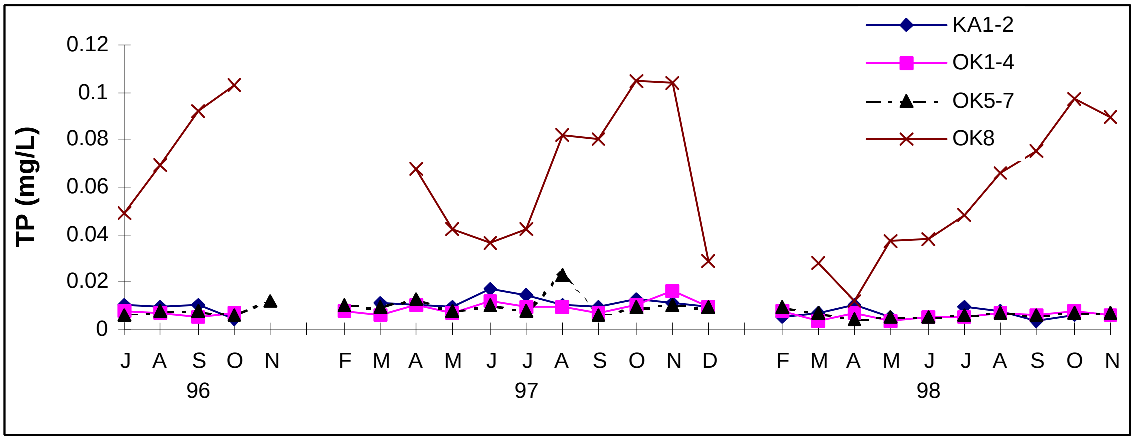
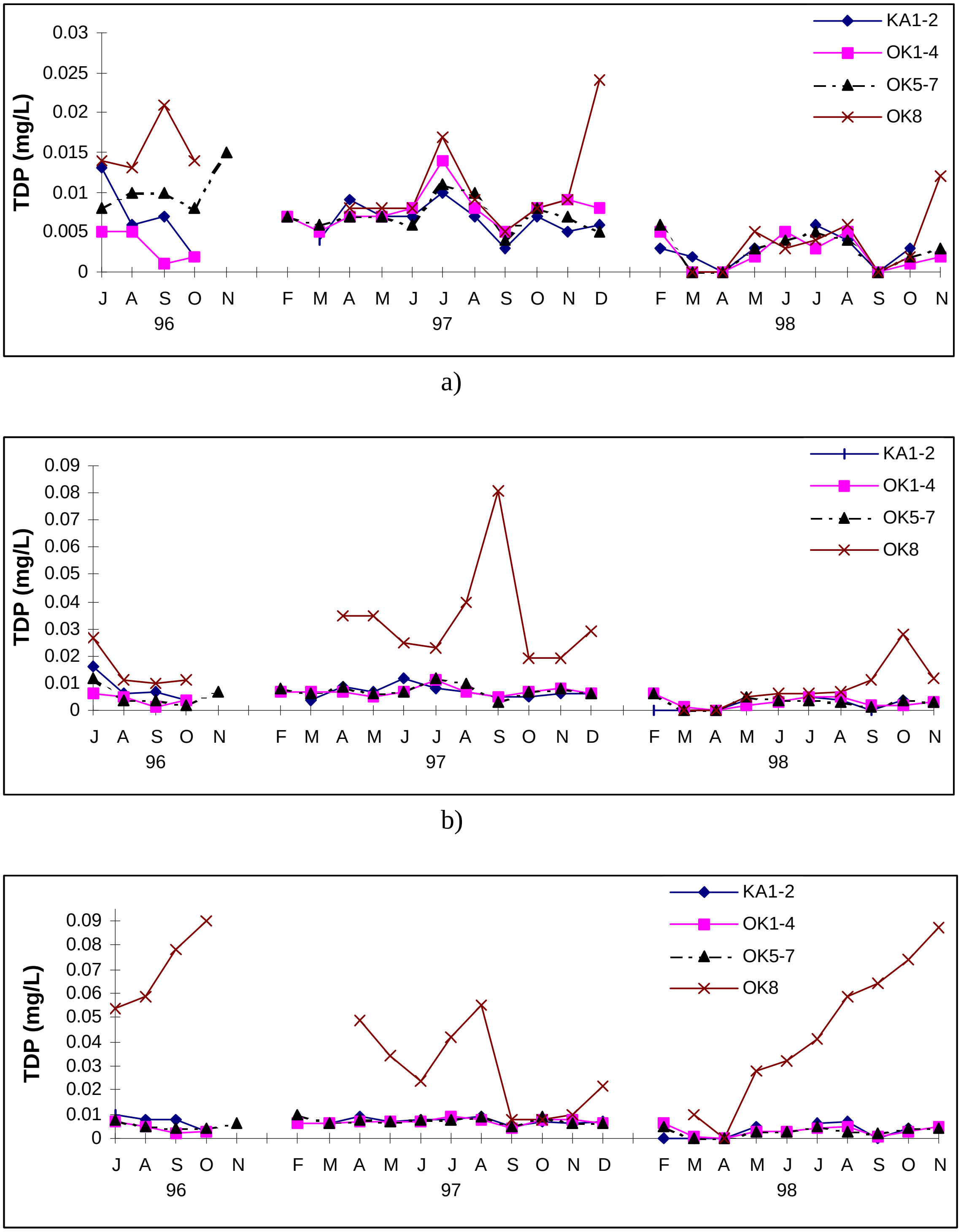


c)

Figure 9. Concentrations of total phosphorus (TP) in Okanagan Lake at the south end sites (OK1-4), the north end sites (OK5-7), Armstrong Arm (OK8) and in Kalamalka Lake (KA1-2) in a) 1- 10 m, at b) 20 m and at c) 45 m.



a)

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Figure 10. Concentrations of total dissolved phosphorus (TDP) in Okanagan Lake at the south end sites (OK1-4), the north end sites (OK5-7), Armstrong Arm (OK8) and in Kalamalka Lake (KA1-2) in a) 1- 10 m, at b) 20 m and at c) 45 m.

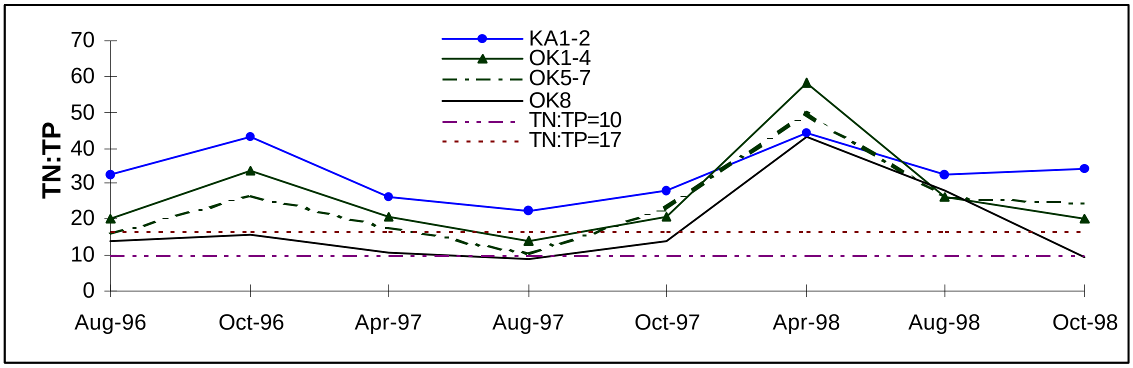


Figure 11. Ratios of total nitrogen to total phosphorus (TN:TP) on selected dates in Okanagan Lake at the south end sites (OK1-4), at the north end sites (OK5-7), Armstrong Arm (OK8) and in Kalamalka Lake (KA1-2). Ratios greater than 17 indicate phosphorus limitation; ratios less than 10 indicate nitrogen limitation (Smith 1982).

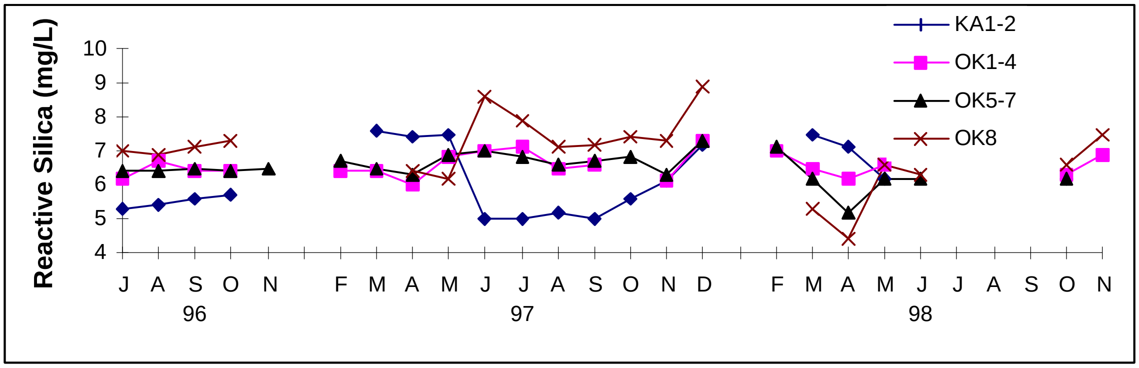


Figure 12. Concentrations of reactive silica in Okanagan Lake at the south end sites (OK1-4), the north end sites (OK5-7), Armstrong Arm (OK8) and in Kalamalka Lake (KA1-2).

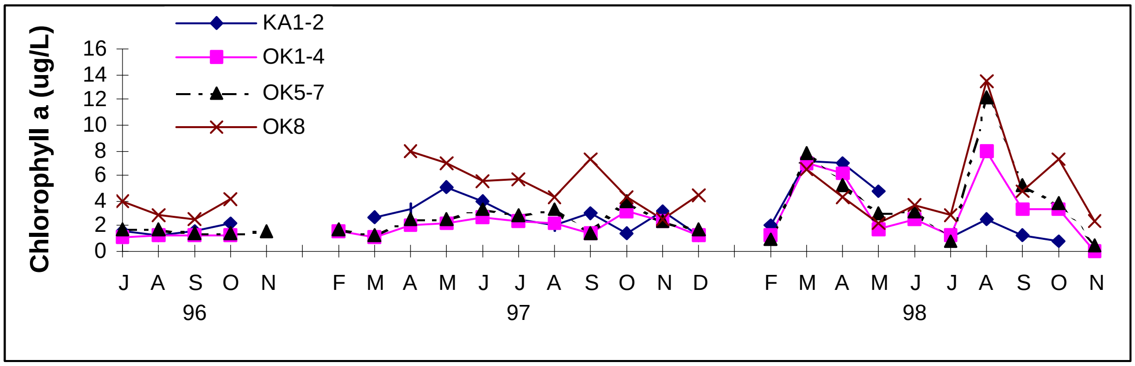
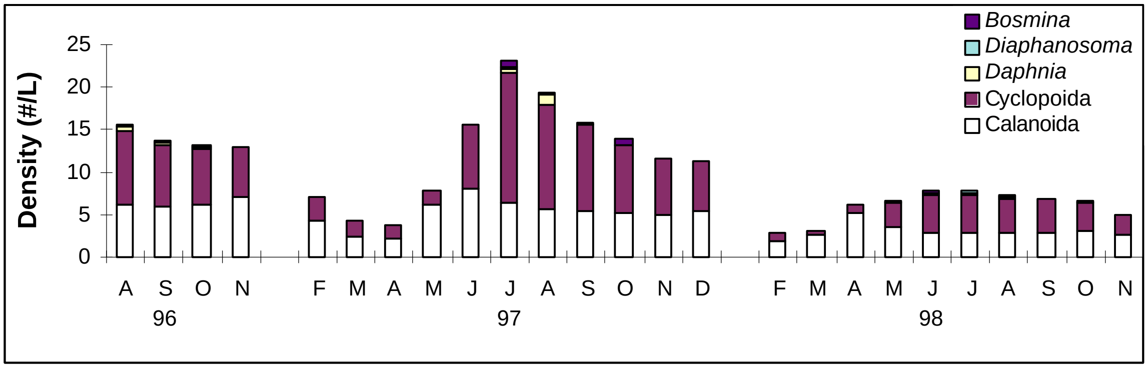


Figure 13. Chlorophyll a concentrations in Okanagan Lake at the south end sites (OK1-4), the north end sites (OK5-7), Armstrong Arm (OK8) and in Kalamalka Lake (KA1-2).



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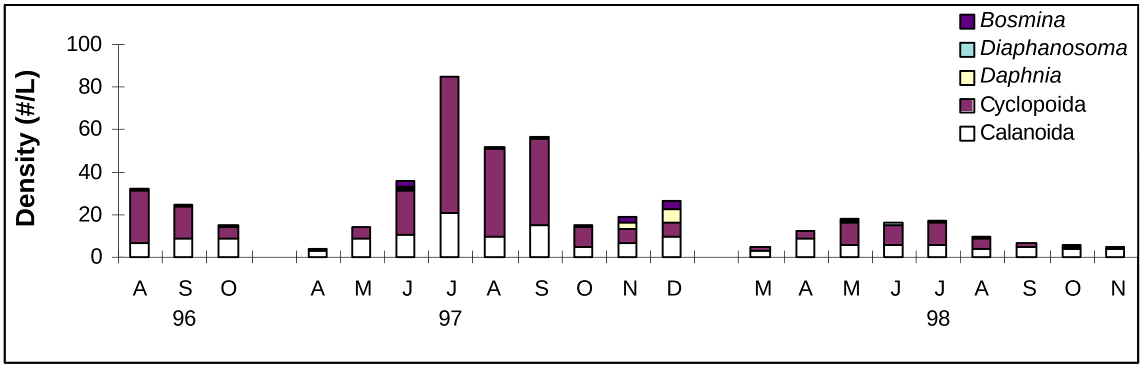

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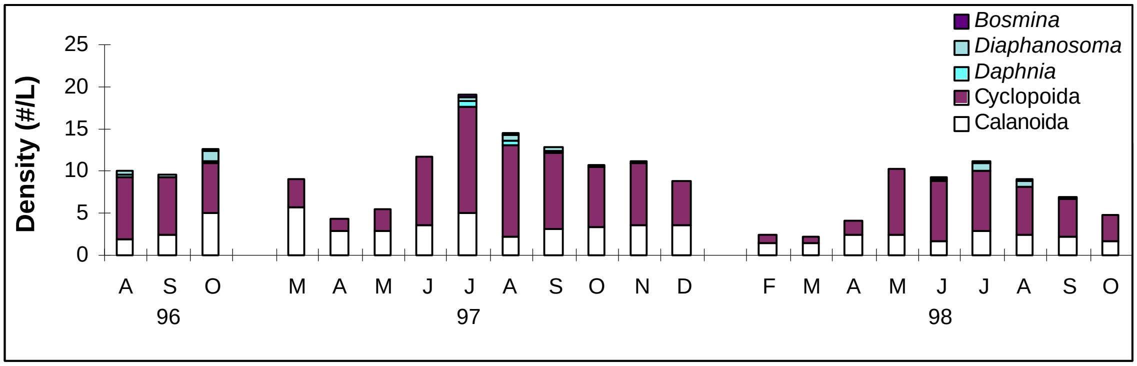
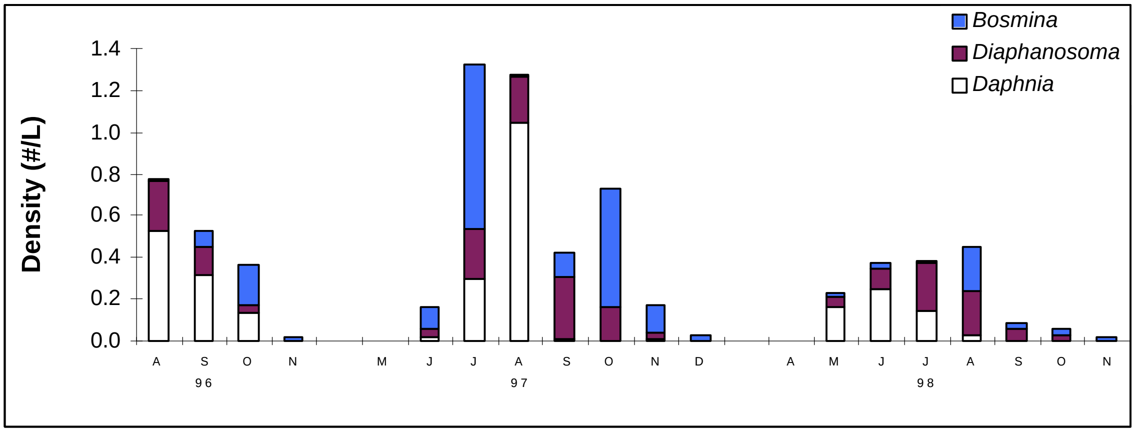


c)

Figure 14. Zooplankton density (1996-1998) for a) Okanagan Lake (OK1-7), b) Armstrong Arm (OK8) and c) Kalamalka Lake (KA1-3).



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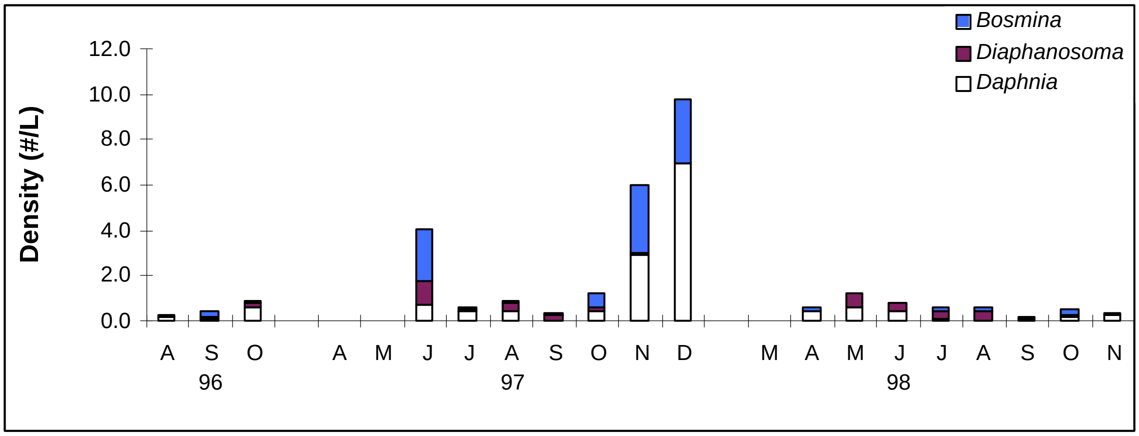

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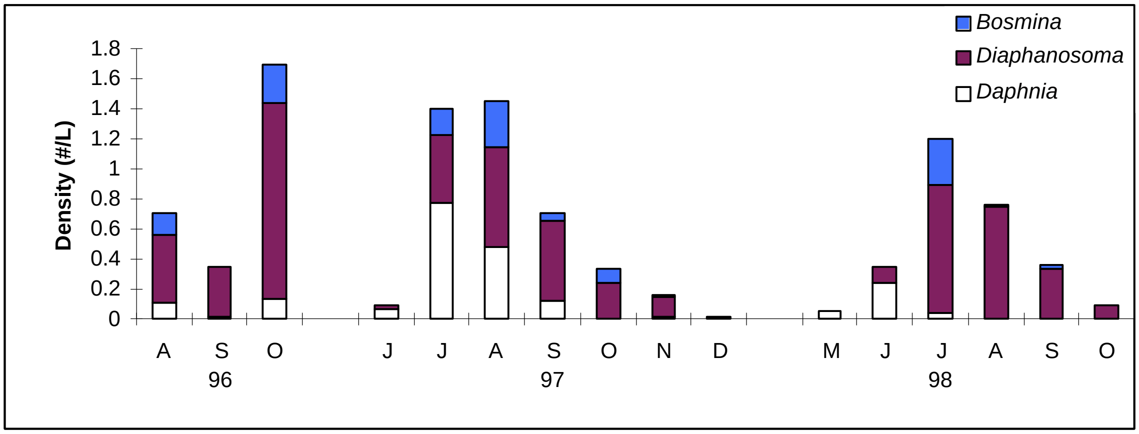


c)

Figure 15. Cladoceran density for a) Okanagan Lake (OK1-7), b) Armstrong Arm (OK8) and c) Kalamalka Lake (KA1-3).

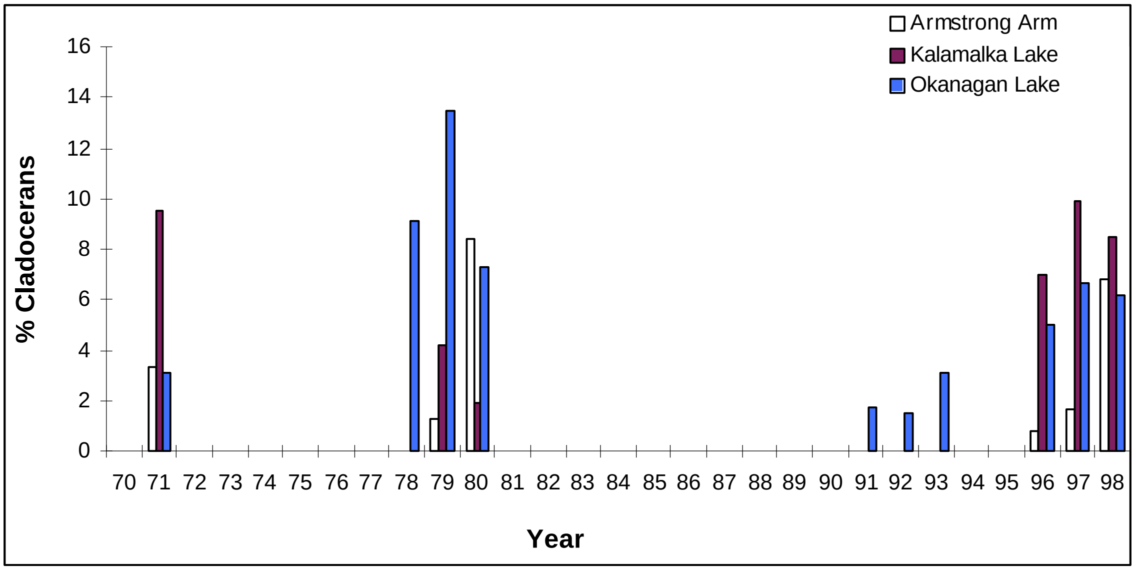
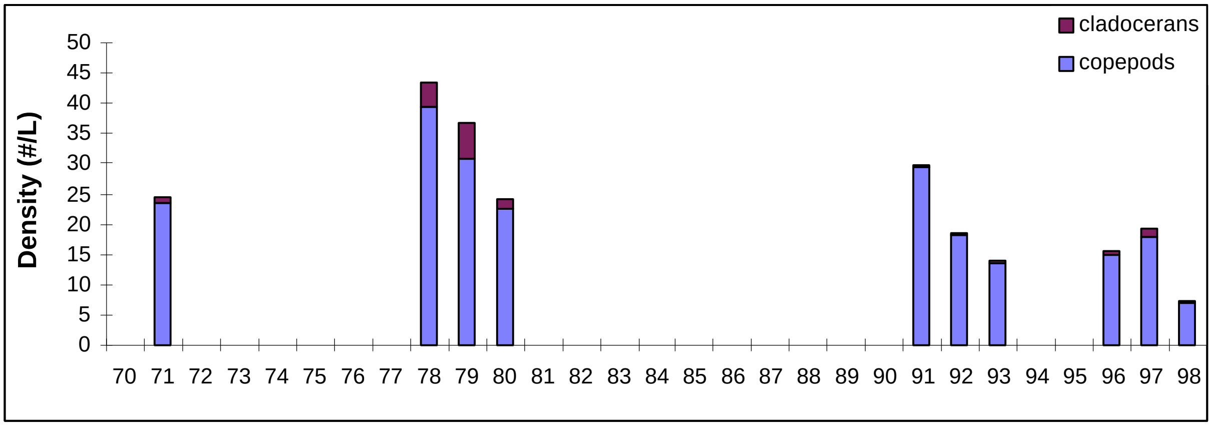


Figure 16. Percentage of cladocerans present in Okanagan Lake, Armstrong Arm and Kalamalka Lake from 1971 through 1998. 1971 values are from Patalas and Salki (1973); 1978 values are from Truscott and Kelso (1979); all other values from routine monitoring by B.C. Environment or under OLAP program (data on file Penticton Fisheries office).



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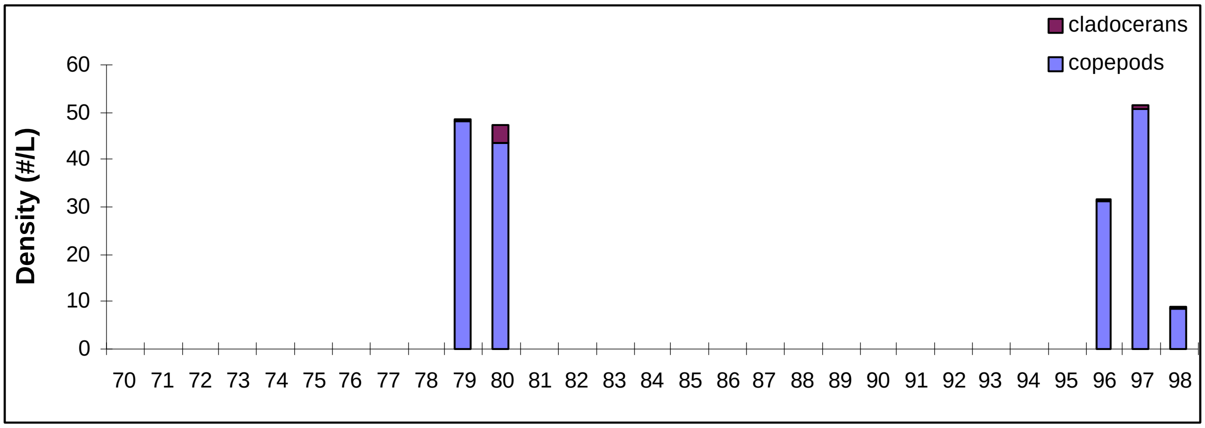

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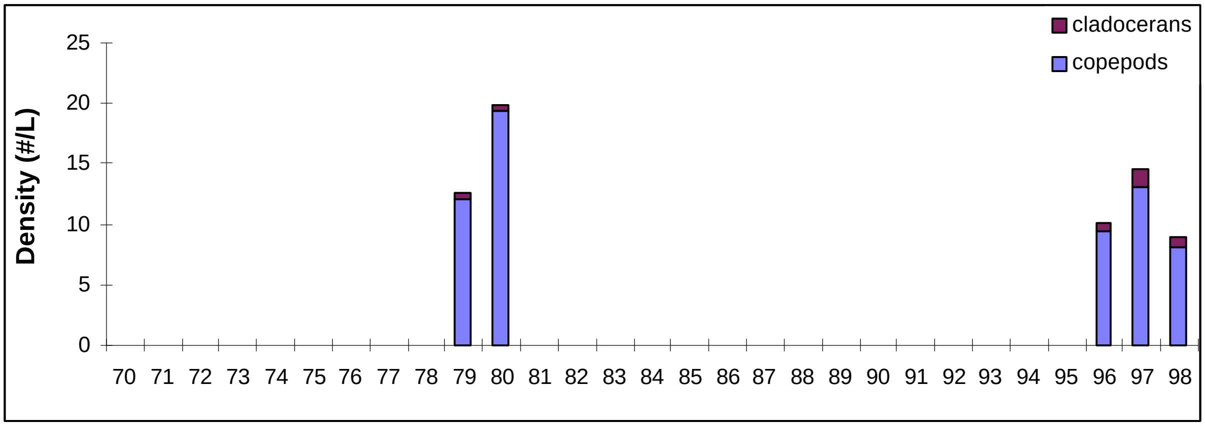

c)

Figure 17. Densities of cladocerans and copepods for a) Okanagan Lake, b) Armstrong Arm and c) Kalamalka Lake. 1978 values from Truscott and Kelso (1979); all other values from routine monitoring by B.C. Environment or under OLAP program.

Appendix 1.

Langmuir circulation

To assess the requirement for taking three separate zooplankton hauls as suggested by Thompson (*in:* Ashley et al. 1998), a crude analysis was undertaken to determine whether differences existed among hauls taken at the center versus those taken 500 m to the east and west sides. For each date and site in 1997 and 1998, a note was made as to which site had the highest number of organisms, whether east, center or west (Table 1). Totals for each station were calculated for each lake (Table 2). For example, of the nine dates on which KA1 was sampled in 1997, zooplankton densities were highest on four of those dates on the west side, on two of those dates in the center and on three of those dates on the east side (Table 2).

Table 1. Zooplankton haul with highest number of organisms, whether west (W), center (C) or east (E), on each sampling date.

1997	**KA1**	**KA2**	**KA3**	**OK1**	**OK2**	**OK3**	**OK4**	**OK5**	**0K6**	**OK7**	**OK8**
April	E	C	-	C	W	W	C	C	C	E	W
May	E	E	-	W	W	W	C	C	W	C	E
June	C	W	-	C	E	C	W	C	C	C	E
July	W	C	-	E	W	E	C	W	W	C	W
August	W	C	C	E	-	E	W	W	E	W	E
September	W	W	E	C	C	W	E	W	C	C	W
October	E	W	-	-	-	W	E	E	C	C	E
November	C	E	C	W	E	C	C	E	C	C	W
December	W	C	W	-	C	W	C	W	E	C	C

1998	**KA1**	**KA2**	**KA3**	**OK1**	**OK2**	**OK3**	**OK4**	**OK5**	**0K6**	**OK7**	**OK8**
Feb. 2-9	-	-	-	W	C	E	W	W	W	E	-
Feb. 23-Mar. 12	C	E	C	W	C	C	W	C	C	E	-
Mar. 23-Apr. 4	W	W	W	W	W	E	W	W	E	W	W
Apr. 20-28	W	W	-	E	-	W	-	-	E	W	E
May 26-June 10	-	E	-	E	-	W	-	-	W	W	E
June 17-July 6	-	E	-	C	-	W	-	-	E	W	E
July 28-30	-	W	-	W	-	F	-	-	E	C	E
Aug. 23-26	-	C	-	E	-	C	E	-	E	W	W
Sept. 24-Oct. 6	-	C	-	C	-	W	-	-	W	W	E
Oct. 20-27	-	W	-	E	-	C	-	-	C	E	E
Nov. 30-Dec. 8	-	-	-	E	-	-	EW (tie)	-	W	W	E

Table 2. Total number of dates for which zooplankton densities were highest in the west (W), center (C) or east (E) hauls.

	1997			**1998**		
	W	**C**	**E**	**W**	**C**	**E**
KA1	4	2	3	2	1	0
KA2	3	4	2	4	3	3
KA3	1	2	1	1	1	0
Total	**8**	**8**	**6**	**7**	**5**	**3**
OK1	2	3	4	4	2	5
OK2	3	2	2	1	2	0
OK3	5	2	2	4	3	3
OK4	2	5	2	3	0	1
OK5	4	3	2	2	1	0
OK6	2	5	2	4	2	5
OK7	1	7	1	7	1	3
OK8	4	1	4	2	0	7
Total	**23**	**28**	**19**	**27**	**11**	**24**

For Kalamalka Lake, zooplankton distribution was approximately equal across the lake in 1997 but tended to be more heavily concentrated on the westside in 1998. For Okanagan Lake, zooplankton densities tended to be highest in the center in 1997, but lowest in the center in 1998. There were no consistent trends within sites over the two years. For example, OK7 showed the highest concentrations at the centre on seven of nine dates in 1997, but in 1998 showed the highest concentrations on the westside on seven of eleven dates (Table 2).

The helical (spiral) flow of Langmuir currents generated by wind and wave energy form a series of parallel clockwise and counterclockwise rotations that result in linear alternations of divergences and convergences (Wetzel 1975). The effect of this action can be a patchiness in horizontal distribution of zooplankton as they aggregate in streaks in these divergences, a phenomenon, which is common on waveswept lakes of any significant size (Wetzel 1975).

Because of the observed variation among the 1997 and 1998 hauls and lack of consistent trends, it is recommended that the practice of taking three vertical hauls at geographically spaced locations be continued for future sampling programs.

TRENDS IN NUTRIENTS, WATER CLARITY, AND PHYTOPLANKTON IN OKANAGAN AND KALAMALKA LAKES, 1969 TO 1998

by

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INTRODUCTION

The limnology of Okanagan and Kalamalka lakes has been the subject of considerable study. The first cursory study was in 1935 (Clemens et al. 1939) at a time when the population of the Okanagan was roughly 28,000 and the main industries were tree fruit, cattle ranching, timber harvest and milling. As the population of the Okanagan valley increased so did the discharge of point source wastes such as municipal sewage and non-point source wastes. By the late 1960s the valley population had reached 100,000 and water quality had deteriorated in a number of the Okanagan lakes, as exemplified by algal blooms in Skaha Lake where secondary treated effluent from the City of Penticton entered the lake. Algal blooms also occurred in Vernon Arm of Okanagan Lake, where secondary treated sewage entered the lake via Vernon Creek. An extensive algal bloom on Wood Lake in 1971 catalyzed the Kalamalka Wood Lake basin water resource management study from 1971 to 1973 (Anon. 1974a).

Public concern for the water resources of Okanagan, Skaha and Osoyoos lakes led to comprehensive monitoring and assessment of water quality and quantity under the Okanagan Basin Study in 1969, the first joint Federal - Provincial watershed study of its kind in Canada. During this study, the limnology of Okanagan Lake was comprehensively described for the first time (Anon, 1974b) and recommendations for phosphorus reduction from point and non-point sources were made. Subsequent monitoring during the Okanagan Basin Implementation Study (Truscott and Kelso 1979; Jensen 1981; Nordin et al. 1990) documented water quality of Okanagan Lake following phosphorus reduction through diversion of Vernon sewage to effluent spray irrigation in August 1977, and tertiary treatment upgrade for the City of Kelowna in 1981.

Since 1973, water quality monitoring of Okanagan and Kalamalka lakes, has been largely carried out by the Ministry of Environment to determine nutrient status and the impact of treated effluent discharge. A review of phosphorus loading and water quality status of Okanagan lakes led to water quality objectives being set for spring total phosphorus levels (Anon. 1985). In September 1985, the province declared the Okanagan basin an environmentally sensitive area and eligible for special funding to assist with the capital costs of controlling sewage discharges.

The Westbank community (see Map 2) sewage treatment plant (STP) was upgraded to tertiary treatment and the outfall moved from Westbank Creek to a deep water outfall in Okanagan Lake

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in 1987. In 1998 Peachland community commenced sewage discharge via the Westbank treatment plant, and Summerland community began discharge of tertiary treated sewage effluent into Okanagan Lake in 1998 as well. The City of Vernon disposes of effluent via spray irrigation on upland slopes on the west side of Kalamalka Lake, while in wet years discharge to Okanagan Lake may occur such as in spring of 1984, 1985 and 1998. The City of Armstrong discharges secondary treated effluent during the spring to Deep Creek, which enters Armstrong Arm in the north end of Okanagan Lake.

The Okanagan valley has continued to be an area of rapid urban growth. Population has exceeded the lowest projection used in the Okanagan Basin Study (300,000 by year 2020) and this number could be reached before early in the next millennium, and reach one million by 2020 if present growth rates continue (Northcote 1995). While considerable public funds and attention have been given to controlling phosphorus discharged from municipal sources, non-point source pollution from storm water runoff, agriculture, septic tanks, timber harvest and land clearing for urban development have been much more problematic to monitor, inventory, and reduce.

Recent concerns regarding declining kokanee numbers in Okanagan Lake have prompted a more detailed examination of seasonal trends in nutrients, plankton, and mysid shrimp populations (see McEachern *in:* Ashley et al. 1998). The question of whether nutrient availability and phytoplankton abundance or character may have changed over the past two or three decades needs to be considered to better understand food chain impacts on kokanee populations.

This document will describe some long-term limnological trends in Okanagan and Kalamalka lakes, with a focus on nutrients, water clarity, and aspects of the phytoplankton populations over the past twenty to twenty-five years.

METHODS

Limnological sampling of Okanagan and Kalamalka lakes by the Ministry of Environment has normally occurred in spring when the lake is isothermal, and in the fall when the lake is fully stratified. Samples for nutrients, chlorophyll *a*, and general ions are collected with a Van Dorn water sample bottle and composited from three depths in the epilimnion (1, 5 and 10 m). Nutrients are also composited from hypolimnetic waters below 20 m but above 45 m. Below 45 m of these two lakes, the changes in chemistry are slight until just above the water/sediment interface.

Although there are a number of shallow stations on both Okanagan and Kalamalka lakes, for the purposes of this descriptive comparison, only data for deep stations, sampled consistently over a number of years is analyzed. The location of these stations is illustrated by Map 2 and are compared to historical sampling stations in Table 1 below.

Table 1. Deep Site Limnological Station Information for Kalamalka and Okanagan Lakes

Station Name of Main Limnological Sampling Station at Deep Sites	Station EMS Number	Okanagan Basin Study 1969-72	Okanagan Basin Implementation Study 1976 to 1978	MOE Spring Fall Monitoring Program	Kal-Wood Study
Okanagan Lake					
opp. Prairie Creek	0500454	phytoplankton		1975-1998	
South Squally Point	0500729	OK-3	Ok-3	1977-1998	
South Powers Creek	E206570			1986-1998	
@ Kelowna Deep Outfall	E222119			1995-1998	
DNS Kelowna STP	0500236	OK-2 + phyto	OK-2	1973-1998	
UPS Kelowna STP	0500456	phytoplankton		1975-1998	
North Okanagan Centre	0500730	OK-1	OK-1	1976-1998	
@ Vernon Outfall	E206611	phytoplankton		1986-1998	
Central Vernon Arm	0500238			1974-1998	
Armstrong Arm	0500239			1974-1998	
Kalamalka Lake					
South Coldstream Creek	0500461			1975-1998	1972-73
Deep Basin	0500847	KA-2 + phyto		1974-1998	1972-73
South End	0500246			1975-1988	1972-73

Over the years, samples have been analyzed by a variety of labs, following standard analytical methods. During the Okanagan Basin Study (1969 to 1972) analyses were performed by a variety of federal laboratories (Anon. 1974b). The BC Ministry of Environment environmental laboratory analyzed samples from 1973 to 1989. Zenon Laboratories performed the analyses from 1989 to 1997. The Pacific Environmental Science Centre has provided water chemistry analyses since 1997. All provincial data (1973 to 1998) is currently archived on the provincial Environment Management System (EMS).

Phytoplankton sampling and analyses on Okanagan lakes has varied over the past 25 years. During the Okanagan Basin Study three stations along transects were sampled at 5 depths and one taxonomic count was made per depth per site (Stein and Coulthard 1971). During this study when high algal populations were encountered, a scale was used to estimate total cell numbers. For example, *Anabaena* sp. were scaled with a count of 1 equaling 12 to 15 cells. During the Okanagan Basin Implementation Study (Truscott and Kelso 1979) phytoplankton samples were collected from 2, 4, 10 metre and photic zone depths at each site. Unfortunately, none of the original data has been located.

Between 1979 and 1998 the Ministry of Environment has routinely collected phytotaxonomy samples from the main lakes on spring and fall dates, using a composite of 1, 5 and 10 metre depths. Taxonomic analyses were periodically conducted. Samples collected monthly under the Okanagan Lake Action Plan (Ashley et al. 1998), using composites of 1, 5 and 10 metre depths, have provided information on phytoplankton change through the growing season. From 1984 to the present time, taxonomic counts were conducted on ten microscope fields counts and reported as an average (L. Looy, pers. comm.). Good continuity in taxonomists has occurred even when the BC Environmental Laboratory was privatized (L. Looy, pers. comm.). Even so, the difference in counts between taxonomists suggests that long-term data assessment should perhaps not rely heavily on identification below the genus level of identification. As well, the various methods of sample collection, such as sample size, number of fields viewed or level of taxonomic detail provided suggest that percentage composition be used rather than absolute numbers of organisms.

Algal biovolumes used in this report are provided in Appendix 1 with citations. Although biovolumes were previously estimated for Okanagan Lake (Truscott and Kelso 1979) the species list was limited, and filament length to cell # estimates were used for blue-greens. Consequently, volumes were selected from a number of other relevant studies with preference given to one on Kootenay Lake (Ashley et al. 1997). Thus the biovolume data provided is only an estimate that will be refined as more accurate and specific algal biovolume is obtained for these two lakes.

RESULTS AND DISCUSSION

To make efficient use of monitoring resources and reduce data variability that would arise without temporally stratified sampling, the Ministry of Environment has focused on spring and fall sampling of Okanagan lakes. There are a number of ways of viewing limnological data to determine change over time:

1. Nutrient concentrations measured in late winter/spring, (prior to spring plankton growth and thermal stratification) can provide a reasonable estimate of nutrient availability for plankton growth in the subsequent months. It also provides the best estimate of the mass of nutrients present. Levels of chlorophyll *a* and oxygen depletion with depth, measured in the fall, can give relative indications of biological productivity. Phytoplankton identity and quantity can characterize status the primary trophic level.

2. Data analysis for all sites, depths and time provide some insight into long-term trends providing the variability in concentrations caused by depth or season is not excessive. When monthly data is available, analysis of seasonal patterns and seasonal means for spatial or temporal patterns can be informative.

3. Comparison between lakes to determine changes over time that are related to common hydrographic phenomena, laboratory method changes, sample contamination problems etc. can be insightful. In large lakes like Okanagan and Kalamalka there is great potential for spatial and temporal variation in biological and chemical constituents. The discussion on the key limnological parameters includes all three methods of data analysis. It should be noted that the chronological scale on the baseline varies for each graph due to the variation in sampling effort between sites.

Phosphorus

Okanagan Lake

Total phosphorus (TP) data for Okanagan Lake is shown in Figures 2 and 3. Spring phosphorus levels are consistently and significantly higher in Armstrong Arm than other parts of Okanagan Lake. Diversion of a significant portion of the City of Armstrong effluent since 1993, has not had a noticeable effect on spring TP in Armstrong Arm of Okanagan Lake (Fig. 2). Spring TP in Vernon Arm has been more similar to levels in the main body of Okanagan Lake since August 1977 when the City of Vernon diverted all effluent to spray irrigation disposal. Spring TP data and all TP data for Okanagan Lake deep sites trended upwards from 1973 to 1983, decreased through 1995 then increased in 1996 and 1997 before decreasing again in 1998. Except for Armstrong Arm, the overall the trend for TP in Okanagan Lake is slightly negative or downward. However, annual variation can be significant as illustrated by fluctuations in spring TP (1996 to 1998) which appear to correlate with variations in hydrology and discharge from Okanagan Lake (Fig. 6). Higher TP values in 1981 to 1983 and 1996 to 1997 are common to many southern interior lakes corresponding to a series of wet years (see Ward *in:* Ashley et al. 1998).

Kalamalka Lake

Similar to Okanagan Lake, Kalamalka Lake has shown variation in spring total phosphorus and all total and dissolved phosphorus data sets (Figs. 4 and 5), with higher values in 1982 to 1983 and 1996 to 1997 which were periods of higher runoff. Total phosphorus levels are declining slightly from levels recorded in the late 1970s and early 1980s. Over the 25 year period no significant and consistent trend is apparent in the TP data. The 1998 average spring TP level for deep sites in Kalamalka Lake (461/847/246) was 5.1 µg· L compared to 7.7 µg· L in Okanagan Lake (454/729/236/456/730). The average for Okanagan Lake would have been somewhat higher except for low levels at the two southern most sites (0500454/729). Total dissolved phosphorus was often below detection limits in both Kalamalka and Okanagan lakes during the spring and fall sampling of 1998 to 1995 (Figs. 7 and 8).

Dissolved phosphorus shows very similar trends as TP but at slightly lower levels; in Okanagan Lake TDP is approximately 58% of the total phosphorus value over the 25 year period (Fig. 7). In Kalamalka Lake, TDP over the 25 year period averages approximately 60% of the total (Fig. 8).

Okanagan Lake at 26,200,000,000 m^3 and 10 µg· L TP would contain 262,000 kg of phosphorus. In 1985 it was estimated that the annual TP load to Okanagan Lake was 69,200 kilograms or perhaps one fourth of the mass of TP in the lake at spring overturn (Anon. 1985). If Okanagan Lake is flushed on average every 53 years, then 1/53th of its phosphorus leaves Okanagan Lake each year and the 57/58ths remaining (67,894 kg) would be removed by biological and physical process and ultimately sedimentation, if the concentration of TP were to remain relatively constant over the years.

To put some perspective on these fluxes of phosphorus, it is useful to recognize that the annual load from the City of Kelowna main treatment plant was 1,824 kg in 1997 or approximately 0.7%

of the mass of phosphorus in Okanagan Lake and approximately 2.7 % of the estimated annual load from all sources. Westbank discharged 209 kg in 1997 or 0.08 % of the mass in Okanagan Lake. These loads of phosphorus would obviously have more numerical and biological significance to the immediate receiving environment, but compared to the existing mass of phosphorus in the lake as a whole, they are rather small. As shown below, phosphorus loading from municipal STPs has been decreasing steadily since 1970. In 1970 the cities of Kelowna, Westbank, Vernon and Armstrong, in total discharged 43,718 kilograms of phosphorus into the surface waters, or approximately 17% of the phosphorus mass in Okanagan Lake. In 1996, all municipal point source loads of TP to Okanagan Lake are via deep water outfalls and accounted for 3.2% of the 1985 estimated annual load and 0.8% of the mass of TP in Okanagan Lake. Septic tank seepage in 1996 theoretically accounted for 23% of the annual phosphorus load to Okanagan Lake (R. Townson pers. comm.) or about 5% of the mass of TP in the lake.

Table 2. Annual Phosphorus Loads from Municipal Sources to Okanagan Lake

	Kelowna	**Armstrong**	**Westbank**	**Brandt's**	**Vernon**	**Total**
1970	20,300	1,023	516		21,879	43,718
1980	11,030	2,411	1,312	111		14,864
1981	9,750	3,228	1,040	1,120		15,138
1982	10,500	3,255	913	1,030		15,698
1983	4,020	2,630	438	491		7,579
1984	6,739	2,431	831	1,416	348	11,765
1985	5,014	1,982	741	865	217	8,819
1986	6,993	2,963	742	289		10,987
1987	5,360	2,681	1,397	133		9,571
1988	3,111	2,980	959	167		7,217
1989	1,384	3,620	1,077	98		6,180
1990	1,034	3,740	70	175		5,020
1991	1,055	5,455	333	23		6,866
1992	1,175	6,484	144	45		7,848
1993	1,241	0	145	23		1,409
1994	2,047	417	113	9		2,586
1995	1,871	256	174	19		2,320
1996	1,616	332	184	24		2,156
1997						
1998						

(R. Townson, G. Huggins, R. Gunoff, unpublished)

The Okanagan Basin Study estimated that Mission Creek discharged an average of 7,200 kilograms of phosphorus to Okanagan Lake per year and ranged between 4,100 and 12,400 kg in dry and wet years (Anon. 1974c). In dry years this load was approximately two times that currently discharged from sewage treatment plants (STP), and during wet years it was 6 times that of the current STP load. All the major streams, on average, contributed a total of 19,228 kilograms of phosphorus to Okanagan Lake (Anon.1974c).

With this information in mind, it is interesting to compare two sites on Okanagan Lake that should be somewhat different in nutrients if point and non-point source phosphorus loading had a measurable influence on spring or fall data. Okanagan Lake North of Okanagan Centre is well removed from point sources of phosphorus and reasonably well removed from non-point source contributions from large creeks. Okanagan Lake downstream of Kelowna STP is not only near the effluent outfall but is also near the mouth of Mission Creek, the largest watershed in the Okanagan. A preliminary comparison of 21 data pairs of spring epilimnetic total phosphorus values from 1977 to 1998 showed on average North Okanagan Centre phosphorus levels were significantly different using a paired T-test ($p \leq 0.015$). However, as all values were less than three times the detection limit, an area of greater analytical uncertainty, even statistical significance would have to be viewed cautiously (Clark and Whitfield 1994). The regression line for spring TP in Okanagan Lake shows a very slight downward trend while in Kalamalka Lake there is no trend (Fig. 9). This relative decrease in Okanagan Lake could be the net result of diminishing phosphorus from municipal STPs, all else being equal. Unfortunately there are many sources of phosphorus in the watersheds and considerable year to year variation in spring TP, which confound inferential assessment. In large lakes with long water residence times, a measurable response to changes in nutrient loading will occur slowly.

Nitrogen

Spring total nitrogen shows no clear trend in Okanagan Lake (Fig. 10). Total nitrogen data for all dates at selected deep sites on Okanagan Lake shows a slight increasing trend (Fig. 12). Kalamalka Lake data shows an increasing trend in spring total nitrogen and total nitrogen (Figs. 11 and 13). The 1998 average spring total nitrogen (TN) level for deep sites in Kalamalka Lake (461/847/246) was 0.35 mg· L compared to 0.22 mg· L in Okanagan Lake (454/729/236/456/730). The 1998 spring TN level in Armstrong Arm (239) of Okanagan Lake was 0.35 mg· L.

Although changing detection limits over time constrain trend interpretation, it is clear that spring nitrate nitrogen trends gradually upwards over the past 25 years in both lakes (Figs. 14 and 15). as reported by Bryan (1990). Nitrate nitrogen in Armstrong Arm of Okanagan Lake is usually lower than the main body of Okanagan Lake and appears to be in short supply relative to phosphorus in the spring. Spring nitrate nitrogen in Kalamalka Lake in 1997 to 1998 was significantly elevated over previous years. In contrast to phosphorus, nitrate nitrogen shows strong seasonal patterns with summer depletion (McEachern 1999, in this report) which has been noted in other oligotrophic lakes such as Lake Chelan (Patmont et al. 1989).

Spring nitrate levels in Sugar, Mabel and Mara lakes in the upper Shuswap drainage over the past 10 years have averaged 0.1 mg· L, 0.09 mg· L and 0.08 mg· L respectively with no trend(s) evident. It is interesting to note that spring nitrate nitrogen levels represented 20 and 28% of the total in Okanagan and Kalamalka lakes respectively but 61% in Mabel Lake. The remaining nitrogen in all three lakes is primarily organic nitrogen. Lower spring nitrate in Okanagan and

Kalamalka lakes may be due to phosphorus availability and higher levels of photosynthesis or perhaps due to characteristics of the surrounding landscape. The Okanagan Basin Study determined that phytoplankton growth in Okanagan and Kalamalka lakes was phosphorus limited, but co-limitation was also possible as greatest algal growth was noted by adding both nutrients to test cultures. Re-evaluation of nutrient limitation would be worthwhile given limited monitoring resources.

Nitrogen to Phosphorus Ratio

When the ratio of nitrogen to phosphorus falls below approximately 15:1 (by weight) phosphorus no long limits phytoplankton growth (Nordin, 1985). Various authors use total nutrient while some use estimates of soluble inorganic forms of nitrogen such as nitrate nitrogen and soluble reactive phosphorus (SRP). Total N:P during the spring sampling is not as useful as more complete seasonal information, but it does give two consistent reference points during the growing season. Analysis of total nutrient levels, even during the spring and fall periods, suggests phosphorus is theoretically limiting phytoplankton growth in both lakes (Figs. 16 and 17). Ratios of nitrate nitrogen to total dissolved phosphorus in Okanagan and Kalamalka lakes are generally below 15:1 even during the early spring.

In warm surface waters, phosphorus may turnover or be recycled from organic to bioavailable inorganic forms in a matter of minutes (Cole 1975). Nitrogen, however, is not recycled by bacteria as quickly as phosphorus in the epilimnion (Wetzel 1975). Consequently, when phosphorus supplies are ample, nitrogen may become limiting at some point during the growing season. As noted previously, nitrate nitrogen is not detectable in surface waters of Armstrong Arm in the spring, and becomes non-detectable in Okanagan and Kalamalka lakes surface waters between June and September (McEachern, *in:* Ashley et al. 1998). Future seasonal sampling should more accurately determine levels of soluble inorganic nitrogen and phosphorus to better understand nutrient availability and limitation.

Annual loadings of nitrogen and phosphorus to Okanagan lakes have been correlated with stream flow in the past (Anon. 1974c). However, the peaks in spring TP in 1983 and 1997 are not matched by similar increases in total nitrogen. Okanagan Lake at 0.2 mg· L total nitrogen (TN) would contain approximately 5,240,000 kg of TN. The Mission Creek load in 1970 was estimated on an average year to be discharge 61,767 kilograms TN or approximately 1.2 % of the total in Okanagan Lake. A similar amount might enter directly via precipitation and dry fallout to the lake (Wetzel 1975). The City of Kelowna discharged approximately 50,000 kilograms of total nitrogen in 1997, or approximately 1% of the TN mass in Okanagan Lake.

That total phosphorus appears to increase in response to a series of wet years, whereas total nitrogen does not begs further comment. Perhaps phosphorus is more closely associated with rapid soil erosion processes in the watershed while nitrogen is associated with slower processes of organic material decomposition and release to surface and groundwaters that may not increase significantly during wet years. In fact, a series of wet years was noted during the Okanagan Basin Study to release successively less nitrogen with each subsequent wet year.

Although some data is now being gathered by Forest Renewal BC inventory projects, current and comprehensive data to describe nutrient loading from Okanagan streams is unfortunately lacking. It is apparent that controllable P from municipal sources has been greatly reduced and is now discharged into deeper waters of Okanagan Lake where any biological uptake during the growing season has little consequence on surface water quality. Up-to-date estimates of P loading from the increasing numbers of septic tanks and other non-point sources will be required to ensure water quality protection. Although large scale fluctuations in phosphorus in Okanagan and Kalamalka lakes appear to be largely driven by inter-annual variation in hydrology, the cumulative effect of increased urbanization, forest harvest, agriculture and reduced municipal effluent loading will still greatly influence water quality.

Kalamalka Lake, having no point source of phosphorus loading, is of particular interest. Comparing spring TP levels shows that between 1969 and 1983 Kalamalka spring TP was equal to or lower than that in Okanagan Lake. From 1984 to 1998 Kalamalka Lake spring TP was less than or equal to Okanagan Lake in only 2 of the 15 years.

Phytoplankton

Phytoplankton abundance in Okanagan and Kalamalka lakes during the fall, as measured by chlorophyll *a*, appears to be gradually increasing and becoming more variable (Figs. 18 and 19). In particular the north end of Okanagan Lake including, North Okanagan Centre, Central Vernon Arm and Armstrong Arm during fall months has shown increasing chlorophyll *a* levels as well as increased variability since 1989. This change may be related to analytical technique changes rather than actual environmental change.

Water Clarity

Okanagan Lake at main deep sites shows a trend in water clarity, as measured by Secchi disk depth (Fig. 20). Water clarity increased from 1973 to 1979, decreased during the early 1980s followed by improvement through the late 1980s and early 1990s with a gradual decrease very recently. Although limited data in the 1970s does reduce confidence in trend assessment, over the 25 year period there appears to be no major change in water clarity. A comparison of spring chlorophyll a and spring Secchi disk depth for the main sites gives an R^2 of 0.19 (figure not shown).

Water clarity in Kalamalka during fall months (Fig. 21) may show a decrease in water clarity over the 25 year period, however the data is highly variable from year to year. There is no obvious relationship between Secchi depth and chlorophyll *a* (spring $R^2 = 0.21$; fall $R^2 = 0.02$) as might be expected from a lake that has marl precipitation events of varying intensity each summer.

Phytoplankton Monitoring

Phytoplankton Density

Large variations in phytoplankton density from year to year and within a growing season occurred from 1996 to 1998, similar to that noted by Stein and Coulthard (1971). From March to November 1997, a comparative period for which sample results are available, the total phytoplankton density (cells· mL) was often higher in Armstrong Arm (2874 cells· mL) than other portions of Okanagan Lake (Fig. 22). The south end of Okanagan Lake south of Squally Pt (Map 1) often had the lowest phytoplankton density (1281 cells· mL). This was occasionally lower than Kalamalka Lake, which overall had a lower average phytoplankton density (739 cells· mL) than the main body of Okanagan Lake (2062 cell· mL). During 1997, phytoplankton density and biovolume maximums were recorded in spring and late summer in Okanagan Lake, but only in the spring in Kalamalka Lake. Stein and Coulthard (1971) reported similar seasonal mean cell density ranging from 1925 cells· mL in the north end of Okanagan Lake to 1350 cells· mL in the south, and 400 cells· mL in Kalamalka Lake. As nutrient levels in Kalamalka Lake are not significantly different from Okanagan Lake (nitrogen is higher but phosphorus lower) the lower phytoplankton density in Kalamalka Lake may be linked to food chain dynamics or general water chemistry. Marl precipitation in Kalamalka Lake would reduce light levels (R. Nordin pers. comm.) and presumably primary productivity.

Phytoplankton Taxonomy

As the taxonomic data is volumous, only data for key sites will be summarized and discussed in this report. For years 1996 to 1998, phytoplankton analysis focused on Okanagan Lake in Armstrong Arm, North of Okanagan Centre, South Squally Point and Kalamalka Lake Deep Basin.

Seasonal data for Okanagan Lake North of Okanagan Centre (0500730) from 1996 to 1998 indicates the spring phytoplankton counts were dominated by blue-greens *Lyngbya limnetica* and *Oscillatoria tenuis* (63-98%) (Figure 23a). The cryptophyte *Cryptomonas* was common (6-33%) in spring 1997 and diatoms *Asterionella* and *Fragilaria* were common (21%) in spring 1996. During the summer months and into the fall, the blue-greens remained dominant (73-98%) and increased in diversity to also include *Aphanonzomenon flos-aquae, Anabaena affinis,* and *Anacystis elachistra*. Phytoplankton biovolume data for Okanagan Lake, North of Okanagan Centre, from 1996 to 1998, is much less consistent from month to month and year to year (Fig. 23b).

In February and March 1998, diatoms *Surirella, Melosira*, and *Cymatopleura* made up approximately 6-49% of the phytoplankton volume, 30-62% was cryptophyte *Cryptomonas* and 6-20% were cyanobacteria of blue-greens such as *Lyngbya limnetica* and *Oscillatoria tenuis. Peridinium,* a pyrrophyte, comprised 54% of the phytoplankton biovolume in early April. June samples contained a balanced mixture of 29% *Dinobryon sp*. a chrysophyte, 27% cyanobacteria, 24% diatoms *Diatoma* and *Fragilaria crotonensis,* and 18% *Oocystis,* a chlorophyte. During the summer cyanophytes increased in volume to 67%. *Aphanizomenon flos-aquae* (85%) dominated the fall sample with minor amounts of the diatom *Fragilaria.* Summer biovolume dominants in 1997 and 1996 were *Aphanizomenon flos-aquae* and *Cryptomonas ovata* respectively.

Armstrong Arm of Okanagan Lake (0500239) exhibited somewhat different algal periodicity from 1996 to 1998 than site 05000730, with less diversity in biovolume and a more consistent dominance by bluegreens in both cell number and volume (Figs. 24a and b). Spring phytoplankton counts were dominated (53-98%) by *Lyngby limnetica, Anabaena sp., Aphanizomenon sp.* and *Oscillatoria sp.* in all three years. Algal biovolumes in the spring were more varied with diatoms *Fragilaria, Tabillaria* and *Melosira, sp.* dominant (40%) in April 1996 but *Dinobryon* dominant (62%) in April 1998. During the summer months the blue-greens increased in dominance in terms of cell count and biovolume (49-93%) then decreased slightly in fall 1996 (32%) and 1998 (52%) to biovolume increases in *Cryptomonas.*

Spring phytoplankton density in the south end of Okanagan Lake (0500729) was dominated by blue-green *Lyngbya limnetica* in 1996 to 1998 and *Chroomonas acuta* and *Melosira italica* were common (Fig. 25a). Blue-greens increased in number through the summer and into the fall of 1996 and 1997 but decreased during the summer of 1998. During the fall of 1996 *Chroomanas*, and *Botryococcus braunii* were common. Phytoplankton biovolume estimates show cryptomonads and diatoms dominant in February 1996 (Fig. 25b). *Cryptomonas* was the dominant biovolume in February1996 and 1998. *Melosira was* a dominant in spring 1997 and 1998, and a co-dominant in 1996. Greens *Ankistrodesmus and Elakatothrix gelatinosa* were common in spring 1997. *Cryptomonas* was the primary biovolume in summer 1996 and 1998. Greens such as *Gloeocystis* and *Sphaerocystis* were significant contributors to summer algal biovolumes in 1996 and 1998 respectively. *Aphanozomenon* dominated the biovolume in the summer of 1997 and fall of 1998. C*ryptomonas* and *Lyngbya* were dominant biovolumes in the fall of 1996 and 1997 respectively.

Phytoplankton density in Kalamalka Lake, during the spring was dominated by *Lyngbya limnetica* in 1997 and by *Lyngbya limnetica* and *Chroomonas acuta* in 1998 (Fig. 26a). Between March and May of 1997, *Lyngbya* and *Dinobryon* increased in number, and *Chroomonas acuta* and *Ankistrodesmus* decreased. In summer 1996 *Lyngbya* dominated, *Fragilaria* decreased but cryptophytes increased. Through the summer of 1997 blue-greens *Anacystis elachista* and *Lyngbya limnetica* increased in number while greens such as *Oocystis*, and *Elaktothrix* decreased. In summer 1998 *Lyngbya* increased while *Sphaerocystis* decreased. Fall months were dominated by *Lyngbya limnetica* in all three years, while *Chroomonas acuta* was a common species in October 1996. Algal biovolumes in Kalamalka Lake were dominated in spring 1997 by *Ankistrodesmus sp.* and Euglenophyte *Phacus*, and in 1998 by *Chryptomonas acuta* (Fig. 26b). Summer phytoplankton biovolumes were dominated by *Dinobryon sp.*, and *Cryptomonas* in 1998, *Elatothrix, Oocystis, Dinobryon sp.*, and *Cryptomonas* in 1997, and *Fragilaria*, pyrrophytes *Ceratium* and *Peridinium* and *Cryptomonas* in 1996. Fall biovolumes were dominated by *Cryptomonas* in 1996 to 1998, with *Lyngbya* as a co-dominant in all three years and *Fragilaria* as an additional co-dominant in 1997.

Clemens (1939) found *Ceratium hirundinella,* and *Dinobryon divergens* abundant, and *Notholca* and *Aphanizomenon flos-aquae* common in Kalamalka Lake in August of 1935. During the summer of 1935, Clemens found the diatoms, *Asterionella, Fragilaria, Melosira, Stephanodiscus* and *Tabellaria* were abundant in Okanagan Lake. Greens such as *Dictyosphaerium*, and *Staurastrum* were abundant as was *Ceratium* and *Dinobryon*. *Botryococcus* was abundant but variable in presence as was *Anabaena flos-aqua*, which was described as very common. A number of other blue-green algae were found to be common but not abundant.

Stein and Coulthard (1971) reported algal species in Okanagan Lake were dominated in early June 1969 diatoms *Fragilaria crotonensis* and *Asterionella formosa*. By mid June, blue-greens *Anabaena flos-aqua* and *Lyngbya limnetica* were dominants. From mid July through September, the blue-greens *Aphanothece nidulans*, *Aph. microscopia*, *Anabaena* sp. *Lyngbya limnetica*, *Chroococcus dispersus* and *Coelosphaerium naegelianum* were dominant. In the fall of 1969 diatoms *Asterionella formosa* and *Melosira italica* increased and in April of 1970 *A. formosa* and *Crypotmonas ovata* were dominant. In the spring of 1969, Kalamalka Lake phytoplankton were dominated by *Anabaena flos-aqua*, *Lyngbya limnetica*, *Asterionella formosa, and Fragilaria crotonensis*. In April of 1977 and 1978 the dominant algal species in Okanagan Lake were diatoms *Selenastrum* sp. and *Asterionella formosa*, and the flagellate cryptomonad *Chroomonas acuta* ; blue-greens accounted for 32% of the assemblage (Truscott and Kelso 1979). Truscott and Kelso (1979) noted that at station OK-2 downstream of Kelowna whereas in the summer of 1969 the blue-green *Aphanotheca nidulans* dominated, in 1976 to 1978 the blue-greens were a minority, with *Asterionella formosa* and *Chroomonas acuta* dominate.

Some changes in phytoplankton species density composition seems to have occurred since studies in 1969 and 1976 to 1978 in Okanagan Lake. *Lyngbya* may now be more prevalent and have replaced diatoms as early spring dominants in Okanagan Lake and replaced *Anabaena flos-aqua* as the blue-green dominant in Kalamalka Lake. While diatoms were common in Kalamalka Lake in spring 1969 to 1970, greens and flagellates were common in spring 1997 to 1998. Stein and Coulthard noted phytoplankton numbers declined during the summer of 1969 and comprised a mix of diatoms and phytoflagellates. In 1996 to 1997 the declining phytoplankton numbers in Kalamalka Lake were dominated by greens and phytoflagellates.

Although the phytoplankton species composition varied for a given season from one year to the next some generalizations are possible. Phytoplankton density in both lakes was clearly dominated in all seasons by *Lyngbya limnetica* and other blue-greens. *Chroomonas, Melosira sp. Asterionella formosa, Cyclotella italica* and *Ankistrodesmus* are common in both lakes in the spring. It is clear that proportional estimates of biovolume show more phytoplankton diversity than cell counts due to the larger size of diatoms, greens and phytoflagellates than blue-greens. Spring biovolumes in Okanagan Lake were most often dominated by *Melosira*, *Fragilaria* and cryptophytes. In Kalamalka Lake, dominance was shared between *Cryptomonas* and *Ankistrodesmus*. Further refinement is required of biovolume calculations presented in this report.

The preponderance of blue-green algae in Okanagan and Kalamalka lakes seem at odds with conventional thinking of blue-green algal dominance under nitrogen limiting and eutrophic conditions. Knowledge of the Okanagan lakes, as with many fresh waters, does not predate human influence. Even anecdotal descriptions of phytoplankton populations in the 1930s can not be considered pre-disturbance characterizations although paleolimnogical studies may offer some insight into historical plankton populations. Review of phytoplankton population succession suggests that phosphorus reduction and detrophication may or may not return phytoplankton populations to pre-disturbance conditions (Reynolds 1984). Permanent phytoplankton species loss may occur during the disturbed state and species introduced at higher trophic levels can cause irreversible change to phytoplankton populations (Stoermer 1988). These human impacts are evident in Okanagan lakes as well.

An extensive bloom of *Microcystis areuginosa var. major* occurred in the south end of Okanagan Lake during the first week of June in 1998. Water clarity was reduced in areas of the lake to only a few centimeters and foul odors were reported hundreds of metres inland. Large accumulations of surface foams occurred on Okanagan Lake from August through to late fall of the same year. Plankton were implicated in the later event, and cell densities in 1998 certainly were elevated over the previous two seasons; however the mechanisms contributing to these two events remain unknown. These events perhaps illustrate that in spite of three decades of periodic study, many aspects of the Okanagan lakes and their response to a quickly changing landscape remain unknown. Improved estimates of nutrient loading, nutrient limitation and food chain studies of Okanagan and Kalamalka lakes will be necessary to better understand their limnology.

SUMMARY STATEMENTS

Hydrologic variability between 1996, 1997 and 1998 probably caused significant variation in spring total phosphorus levels in Kalamalka and Okanagan lakes.

Spring total phosphorus levels have not changed appreciably over the 25 year study period, but do vary significantly from year to year due to increased loading from the watershed during years of high runoff. Okanagan Lake data shows a slight decline in spring total phosphorus while Kalamalka Lake shows no trend.

Over the past 15 years (1984 to 1998) average spring TP has been slightly lower in Okanagan Lake than Kalamalka Lake. Previous to that (1969 to 1983) the reverse was more often the case.

Spring total nitrogen does not show an obvious positive relationship to hydrologic discharge in either lake over the study period 1969 to 1998.

Total nitrogen is slowly increasing in Okanagan and Kalamalka lakes. Kalamalka Lake has slightly higher total nitrogen levels but significantly higher spring nitrate levels than Okanagan Lake.

Spring nitrate nitrogen has increased significantly in Okanagan and Kalamalka lakes over the 25 year study period. Spring total nitrogen in Kalamalka Lake is similar to Armstrong Arm of Okanagan Lake.

Nitrogen to phosphorus ratios in both Okanagan and Kalamalka lakes indicate that phosphorus limits phytoplankton growth during the spring and fall periods. Nutrient limitation studies should be carried out to provide current information during the growing season.

Water clarity in Okanagan Lake, during the fall months, increased from 1973 to 1987 but has been decreasing since then.

Water clarity of Kalamalka Lake during the fall may be decreasing, however the variation in marl precipitation from year to year is very high and likely obscures any changes due to plankton.

Phytoplankton density in Okanagan and Kalamalka Lakes has not changed appreciably in number since 1969. Blue-green algae continue to dominate phytoplankton numbers but *Lyngbya limnetica* may be increasing in dominance relative to other blue-greens.

Phytoplankton biovolume estimates suggest a more varied composition of diatoms, cryptophytes and blue-greens as co-dominants in spring and summer assemblages of Okanagan Lake except in Armstrong Arm where *Lyngbya* biovolume appears to dominate much of the year. Algal biovolume in Kalamalka Lake is dominated by phytoflagellates, greens and diatoms. Refinement of phytoplankton biovolumes would be required to verify this.

ACKNOWLEDGEMENTS

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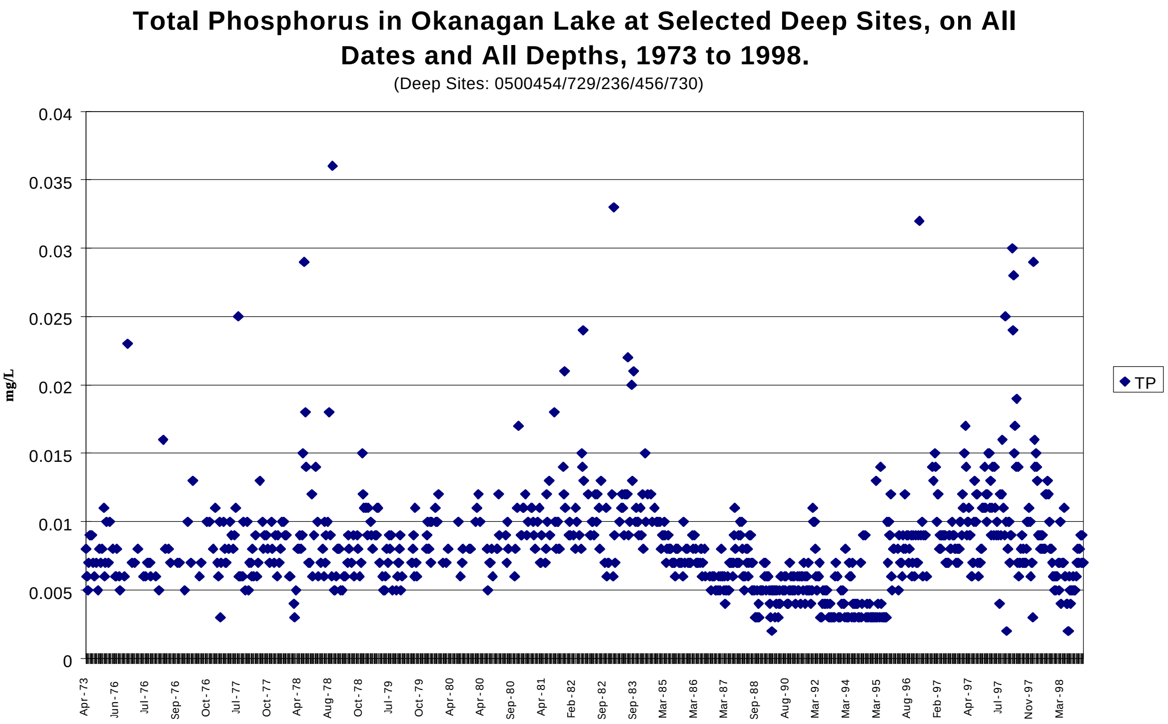


Figure 2.

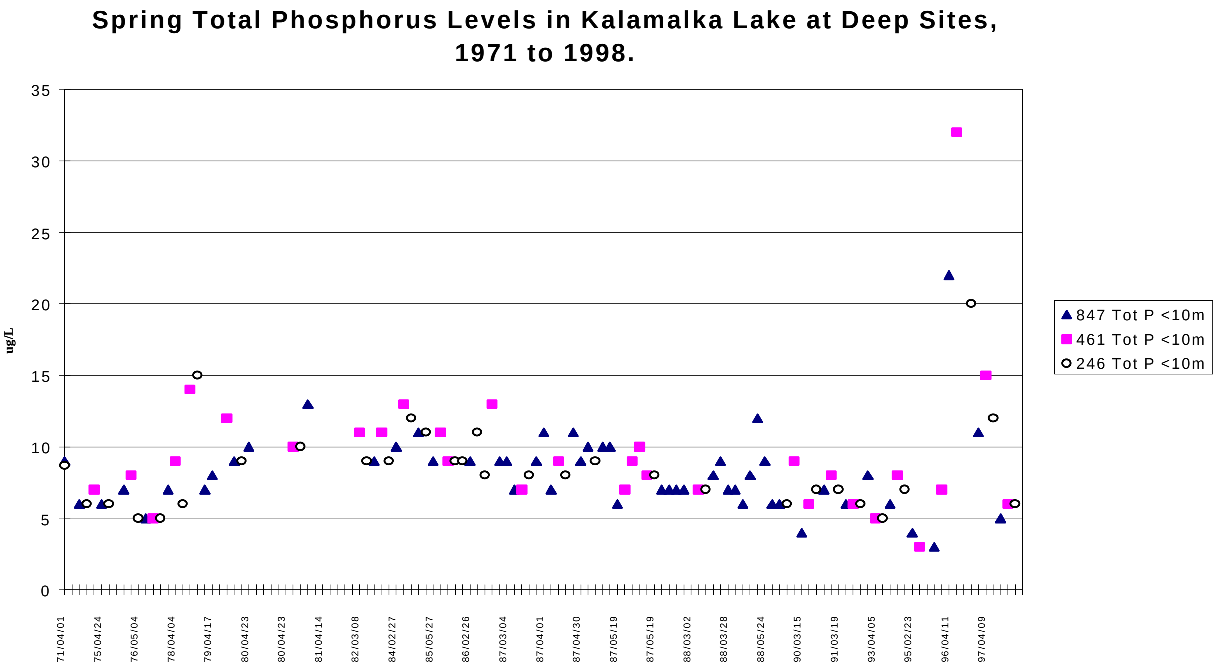
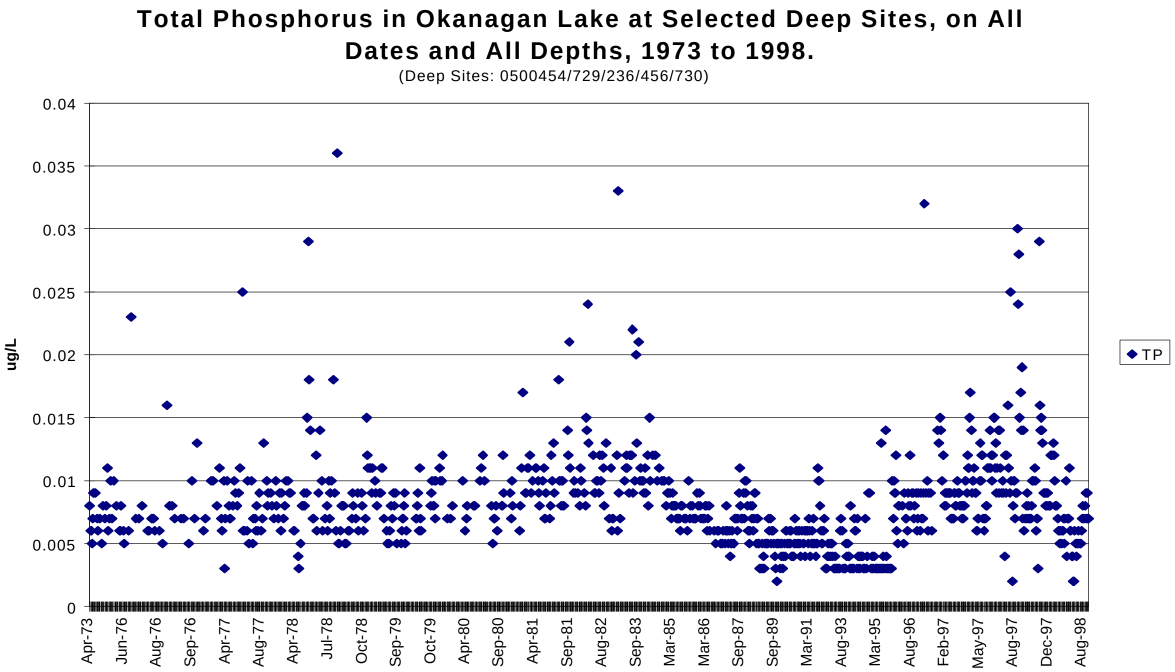
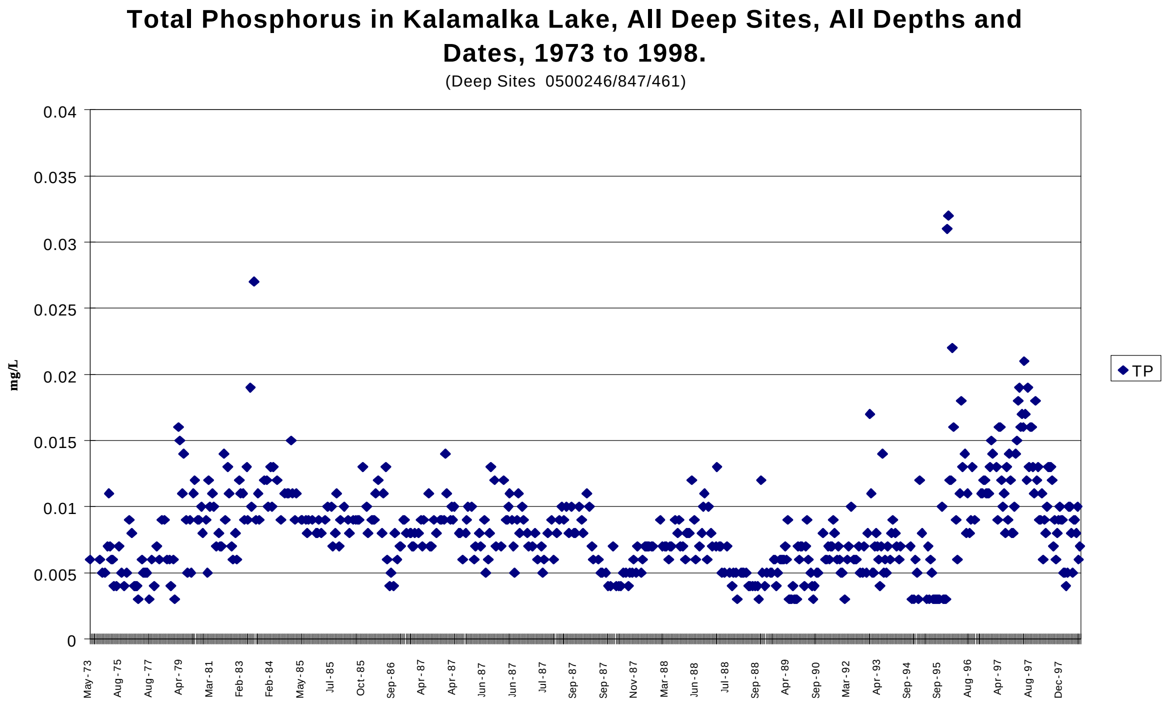


Figure 3.


Total Phosphorus in Okanagan Lake at Selected Deep Sites, on All Dates and All Depths, 1973 to 1998.

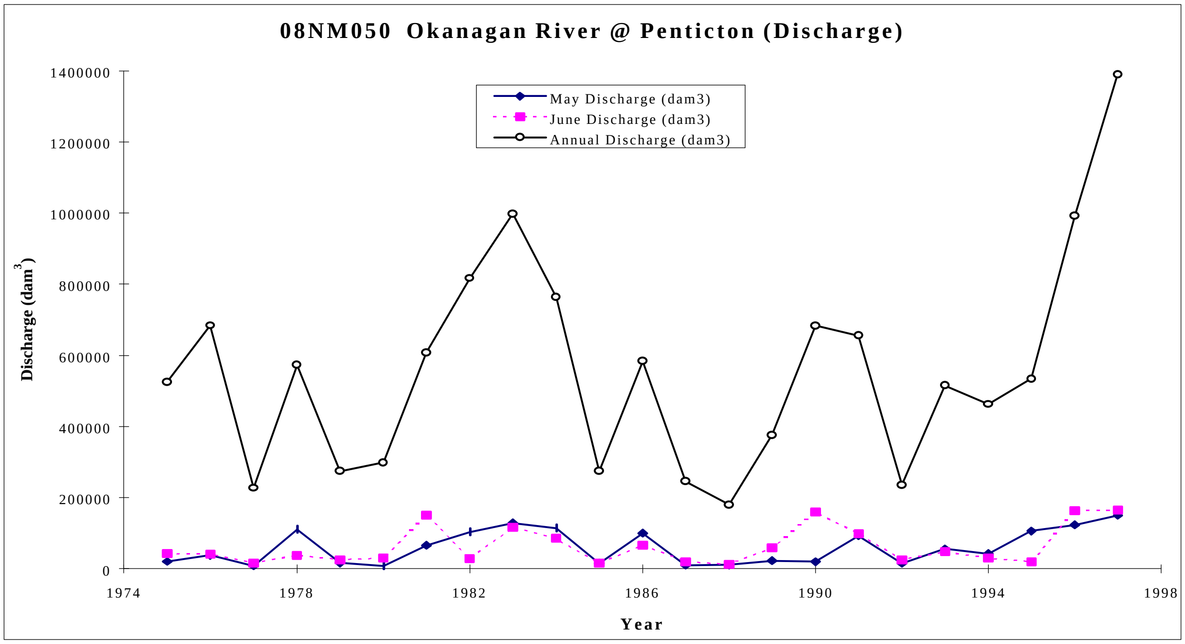
(Deep Sites: 0500454/729/236/456/730)

Figure 4.


Total Phosphorus in Kalamalka Lake, All Deep Sites, All Depths and Dates, 1973 to 1998.

(Deep Sites 0500246/847/461)

Figure 5.



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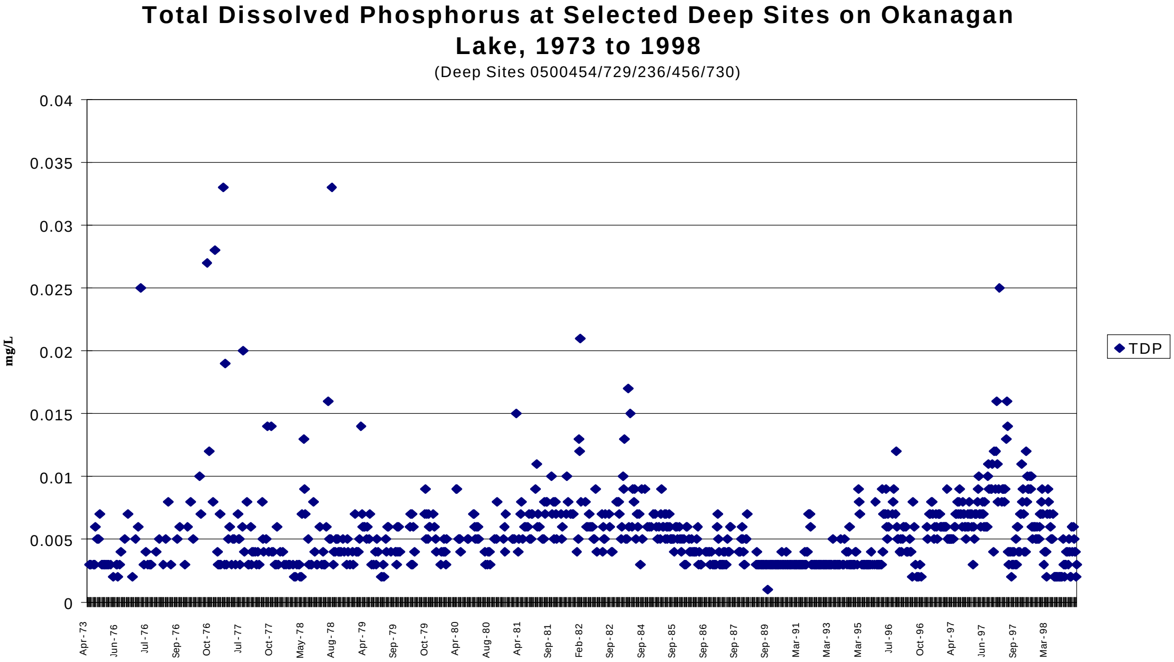

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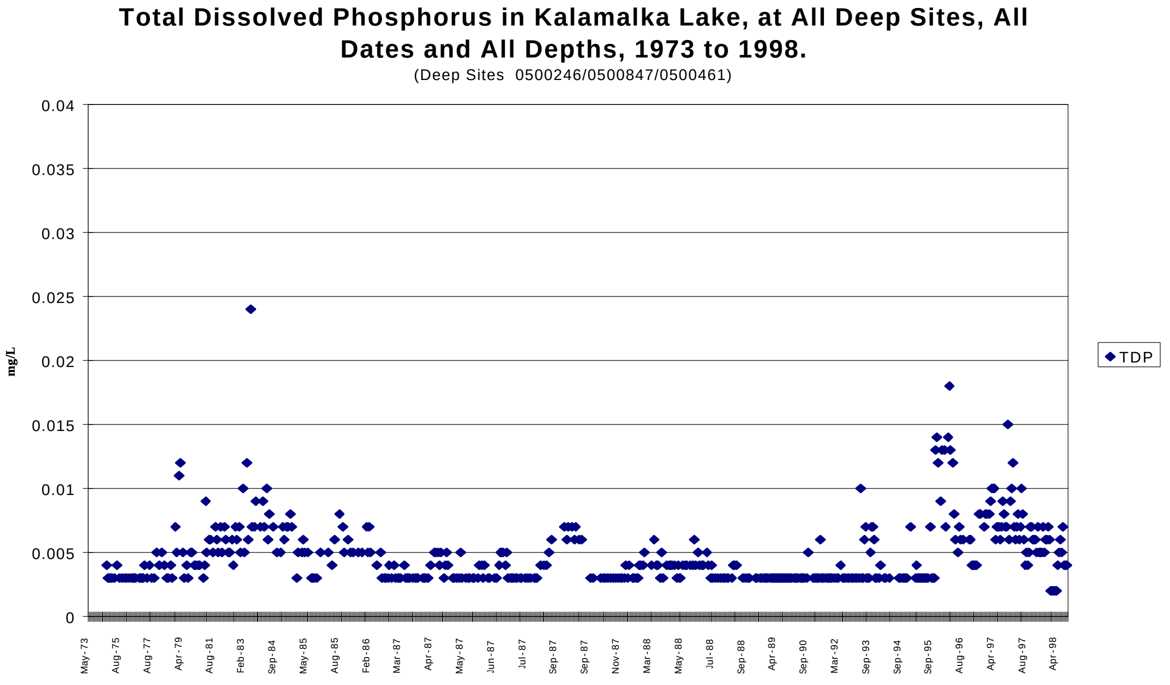

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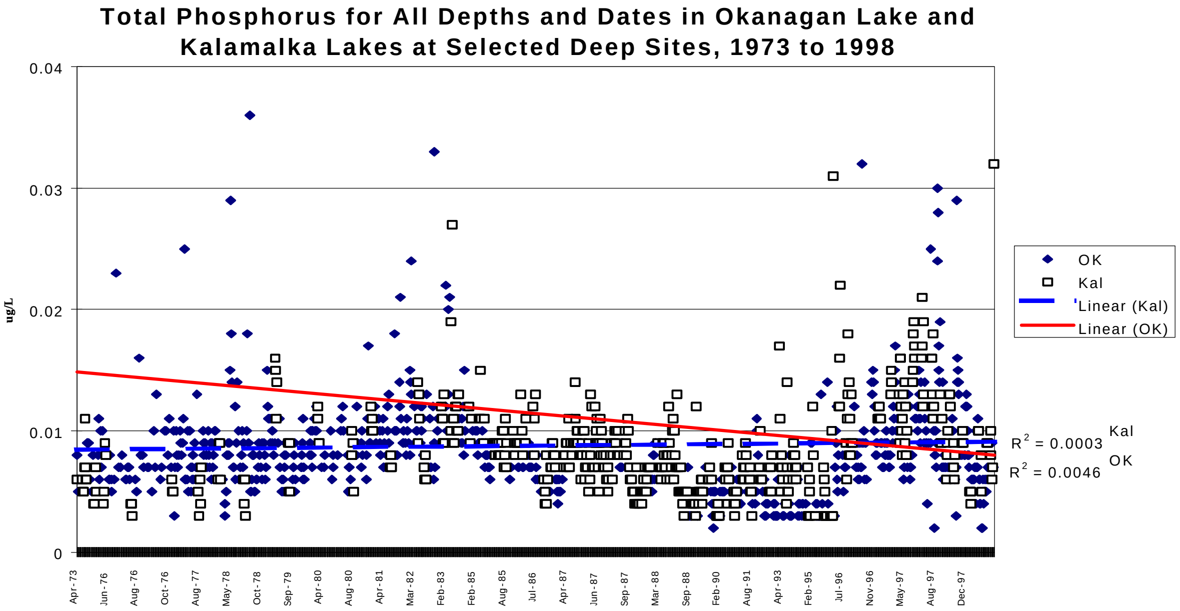

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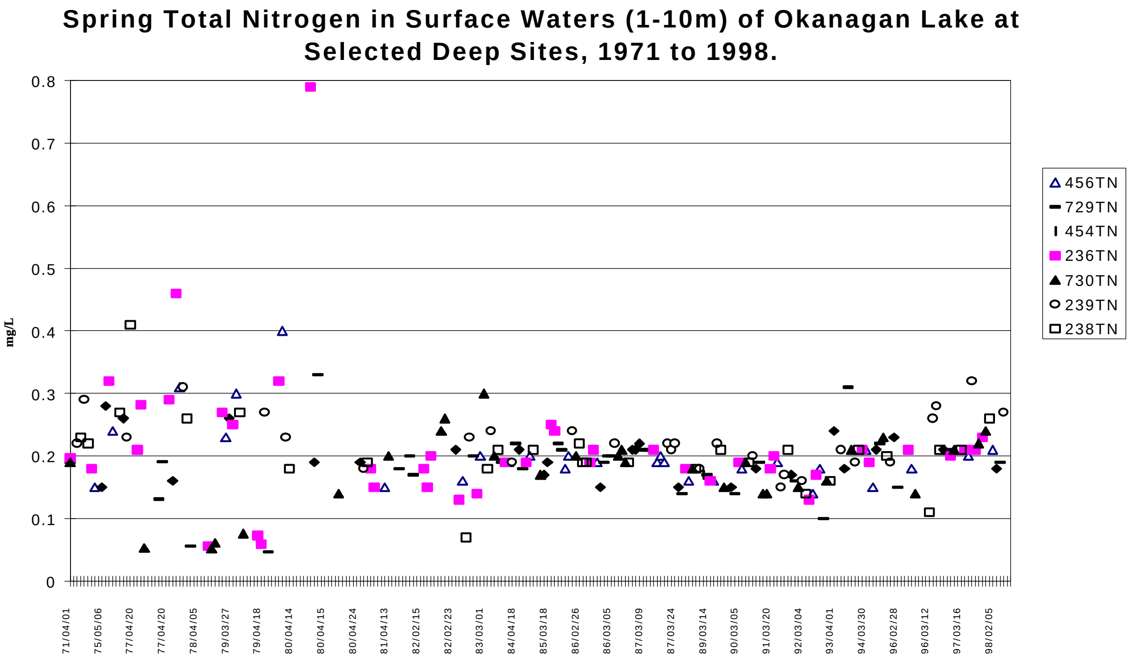

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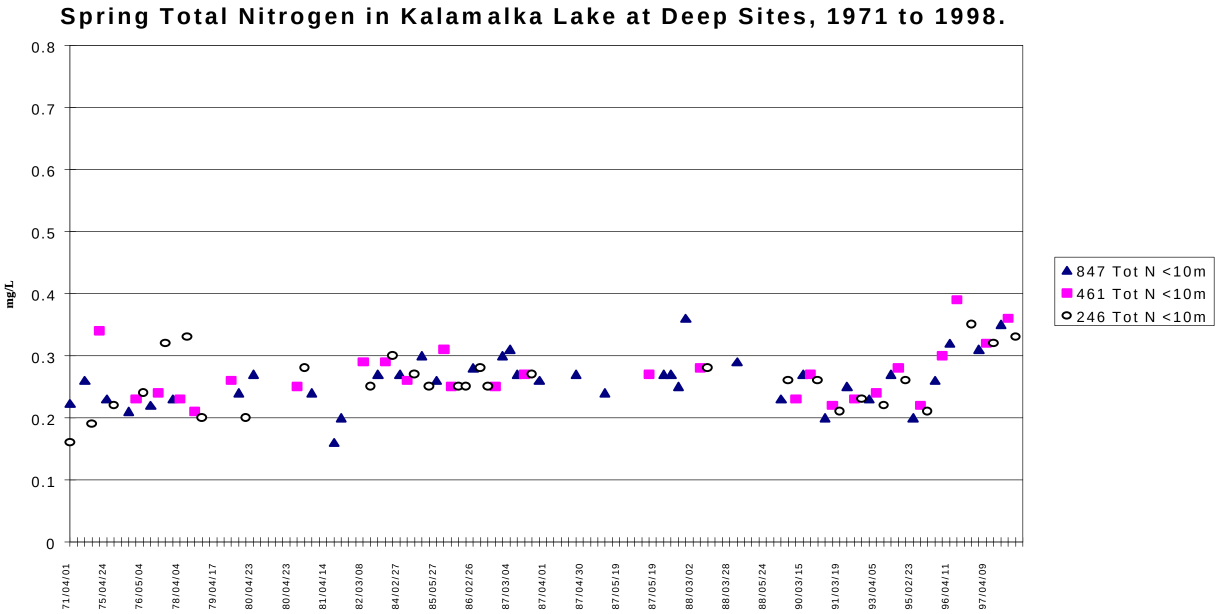


Figure 11.

Total Nitrogen at Selected Deep Stations on Okanagan Lake, All Dates and Depths, 1973 to 1998

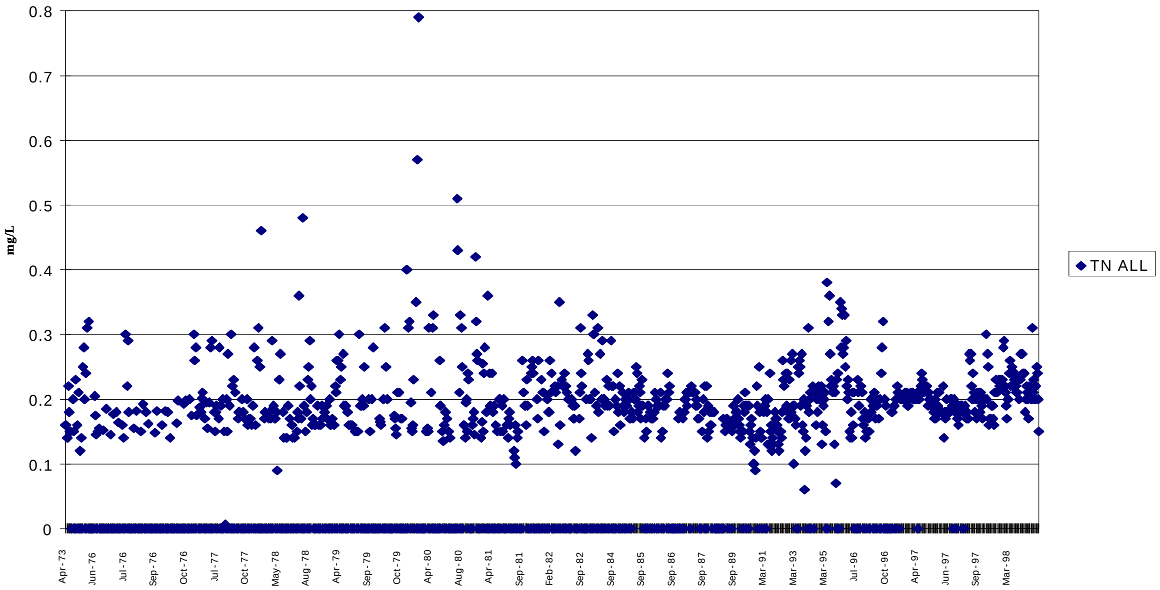


Figure 12.

Total Nitrogen in Kalamalka Lake, All Deep Sites, All Dates and All Depths, 1973 to 1998

(Deep Sites 0500461/246/847)

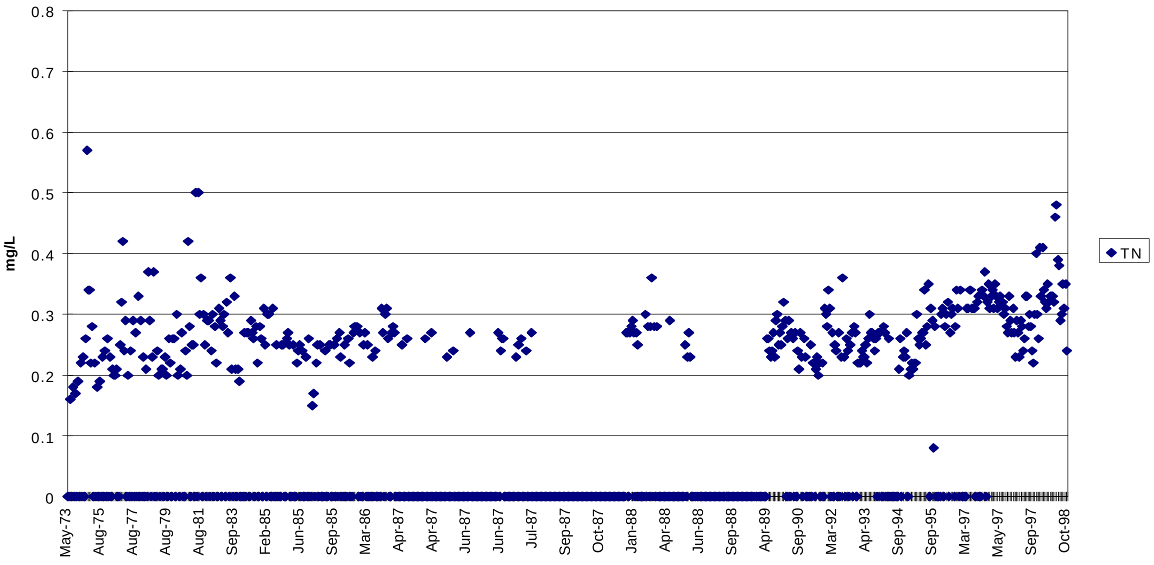


Figure 13.

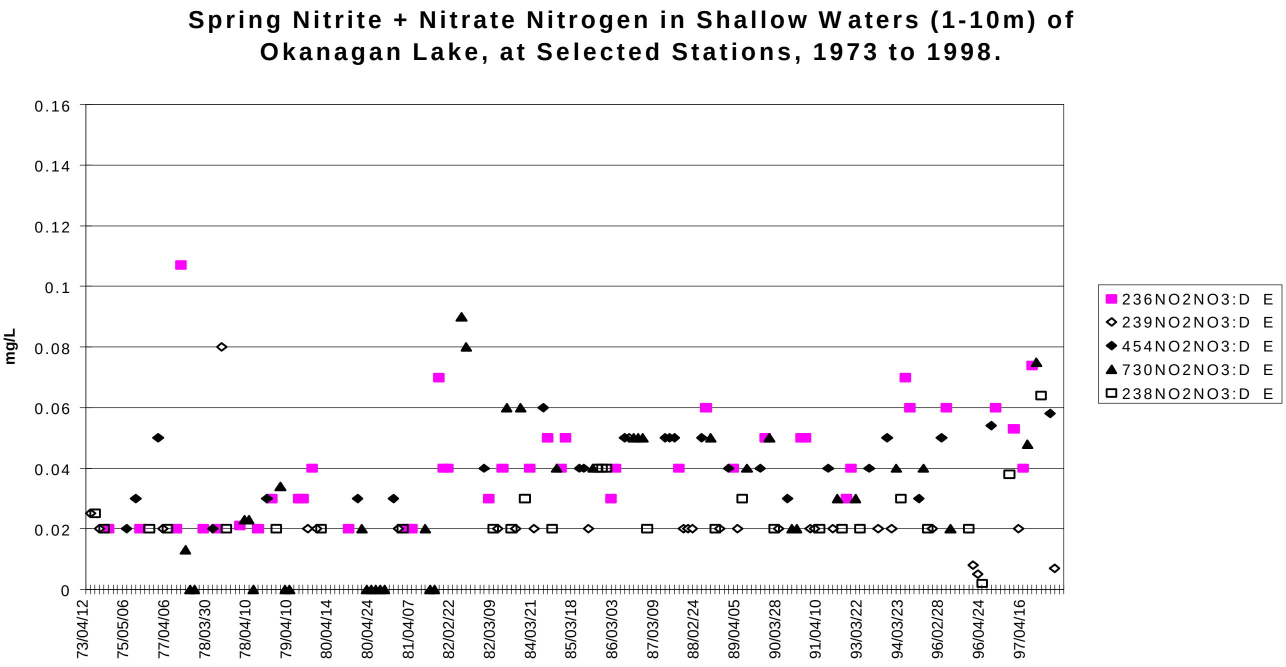

Spring Nitrite + Nitrate Nitrogen in Shallow Waters (1-10m) of Okanagan Lake, at Selected Stations, 1973 to 1998.

Figure 14.

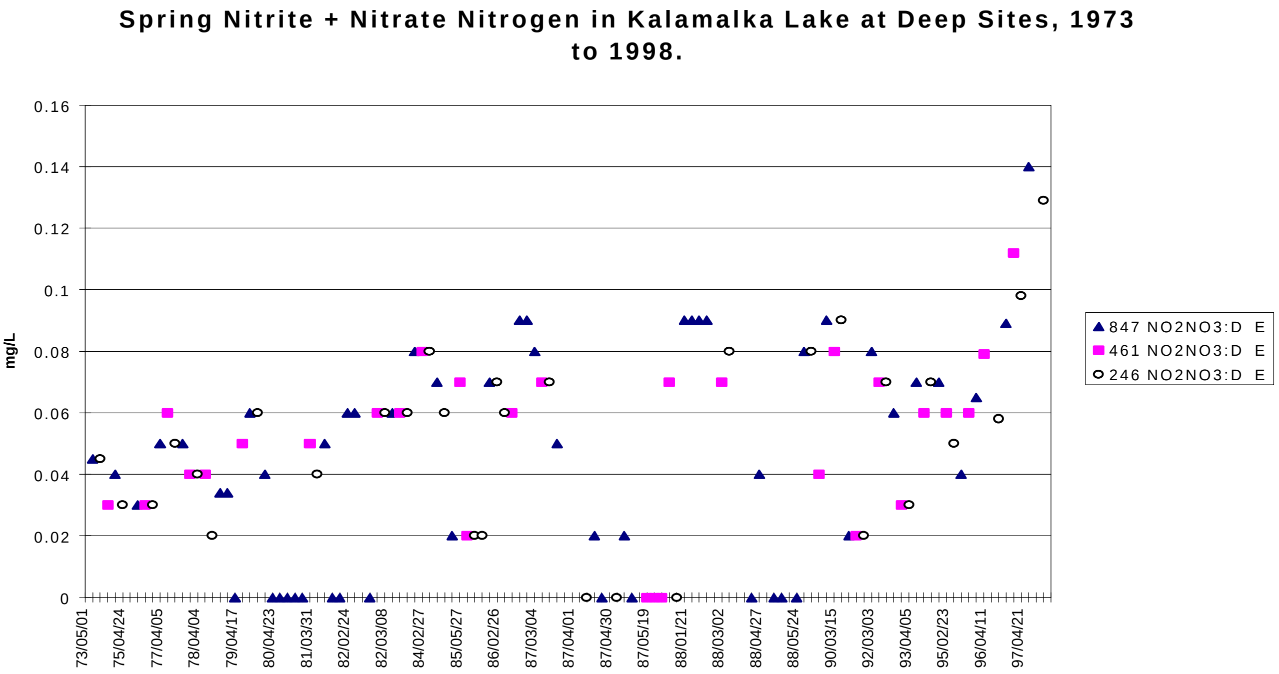
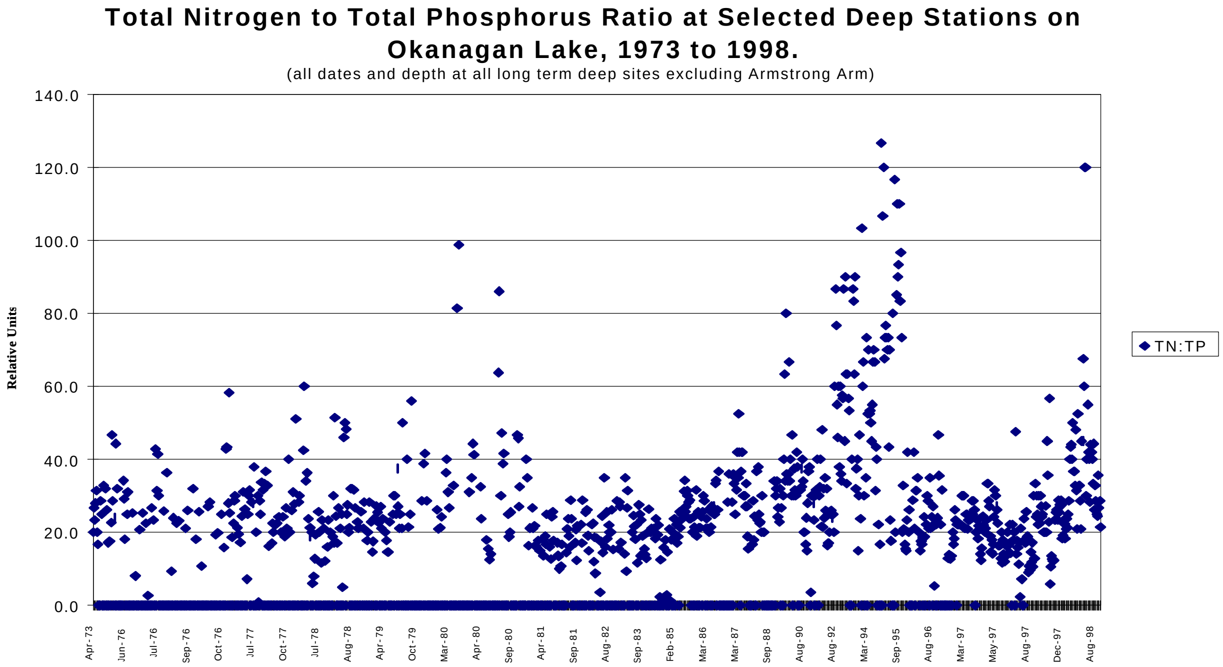

Spring Nitrite + Nitrate Nitrogen in Kalamalka Lake at Deep Sites, 1973 to 1998.

Figure 15.



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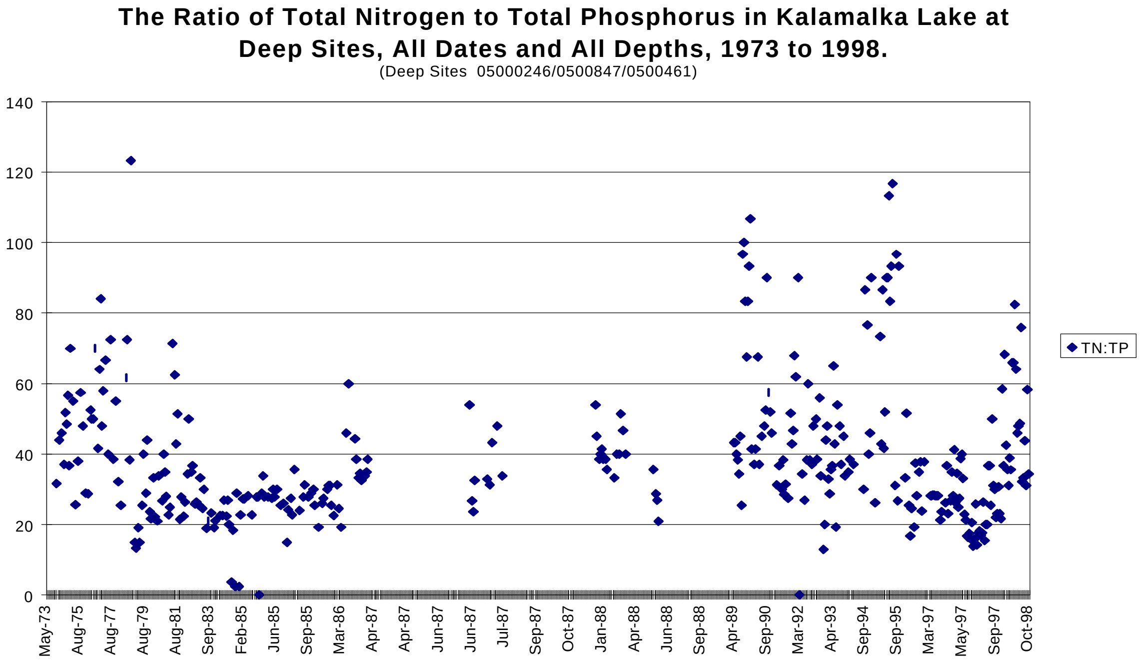
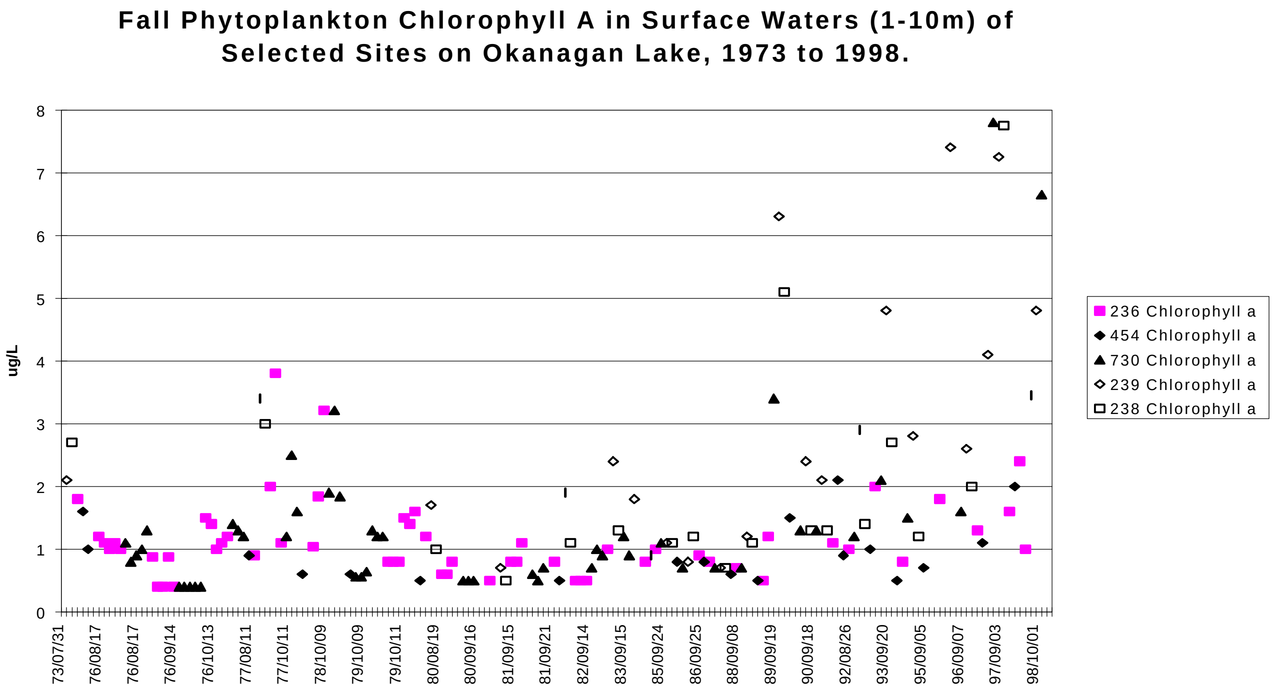


Figure 17.



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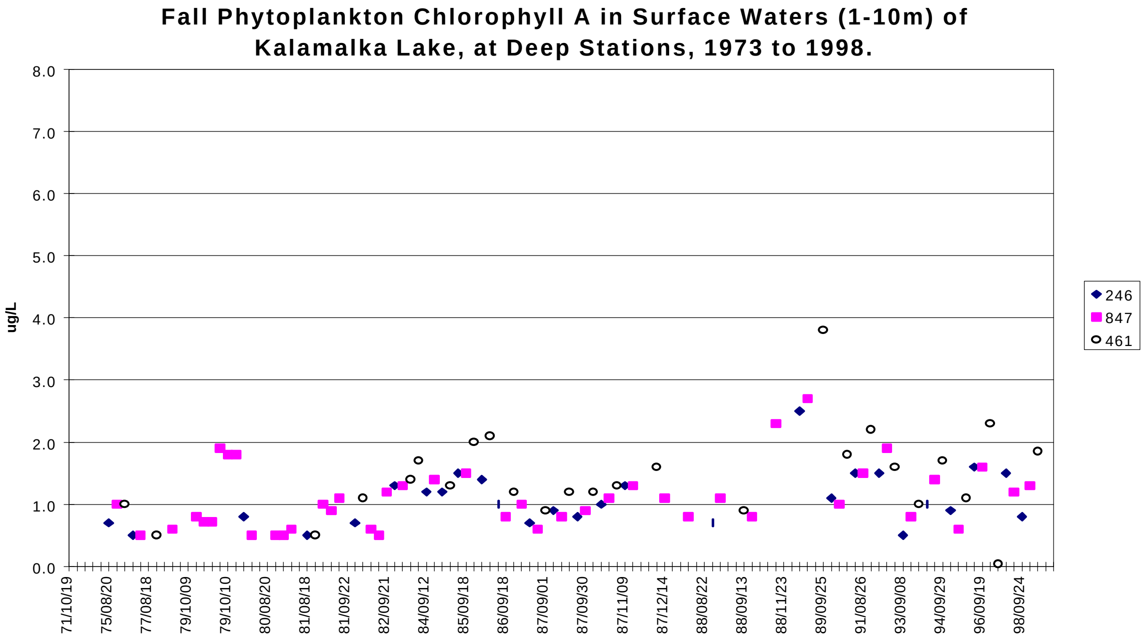
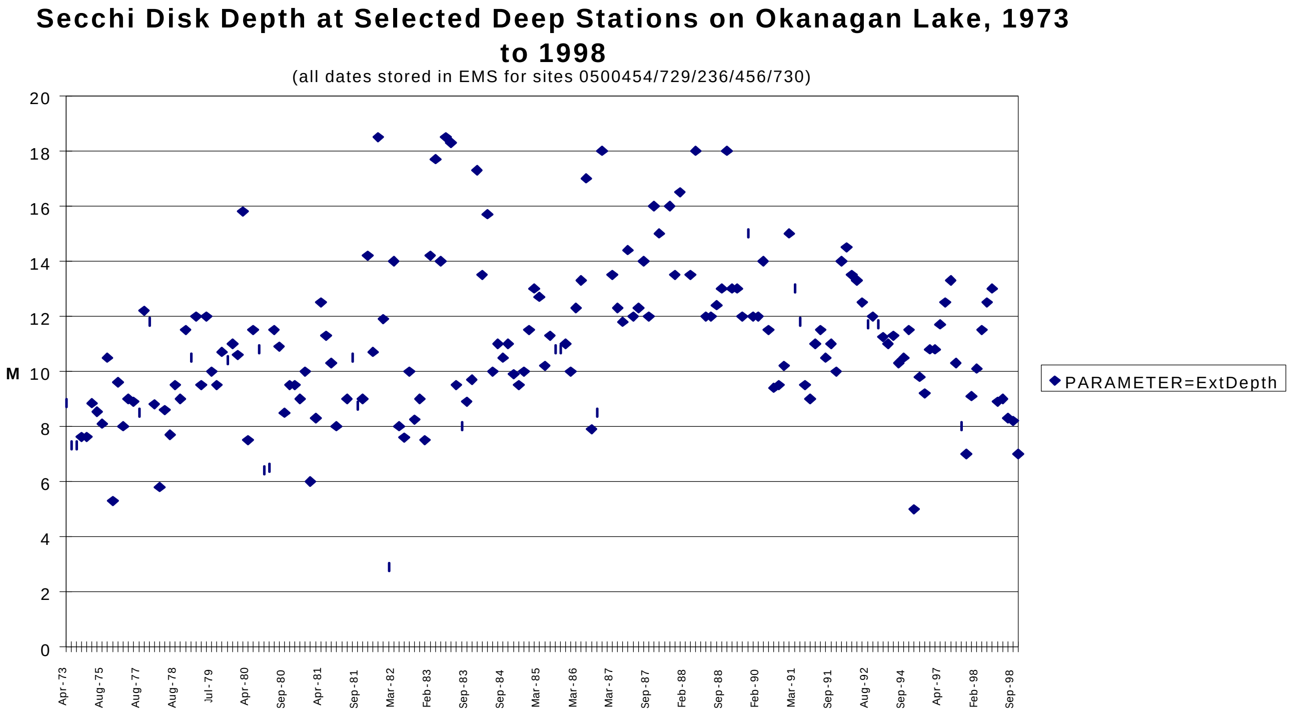


Figure 19.


Secchi Disk Depth at Selected Deep Stations on Okanagan Lake, 1973 to 1998

(all dates stored in EMS for sites 0500454/729/236/456/730)

Figure 20.

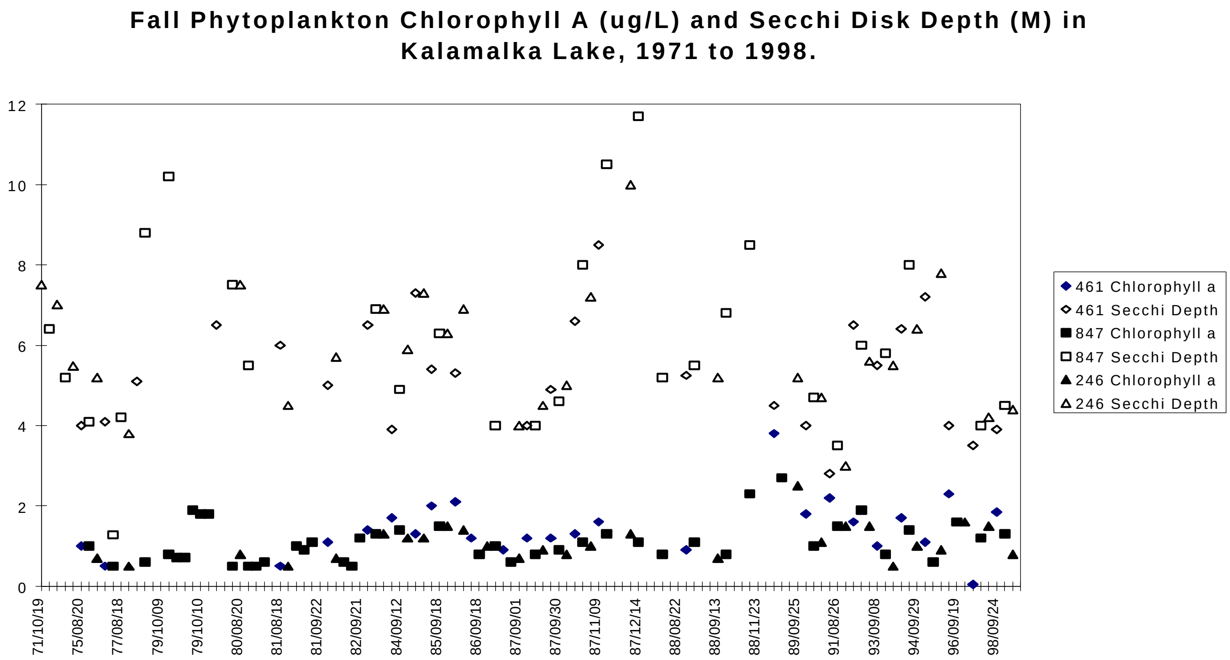

Fall Phytoplankton Chlorophyll A (ug/L) and Secchi Disk Depth (M) in Kalamalka Lake, 1971 to 1998.

Figure 21.

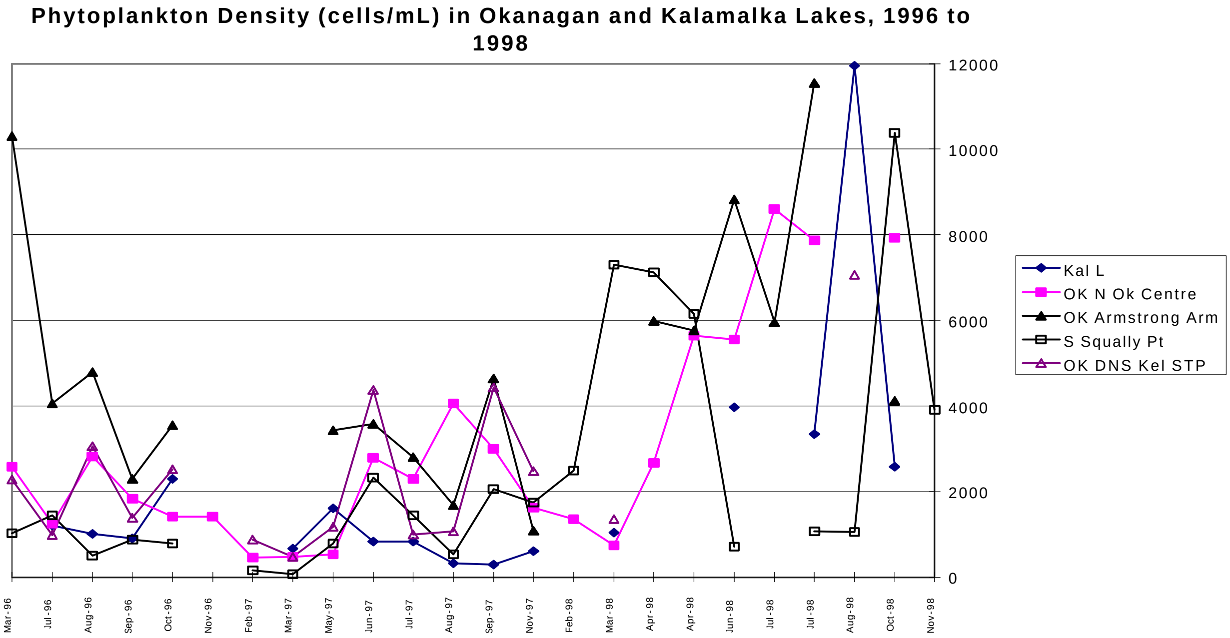
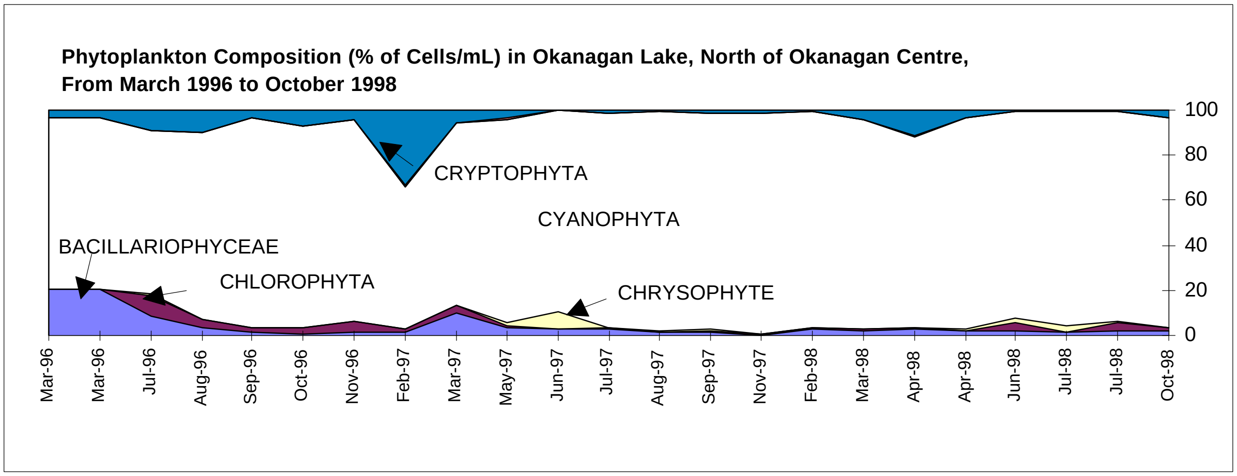
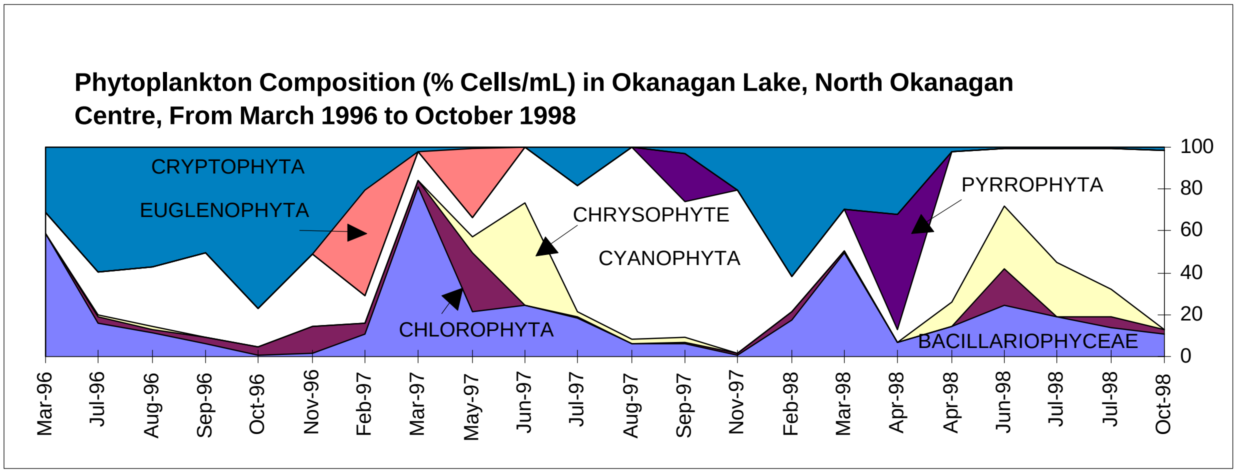

Phytoplankton Density (cells/mL) in Okanagan and Kalamalka Lakes, 1996 to 1998
12000
10000
8000
6000
4000
2000
0
Mar-96
Jul-96
Aug-96
Sep-96
Oct-96
Nov-96
Feb-97
Mar-97
May-97
Jun-97
Jul-97
Aug-97
Sep-97
Nov-97
Feb-98
Mar-98
Apr-98
Apr-98
Jun-98
Jul-98
Jul-98
Aug-98
Oct-98
Nov-98
Kal L
OK N Ok Centre
OK Armstrong Arm
S Squally Pt
OK DNS Kel STP

Figure 22.

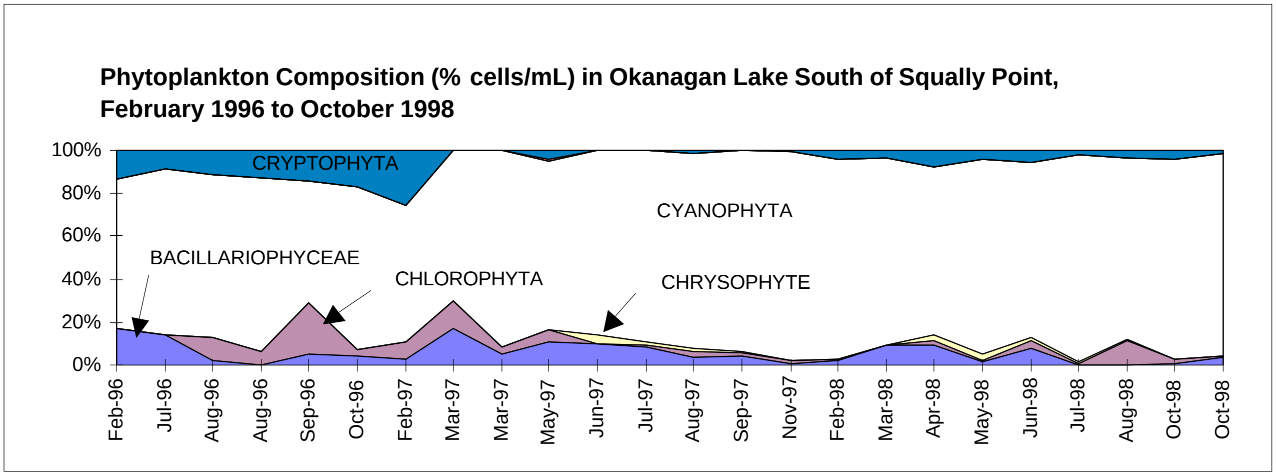


Phytoplankton Composition (% of Cells/mL) in Okanagan Lake, North of Okanagan Centre, From March 1996 to October 1998

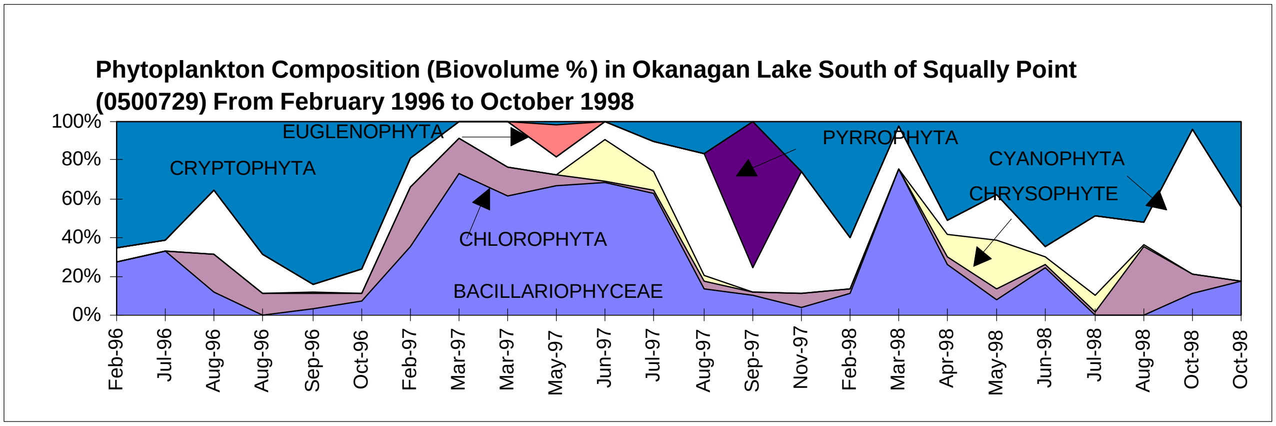


Phytoplankton Composition (% Cells/mL) in Okanagan Lake, North Okanagan Centre, From March 1996 to October 1998

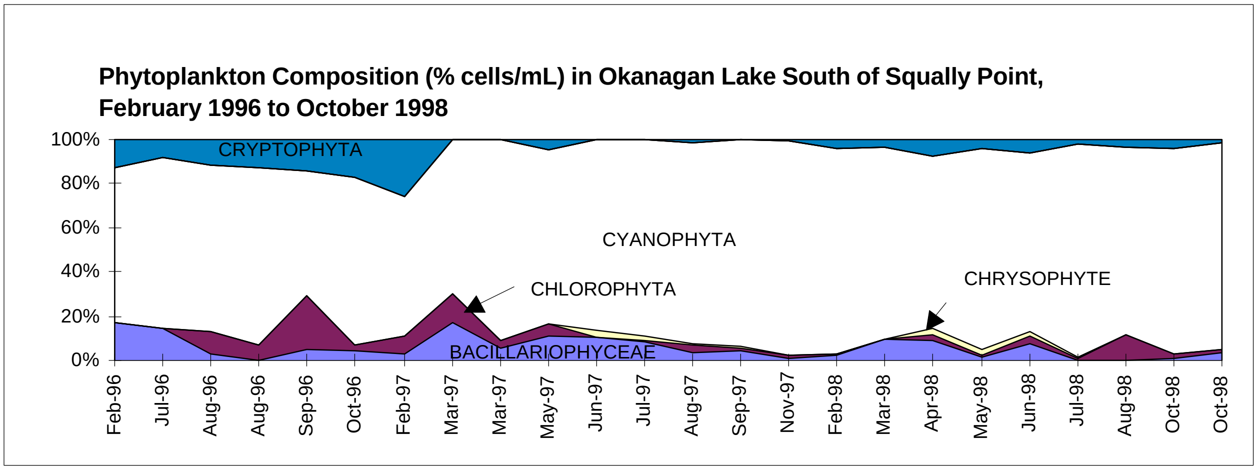
Figures 23a and 23b



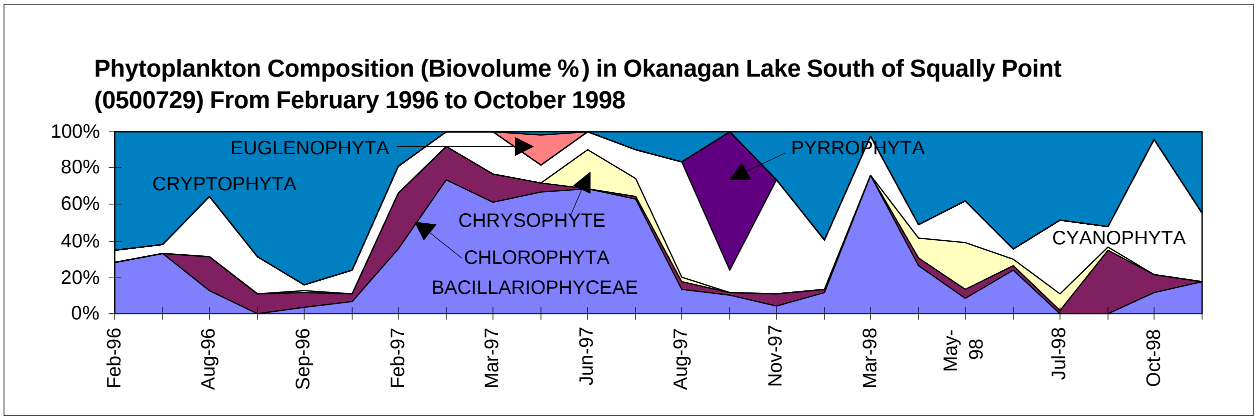
Phytoplankton Composition (% cells/mL) in Okanagan Lake South of Squally Point, February 1996 to October 1998



Phytoplankton Composition (Biovolume %) in Okanagan Lake South of Squally Point (0500729) From February 1996 to October 1998

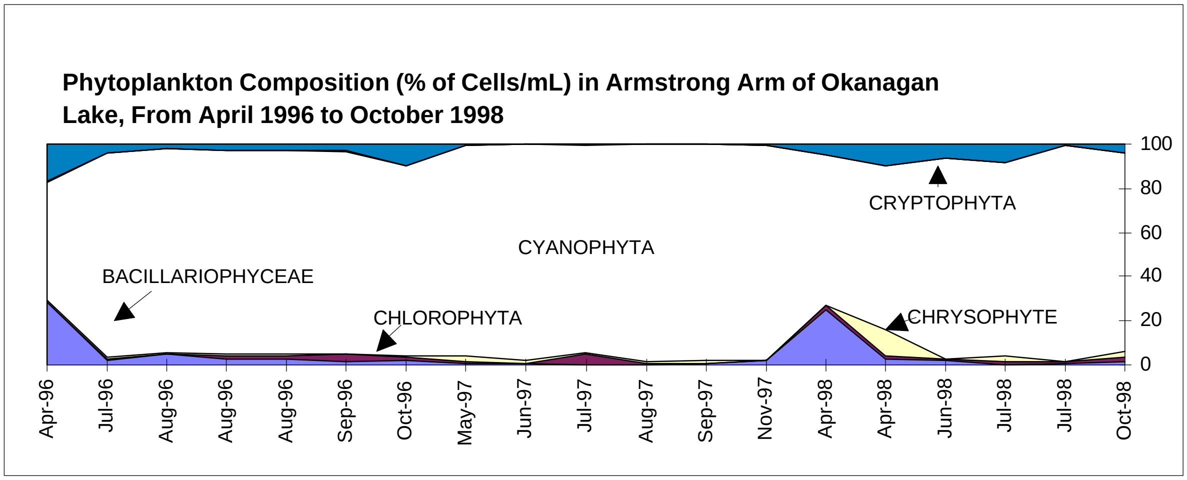


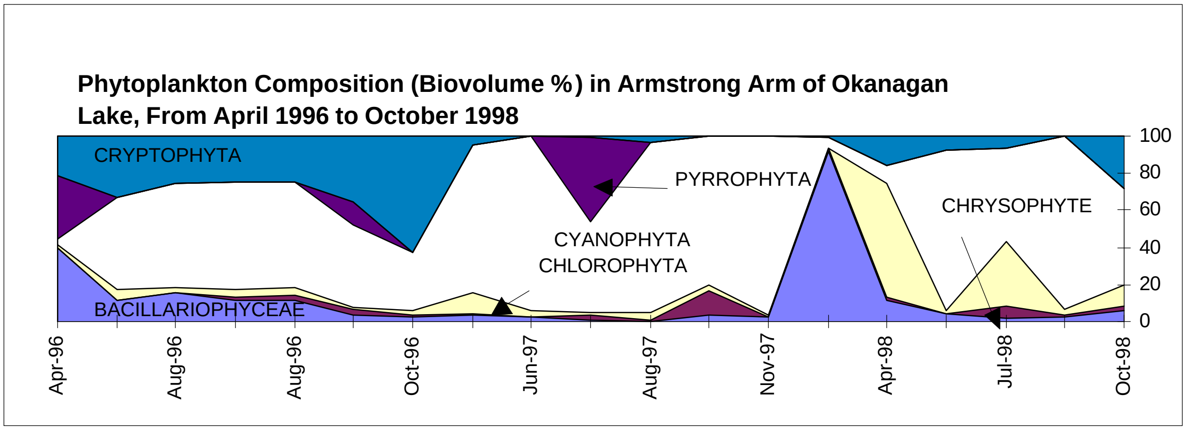
Phytoplankton Composition (% cells/mL) in Okanagan Lake South of Squally Point, February 1996 to October 1998



Phytoplankton Composition (Biovolume %) in Okanagan Lake South of Squally Point (0500729) From February 1996 to October 1998

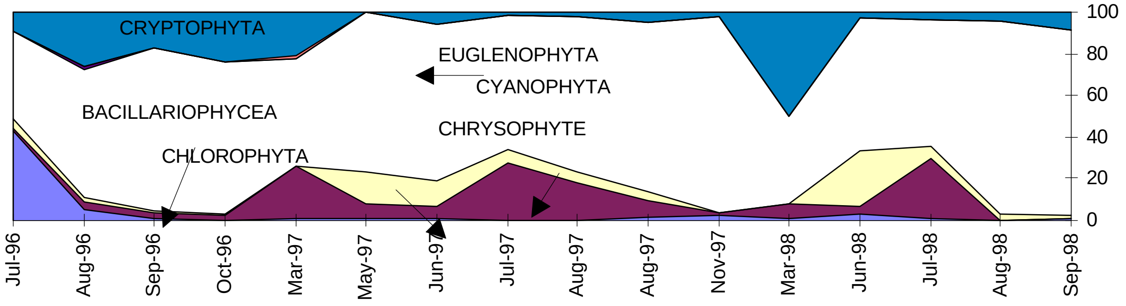
Figures 24a and 24b


Phytoplankton Composition (% of Cells/mL) in Armstrong Arm of Okanagan Lake, From April 1996 to October 1998

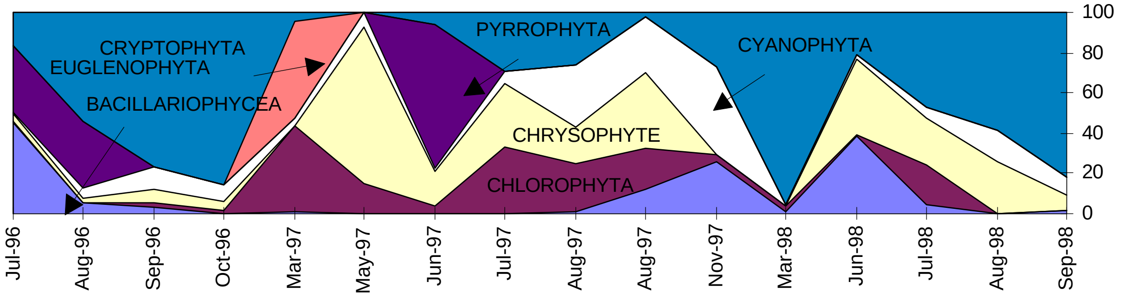

Phytoplankton Composition (Biovolume %) in Armstrong Arm of Okanagan Lake, From April 1996 to October 1998

Figures 25a and 25b

Phytoplankton Composition (% Cells/mL) in Kalamalka Lake at Deep Site (0500847), July 1996 to September 1998



Phytoplankton Composition (Biovolume %) in Kalamalka Lake at Deep Site (0500847), July 1996 to September 1998



Figures 26a and 26b

Appendix 1. Biovolume Estimates Used for Okanagan and Kalamalka Lake Phytoplankton

BACILLARIOPHYCEAE (Diatoms)			**CHLOROPHYTA (Greens)**			**CYANOPHYTA (Blue Greens)**		
Order : Centrales	**um3**	**source**	**Order : Chlorococcales**	**um3**	**source**	**Order : Oscillatoriales**	**um3**	**source**
Coscinodiscus sp.			*Ankistrodesmus falcatus*	200	1	*Lyngbya limnetica*	10	1
Cyclotella bodanica	750	1	*Ankistrodesmus spiralis*	25	1	*Lyngbya subtilis*	10	1
Cyclotella glomerata	60	1	*Ankistrodesmus*	200		*Lyngbya contorta*	10	1
Cyclotella kutzingiana	100	1	*Botryococcus braunii*	50	10	*Lyngbya*	10	1
Cyclotella ocellata	180	1	*Botryococcus*	50		*Oscillatoria agardhii*	15	1
Cyclotella	180		*Closteriopsis*	2440		*Oscillatoria limnetica*	15	1
Melosira granulata	750	1	*Coelastrum*	10000	5	*Oscillatoria tenuis*	15	1
Melosira italica	100	1	*Crucigenia quadrata*	23	2	*Oscillatoria*	15	1
Melosira varians	2000	1	*Crucigenia rectangularis*	23		*Pseudanabaena catanata*		
Melosira	530	1	*Crucigenia*			*Pseudanabaena*		
Rhizosolenia eriensis/longiseta	250	1	*Elakatothrix gelatinosa*	75	5	Order : Nostocales		
Rhizosolenia	250	1	*Elakatothrix*	75	5	*Anabaena affinis*	85	
Skeletonema sp?			*Nephrocytium*	100		*Anabaena spiroides*	125	1
Stephanodiscus niagarae	5000	4	*Oocystis lacustris*	200		*Anabaena flos-aquae*	85	1
Stephanodiscus tenuis			*Oocystis*	200		*Anabaena*	100	1
Stephanodiscus	750	1	*Quadrigula*	60		*Aphanizomenon flos-aquae*	200	1
Order : Pennales			*Scenedesmus*	100		*Anabaena planktonica*	75	1
Achnanthes minutissima	50	1	*Schroederia sp.*	80		*Anabaena*	100	1
Achnanthes	100		*Selenastrum*	75	5	Order : Chroococcales		
Amphora ovales	320	1	*Sphaerocystis schroeteri*	250	1	*Agmenellum tenuissima*		
Amphora	300	1	*Sphaerocystis*	250		*Anacystis elachista*	50	
Asterionella formosa	120	7	Order : Ulothricales			*Anacystis elakista*	50	
Asterionella	120		*Geminella*			*Anacystis limneticus*	50	
Ceratoneis arcus	2500	1	*Ulothrix*	75		*Anacystis*	50	
Cocconeis	510	1	Order : Volvocales			*Aphanothece*	10	4
Cymatopleura	3360	1	*Chlamydomonas*	250	4	*Coelosphaerium naegelianum*		
Cymbella affinis	1300	3	*Gonium sociale*			*Chroococcus*	250	1
Cymbella	1300	1	Order : Tetrasporales			*Dactylococcopsis smithii*		
Diatoma elongatum	400	1	*Elakatothrix*	70	1	*Gomphosphaeria aponica*	25	1
Diatoma	400		*Gloeocystis ampla*	500	1	*Gomphosphaeria aponina*	25	1
Epithemia sorex	820	1	*Tetraspora sp.*			*Gomphosphaeria pallidum*	25	
Epithemia	820		Order : Zygnematales (Desmids)			*Gomphosphaerium pallidum*	25	
Eunotia	500		*Arthrodesmus*	1000	5	*Gomphosphaeria sp.*	25	
Fragilaria crotonensis	500	1	*Closteriopsis*	2400		*Merismopedia*	8	4
Fragilaria	500		*Closterium*	2250	5	*Synechosystis sp.*		
Frustulia	2000		*Cosmarium*	3000	4	CRYPTOPHYTA		
Gomphonema	300	1	*Mougeotia*			Order : Cryptomonadales		
Meridion circulare	400	1	*Spondylosium planum*	300		*Chroomonas acuta*	30	1
Meridion	400		*Spondylosium*	300		*Chroomonas*	30	1
Navicula	250	1	*Staurastrum paradoxum*	20000	4	*Cryptomonas marsonii*	2000	5
Nitzschia dissipata	560	1	CHRYSOPHYTA			*Cryptomonas ovata / erosa*	5500	5
Nitzschia	125	1	Order : Ochromonadales			*Cryptomonas*	5500	
Pleurosigma/Gyrosigma			*Dinobryon bavaricum*	500	1	PYRROPHYTA		
Rhizosolenia	3000		*Dinobryon divergens*	500	1	Order : Dinokontae		
Rhopalodia gibba	8920	3	*Dinobryon cylindricum*	700	1	*Ceratium hirundinella*	70000	1
Stauroneis			*Dinobryon*	500		*Dinoflagellate*		
Surirella	1500		Order : Chrysomonadales			*Gymnodinium*	10000	4
Synedra acus	100	1	*Mallomonas acroides*	1500	5	*Peridinium inconspicuum*	20000	1
Synedra actinastroides	300	1	*Mallomonas*	1500		*Peridinium sp.*	20000	1
Synedra delicatisima	750	1	*Mallomonas*	1500		EUGLENOPHYTA		
Synedra ulna	5000	1	*Chromulina sp.*	150	5	Order : Euglenales		
Synedra	1000	1	Order : Rhizochrysidales			*Euglena*	9000	5
Tabellaria fenestrata	1025	1	*Diceras phaseolus*			*Phacus*	5000	5
Tabellaria flocculosa	1000					*Trachelamonas*		
Tabellaria	1000							

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MISSION CREEK KOKANEE SPAWNING CHANNEL DATA SUMMARY

1988 to 1998

by

H. Andrusak[1]

INTRODUCTION

Mission Creek is the largest kokanee spawning stream on Okanagan Lake (Shepherd *in:* Ashley et al. 1998) and probably also for rainbow trout (Wightman and Sebastian 1979, MS). In 1971, over 300,000 kokanee were enumerated through a fish fence located on Mission Creek 1.2 km upstream from Okanagan Lake (Northcote et al. 1972). Over the last two decades, kokanee escapements have been gradually decreasing, with an unprecedented low of only 1,000 in Mission Creek and 12,000 for all streams recorded in 1998. Over the past twenty years much of the lower 10 km has been channelized for flood control purposes. However, the downward trend in kokanee numbers has not been restricted to Mission Creek alone as other smaller tributary stream escapements also have declined (Shepherd in Ashley et al. 1998).

Fisheries management began to seriously consider improvements to Mission Creek fish habitat as early as the mid 1970s. A series of technical assessments of Mission Creek habitat capability were conducted (see Wightman and Sebastian 1979, MS; Wightman 1980, MS; and Wightman and Yaworski 1982, MS) but the primary focus of these studies was rainbow trout. Concern for kokanee in Mission Creek and elsewhere in Okanagan Lake was expressed by Bull (1987, MS) and again by Shepherd (1990b, MS) as the continued decline in numbers was apparent. A short-term fry stocking program was initiated in the 1980s and Mission and Meadow Creek fed fry were released into Mission Creek from 1986 to 1991.

Consideration of enhancing Mission Creek for kokanee spawning actually began with some stream assessment work by Tredger in the late 1980s (see Tredger 1988, MS; Tredger 1989a,b, MS). Private property constraints and priority for flood control severely limited fish habitat improvement options. Somewhat ironically the opportunity for kokanee enhancement in Mission Creek arose from an abandoned irrigation dam. In 1980 a water diversion channel was excavated parallel to Mission Creek as part of the Smithson-Alphonse Dam removal project. This diversion ditch, located approximately 8 km upstream from Okanagan Lake, was abandoned and then reconfigured in 1988 to form a rudimentary kokanee spawning channel. After several years of minor modifications and a series of flood and siltation events the channel was completely re-engineered and renovated in 1995. Reasons for channel renovation included improved water intake to resolve low flow problems associated with ice-jams, settling pond reconstruction to

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reduce sedimentation in the channel and channel lining to prevent loss of water during the summer months.

Commencing in 1990, efforts were made to assess kokanee spawner use and fry production from the channel (Shepherd 1990a, MS). Since 1991, annual adult and subsequent fry production estimates have been made by Dr. P. Dill and assisted by students from Okanagan University College. Dill and or his students have reported on adult and subsequent fry production since 1991 (see references for individual reports). Spawning channel renovations occurred in 1995 and 1996 resulting in no fry production estimates in 1994 and 1995.

This report summarizes results from the Mission Creek spawning channel found in annual reports of Dill (1990 to 1993, 1996, 1998, MS), Andolfatto and Dill (1997, MS), Taylor and Dill (1997; MS) and other data collected by Ministry of Environment-Fisheries staff over the years.

BACKGROUND

Okanagan Lake has been the subject of some large-scale studies primarily driven by the agricultural and domestic demand for and shortage of water. In 1969, a Canada-British Columbia Okanagan Basin Agreement was reached between the two levels of government. A series of studies was launched in an attempt to integrate development and management of water resources in the Okanagan Basin (Shepherd 1990b, MS). The main report (Canada-British Columbia Okanagan Basin Agreement, 1974) included several key recommendations for fish including specific stream flows to protect Mission Creek fish and fish habitat. Also recommended by the Okanagan Basin work was design and implementation of a habitat improvement program for Mission Creek. It was during the Basin Agreement work that Northcote et al. (1972) conducted the first and only full enumeration of kokanee spawning in Mission Creek using a counting fence.

Okanagan Lake at one time supported a very productive sport fishery for kokanee and rainbow trout. An estimate of fishing effort in 1971 was 188,000 angler hours resulting in a catch of 178,000 kokanee (Shepherd 1994b, MS). By the early 1990s annual effort had increased to approximately 250,000 hours but kokanee catch had declined to only 37,000 (Shepherd 1994, MS). By the mid 1990s the collapse of kokanee was very evident and a ban on fishing for kokanee was imposed in 1995.

As noted earlier, the observed decline of Okanagan Lake kokanee was initially believed to be due to poor stream spawning success resulting from stream channelization and severe water withdrawals for agriculture. Some limited success in kokanee stocking of the lake from 1987 to 1991 (Shepherd 1994, MS) and some specific stream stockings with hatchery reared fed-fry probably masked the continued downward trend of wild kokanee numbers. Aside from stream habitat deterioration the impact of *Mysis relicta* on kokanee fry survival was recognized as a problem by Shepherd (1990, MS) but the degree of impact was poorly understood. A workshop conducted in 1995 identified that lake carrying capacity had decreased and that no “quick fix” solutions were possible (Ashley and Shepherd 1996, MS). Mysid competition with kokanee for zooplankton, and/or deterioration of spawning habitat, were also identified as limitations to kokanee.

A comprehensive interdisciplinary, long-term Action Plan to rebuild wild kokanee was developed in late 1995 (Ashley and Shepherd 1996). The action plan was designed to gain a better understanding of whole lake biological relationships, define limiting factors and identify and implement remedial measures. Key to understanding and resolving the problems facing kokanee in Okanagan Lake is a good data set that can be used to track changes both to the stream and shore spawning populations, as well as in-lake changes. The work on Mission Creek and, specifically the Mission Creek spawning channel, offers the best opportunity for long-term trend analysis.

SITE DESCRIPTION

Mission Creek is the primary drainage of the local Midway Mountains on the western slope of the Monashee Mountain range with a drainage area of approximately 880 km^2. The lower 19 km of Mission Creek is accessible to spawning rainbow trout (Wightman and Sebastian 1979, MS) and kokanee from Okanagan Lake. At this point, there is an impassable set of waterfalls and cascades known as Gallagher's Falls. The lower 13 km of Mission Creek has been channelized to varying degrees for flood control purposes as it flows through agricultural and residential areas adjacent to and within the City of Kelowna.

The lower end of present day Mission Creek spawning channel is located approximately 7 km upstream of Okanagan Lake within the City of Kelowna. The channel (Fig. 1) is now 900 m long and 3.6 m wide and has an average reach gradient of 0.025 % (Bill Mottram, Ministry of Fisheries, Victoria BC, pers. comm.). It is located on the south side of Mission Creek in the Sutherland Regional Park, Kelowna, BC.

METHODS

Escapements

Dill (1990 to 1993, 1996, 1998, MS) and Taylor and Dill (1997, MS) visually counted adult fish in the channel every second day in the early 1990s. In recent years, daily counts have been once or twice per week with frequency of counts dependent upon run timing, occurrence of peak spawning and mortalities. Cumulative fish-days were determined as the fish days under the live-count curve. Carcass counts were also made at weekly or twice-weekly intervals in the latter part of the 1990s, but every second day in the early 1990s. Extrapolations were made between actual counts to determine spawner numbers on those days not sampled. Annual escapement estimates were determined from the live curve count (fish days) divided by the residence time. Residence time was determined annually by best fitting the daily live count curve with the carcass count curve. The exact method and detail of sampling frequency for a specific year can be found in the annual reports of Dill (1991 to 1993,1996, 1998, MS) and Taylor and Dill (1997, MS). A detailed updated description of estimating residence time can be found in Dill and Larson (1995, MS).

Aside from spawner counts, some biological data also were collected annually. Length (nose-fork length) of a minimum 100 fresh, dead fish have been recorded annually and scale samples taken.

In 1997 and 1998, otoliths were also taken for age determination, due to concerns over resorption of scales of larger and presumed older fish. Sex ratios and egg retention of female spawners were also recorded. In some years, fecundity was obtained by directly counting eggs from pre-spawning fish. In most years a regression formula of fecundity on length was used to derive fecundity. Dill (1992a, MS) developed a length-fecundity equation using pre-spawning mortalities (eggs still in skeins) randomly collected from the Mission spawning channel in 1991 and 1992. The resultant equation was:

$$\mathrm{Log}_{10}(\mathrm{Eggs}) = 3.260 \times \mathrm{Log}_{10}(\text{length in mm}) - 5.215 \ (r^2 = 0.79;\ n = 85)$$

Ministry of Environment-Fisheries (Fisheries Branch) stream spawner surveys were also conducted on Mission Creek independent of Dill’s work as part of the annual Okanagan Lake stream survey work (B. Shepherd, pers. comm. Penticton Fisheries Branch). Each year a two-person crew walked the stream and visually estimated spawner numbers. These counts were conducted at least once every ten days at the beginning of the spawning season with frequency reduced to once every five days prior to and just after the peak of the run. More detail on methods used to estimate stream spawners can be found in Shepherd (*in:* Ashley et al. 1998).

For this report, all stream survey peak counts were adjusted by 1.5 to provide an estimate of total number. The 1.5 adjustment was based on data from Dill[1] (Table 1) and results of enumerations for several years at Hill Creek spawning channel on Arrow reservoir (Andrusak 1999, MS).

Fry Enumeration

The onset of kokanee fry outmigration was determined with a single 30 cm wide fyke net that was fished overnight. Once outmigration began, a standard sub-sampling netting procedure commenced (Andolfatto and Dill 1997, MS). Fry sampling consisted of placing three traps each 31 cm wide 31 cm high and 61 cm deep equidistant across the 3.6 m wide channel. At the sampling site the channel bed is level therefore the cross sectional area is fully sub-sampled. The traps were typically placed in the channel at dusk and fished for a designated period of time each hour every hour until dawn. If fishing ceased prior to dawn a correction factor was employed to account for the time period not sampled in order to estimate the entire night out-migration. Fishing times of 1 to 20 minutes per hour were used and adjusted within the night to catch 15 to 25 fry per net. The number of fry passing by the sampling site per night were extrapolated from the hourly sub sample and the number over the entire spring period were extrapolated from the estimates on sample nights (Dill 1997, MS). In most years fry sampling occurred virtually every night.

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[1] The sum of Dill’s peak counts divided into the sum of his total estimates for eight years data = 1.54

RESULTS AND DISCUSSION

Methods and procedures employed to determine escapements, egg deposition and subsequent fry production estimates at the Mission Creek channel have been sufficiently consistent to allow for comparisons from 1991 to 1998. Reconstruction of the channel in 1995 to 1996 precluded fry production estimates for 1994 and 1995.

Escapements

Dill's work from 1991 to 1998 and Taylor and Dill (1997, MS) provides two spawner estimates; an instantaneous peak count by visual estimation and an estimate of total numbers derived from the area under the live curve. As well, stream survey work conducted by MELP-Fisheries crews provides an estimate of peak count for Mission Creek and the spawning channel (Table 1). Methods and detailed results of this survey work can be found in Shepherd (*in:* Ashley et al 1998).

Total spawner numbers in the channel determined by Dill (1991 to 1993, 1996, 1998, and Taylor and Dill 1997, MS) are shown in Figure 2 along with the Fisheries crew stream survey results. Except for 1990, there has been good agreement for total estimated numbers for all years between the stream survey method and Dill's estimates. Highest estimated use of the channel was in 1992 (25,541 fish) with the lowest year 1997 having only 3,422 spawners (Table 1).

A density of 7 to 8 kokanee per m^2 has been considered the optimum for spawning channels (Andrusak 1999, MS). Since Mission Creek kokanee were slightly larger than most kokanee found in BC lakes 7 fish per m^2 was used as the design standard. With this density the theoretical carrying capacity of the Mission Creek channel is approximately 21,000 fish. Only in 1992 was the channel filled to capacity, with all other years less than 50%. This is probably due to the location of the channel relatively far upstream of the lake, declining numbers, as well as only partial diversion of fish into the channel in some years.

Length of Spawners

Length measurements of Mission Creek kokanee spawners have been taken since the early 1970s. Mean size has ranged from 255 to 352 mm with an overall mean of 279 mm (Fig. 3; Table 2). This is similar to the value of 260 mm that Northcote et al. (1972) reported for Mission Creek kokanee sampled in 1971. Males tend to be slightly larger than females (Fig. 3). Length frequencies (Fig. 4) from 1990 to 1997 illustrate a primary mode at 230 to 260 mm. At least two much smaller modes are evident at 330 to 370 mm and 400 to 440 mm suggesting several year classes contribute to the spawning population.

Mission Creek kokanee tend to be larger than Kootenay and Arrow lakes kokanee, which are typically 20 to 23 cm in size (Andrusak 1999, MS). They are similar in size to West Arm of Kootenay Lake kokanee, which are usually 26 to 30 cm at spawning. Both West Arm of Kootenay Lake and Mission Creek kokanee have some very large size individual fish that are >40 cm.

Table 1. Stream escapements estimated by MELP Fisheries field crews and Mission Creek estimates by Dill (1990 to 1993, 1996, 1998 and Taylor and Dill 1997, MS)

	MELP - Fisheries Escapement Estimates 1971 to 1997			**Mission Channel Estimates by Dill (1990 to 1997)**	
				Spawning channel	
YEAR	**Stream Peak Count x 1.5**	**Channel Peak Count**	**Stream + Channel**	**Peak Count**	**Total Estimate**
1971	312,100		312,100		
1972	N/A				
1973	N/A				
1974	136,304				
1975	40,434				
1976	31,957				
1977	33,913				
1978	90,653				
1979	117,391				
1980	78,261				
1981	61,957				
1982					
1983	37,826				
1984	76,304				
1985	98,478				
1986	41,739				
1987	16,304				
1988	20,217				
1989	13,043	4,566	17,609		
1990	16,304	3,913	20,217	3,975	9,200
1991	61,500	14,022	75,522	8,000	11,765
1992	41,153	23,478	64,630	15,341	25,541
1993	20,870	9,783	30,653	8,812	9,003
1994	12,783	3,783	16,566	2,300	3,881
1995	7,043	3,261	10,304	1,919	6,021
1996	14,804	7,826	22,630	4,598	7,030
1997	8,283	3,653	11,935	2,187	3,422

[2] From Northcote et al. 1972 (actual count from fence operation).

Table 2. Mission Creek kokanee lengths: mean female, male and combined lengths, 1970 to 1997[1].

YEAR	FEMALE N	FEMALE MEAN	FEMALE STD DEV	FEMALE SE	MALE N	MALE MEAN	MALE STD DEV	MALE SE	TOTAL N	TOTAL MEAN	TOTAL STD DEV	TOTAL SE
1970	10	266			10	268			20	267		
1971	25	259			53	264			78	262		
1974	49	255			61	268			110	262		
1986	72	261	21	3	28	275	19	4	100	265	21	2
1987	115	341	83	8	86	367	85	9	201	352	85	6
1988	52	266	26	4	48	273	24	3	100	270	25	3
1989	77	293	57	6	20	257	12	3	97	285	53	5
1990	326	289	53	3	260	303	69	4	587	295	61	3
1991	364	277	57	3	260	304	82	5	626	289	69	3
1992	468	258	47	2	453	262	48	2	921	260	47	2
1993	257	249	30	2	141	266	42	4	398	255	36	2
1994	323	262	55	3	322	271	71	4	645	267	64	3
1995	124	280	55	5	160	303	70	6	284	293	64	4
1996	105	290	51	7	130	309	72	9	235	300	64	6
1997	135	263	60	4	191	272	56	5	327	268	52	4

[1] Data from Penticton Fisheries files.

Age Composition

Northcote et al. (1972) reported the majority of Okanagan Lake kokanee in the summer were age 3 (i.e., 3+ at spawning) although no distinction was made between shore and stream spawners. Shepherd (*in:* Ashley et al. 1998) also reported that the majority of Mission Creek spawners were age 3+ with ages 2+ and 4+ also present. However Shepherd (*in:* Ashley et al. 1998) expressed uncertainty regarding age determination of kokanee using scales due to resorption and summer check problems and concluded that the older age groups could be under-represented.

Otoliths have been collected in 1997 and 1998 because of the uncertainty of using scales for age determination. Limited results from otolith aging suggest the majority of Mission Creek spawners are 3+ (D. Sebastian Ministry of Fisheries, Victoria, BC, pers. comm.). As well, examination of juvenile kokanee caught in September-October (after stream spawning has occurred) by trawl net (Sebastian and Scholten *in*: Ashley et al. 1998) suggest that the majority must spawn as 3+ i.e., the majority of larger, immature juveniles (excluding 0+ fish) caught in the fall are 2+ hence would most likely spawn as 3+ the following year.

Fecundity

Actual counts of eggs per female have been conducted since 1987 with reasonable sample sizes (> 20) available for 1989 through 1995 (Table 3). Derived fecundities have been made since 1991 by Dill (1992b, MS) using a regression formula of fecundity on measured lengths (Table 4). This information has been used to determine channel egg depositions for this report.

Table 3. Mission Creek kokanee fecundity based on actual counts (from Shepherd *in:* Ashley et al. 1998).

		EGGS/FEMALE			FEMALE LENGTH (mm)		
YEAR	**N**	**MEAN**	**STD DEV**	**SE**	**MEAN**	**STD DEV**	**SE**
1987	6	785	427	174	320	50	20
1989	23	611	464	97	339	65	14
1990	49	521	314	45	299	60	9
1991	117	503	326	30	287	69	6
1992	116	451	280	26	265	54	5
1993	21	484	240	52	269	35	8
1994	35	315	233	39	294	70	12
1995	25	446	286	57	305	62	12
1996	2	323	52	37	263	8	6
1997	5	384	110	49	279	16	7

Table 4. Derived fecundities[1] using average length of samples from Mission Creek channel and stream (from Dill 1991 to 1997).

YEAR	FEMALE MEAN L	PREDICTED FECUNDITY
1986	261	461
1987	341	1,101
1988	266	490
1989	293	671
1990	289	642
1991	277	559
1992	258	443
1993	249	395
1994	262	466
1995	280	579
1996	289	641
1997	262	466

[1] Formula from Dill (1992, MS), Using Dill, 1992 regression formula LOG (Egg No) = 3.260*LOG (Length in mm) - 5.215). Table from Shepherd (*in:* Ashley et al. 1998).

Egg deposition

Channel egg deposition estimates are available since 1990 (Table 5). Estimates ranged from a high of 2.5 million (1992) to a low of only 0.57 million (1997). Predicted potential egg deposition for Mission Creek channel at full capacity, using either 3 or 4 females per m^2 is between 4 to 6 million eggs respectively depending upon the annual fecundity estimate.

Actual egg deposition per m^2 has ranged from a high of 772 eggs to a low of 176 eggs per m^2. This assumes that all gravel is utilized but as Taylor and Dill (1997, MS) point out a significant portion of the channel has been less than ideal for spawning due to heavy accumulations of fines and sections with exposed gravel. Kokanee spawning channels for similar sized fish on Kootenay Lake at Kokanee and Redfish creeks have an optimum densities of 2,750 eggs m^2 and 2,400 eggs m^2 respectively (Andrusak 1999, MS).

Fry Production Estimates and Survival Rates

Estimates of fry production have ranged from a high of nearly 0.9 million (1993) to a low of only 46 thousand (1998). The egg-to-fry survival rates have varied from a low of 8% to a high of nearly 43% (Table 5).

Table 5. Estimates of kokanee egg deposition, fry production and egg-to-fry survival rates from Mission Creek spawning channel 1990 to 1998.

Adult Year	Channel	Female Mean Length (mm)	Fecundity	Egg Deposition x 10^6	Fry Year	Fry Production	% egg/fry Survival Rate
1990	9,200	289	500	1.60	1991	484,324	30.3
1991	11,765	277	595	2.46	1992	203,146	8.3
1992	25,541	258	559	2.51	1993	890,361	35.5
1993	9,003	249	392	1.64	1994		
1994	3,881	262	471	0.92	1995		
1995	6,021	280	609	1.35	1996	574,456	42.6
1996	7,030	290	649	1.28	1997	509,873	39.8
1997	3,422	263	429	0.57	1988	45,648	8.0
1998	1,000				1999		

Residence Time

Dill (1991 to 1993, 1996, 1998, MS) estimated residence time of spawners in the channel annually since 1991. Residence time of spawners has varied between 6 to 16 days with an average of about 11 days (Table 6). These estimates are close to the 12.6 days estimated by Northcote et al (1972) for kokanee spawning in Peachland Creek and 12 days assumed for Redfish Creek (Fleck and Andrusak 1977).

Table 6. Estimated residence time of kokanee spawners in Mission Creek channel (Dill 1991 to 1993, 1996, 1998, MS and Taylor and Dill, 1997, MS).

Year	Estimated residence time (days)
1991	9.0
1992	8.8
1993	16.0
1994	15.0
1995	6.0
1996	11.0
1997	10.0
Average time	10.8

Fry-to-adult survival rates

Fry-to-adult survival rates for Mission Creek kokanee cannot be determined directly since there has not been any fry enumerations of the main stream. However, there has been enough data collected from the spawning channel and stream escapements that some crude estimates of fry-to-adult survival rates can be derived for the whole stream (Appendix 2). While these estimates are based on a number of assumptions felt reasonable and supported by data from other kokanee spawning channels, they should not be considered as accurate estimates but rather only as trend indicators for Mission Creek kokanee production.

Appendix 2 displays the population estimate data and extrapolations made to calculate theoretical fry-to-adult survival rates for Mission Creek. Spawner estimates from Shepherd (*in:* Ashley et al. 1998) were assumed to be 50:50 male:female. Slight variation in this ratio makes little difference to the calculated survival rates. Based on Dill's work on the spawning channel a 20% pre-spawn mortality has been assigned as Dill (1995, 1996, and Taylor and Dill 1997, MS) often noted high mortality probably due to very warm >15°C water. A mean spawning channel fecundity of 412 eggs (reduced by 108 eggs due to retention) from Dill (1991 to 1993, 1996, 1998 and Taylor and Dill 1997, MS) was then assigned to the years 1984 to 1989 to determine stream egg deposition for those years. From 1990 to 1997 actual data from Dill (1991 to 1993, 1996, 1998 and Taylor and Dill 1997, MS) was used.

A conservative 5% egg-to-fry survival rate was applied to all stream production, based on natural stream production values of 5 to 8% found at Redfish Creek (Fleck and Andrusak 1977) and Meadow Creek (Andrusak 1999, MS). Since there appears to problems with the quality of the natural spawning habitat in Mission Creek, use of the lower value of 5% was deemed reasonable. For those two years (1994 to 1995) when the spawning channel was not evaluated for fry production a conservative value of 20% egg-to-fry survival was assigned to the channel. This was considered reasonable since the channel was being renovated due to deteriorating conditions and rates had been 30, 8 and 36% in the three previous years.

Kokanee harvest on Okanagan Lake was monitored from 1988 to 1992 and an estimate of 178,000 was made in 1971 and 63,000 in 1988 (Shepherd 1994, MS). Judging from the data in Shepherd (1994, MS) a harvest level of 150,000 was assigned to 1974 and 85,000 was assigned for 1984. Harvests were then extrapolated for 1974 to 1977 and 1984 to 1987. There was no estimate of number of shore vs stream spawners but as Shepherd (1994, MS) pointed out stream spawners were larger than shore spawners and therefore were more vulnerable to fishing. It has been assumed that 60% of the annual harvest was stream-origin fish. It is known that 70% of all the stream spawners have been found in Mission Creek (Shepherd *in:* Ashley et al. 1998) and this factor was used in the final determination of harvest of Mission Creek (only) fish.

Fry-to-adult survival rates have been derived using two scenarios as shown in Appendix 2. Due to uncertainty of age at spawning survival rates have been generated for spawning fish at ages 3+ and 2+. While the survival rate values should not be considered accurate, a downward trend (Fig. 5) is evident using for either age at spawning. Clearly, the very low rates for 1998 adults (for both age scenarios) are very telling, as recruits per spawner have declined well below replacement level.

The downward trend in fry-adult survival rates over the 12 year period supports the theory of Ashley et al. (1998, MS) that in-lake kokanee survival is the primary problem. The fed fry releases (Appendix 2) of the late 1980s appear to be responsible for improved fry-to-adult survival rates in the early 1990s (Fig. 5). At that point in time, a reasonable interpretation may have been that poor stream production was largely responsible for the decline in numbers of spawners (i.e., the decline of Mission Creek kokanee was due only to in-stream problems related to habitat deterioration). However, cessation of fed fry releases in 1992 coincided with increased fry as a result of spawning channel production. Increased fry production due to the channel has not resulted in improved fry-to-adult survival but rather a decline for the 3+ scenario and a “steady state” in the 2+ age scenario (Fig. 5). A decline in fry-adult survival rates even with increased fry production from the channel suggests in-lake survival problems rather than in-stream problems. This assertion is supported by Sebastian and Scholten (*in:* Ashley et al. 1998) who have recorded a downward trend in juvenile kokanee populations in Okanagan Lake, despite increased production from the Mission Creek spawning channel.

SUMMARY

Use of the Mission Creek spawning channel by kokanee spawners has been less than expected primarily because of declining escapements and the distance of the channel from the lake. For these reasons egg deposition densities have been well below the designed optimum. The range of estimated egg-to-fry survival rates suggests the channel is capable of good fry production (>25%) if sufficient spawners are available. The calculated fry-to-adult survival rates suggest in-lake survival problems over shadow any potential in-stream survival rate problems.

RECOMMENDATIONS

1. Use a conversion factor of 1.5 times the peak l count of adult kokanee to estimate stream and channel spawner populations.
2. The frequency of visual counts by the stream survey crew should be increased for Mission Creek with daily counts conducted at time of the peak.
3. Channel enumeration should change to daily trapping and release. This would eliminate uncertainty and bias related to length and fecundity measurements.
4. Kokanee should be diverted into the channel by use of a full mainstem fence until capacity is achieved.
5. A minimum 100 fish should be randomly collected from the lower fence trap and measured for length.
6. A minimum of 60 pre-spawn females should be taken from the trap at the beginning (10), mid point (40) and near end (10) of spawning run for direct egg counts.
7. Otoliths from 60 females and from 60 males should be collected for age determination.
8. Upper fence panels should be replaced with vertical bar wheels commonly used on other kokanee spawning channels.
9. Fry enumeration methods should continue to be conducted as described by Dill.

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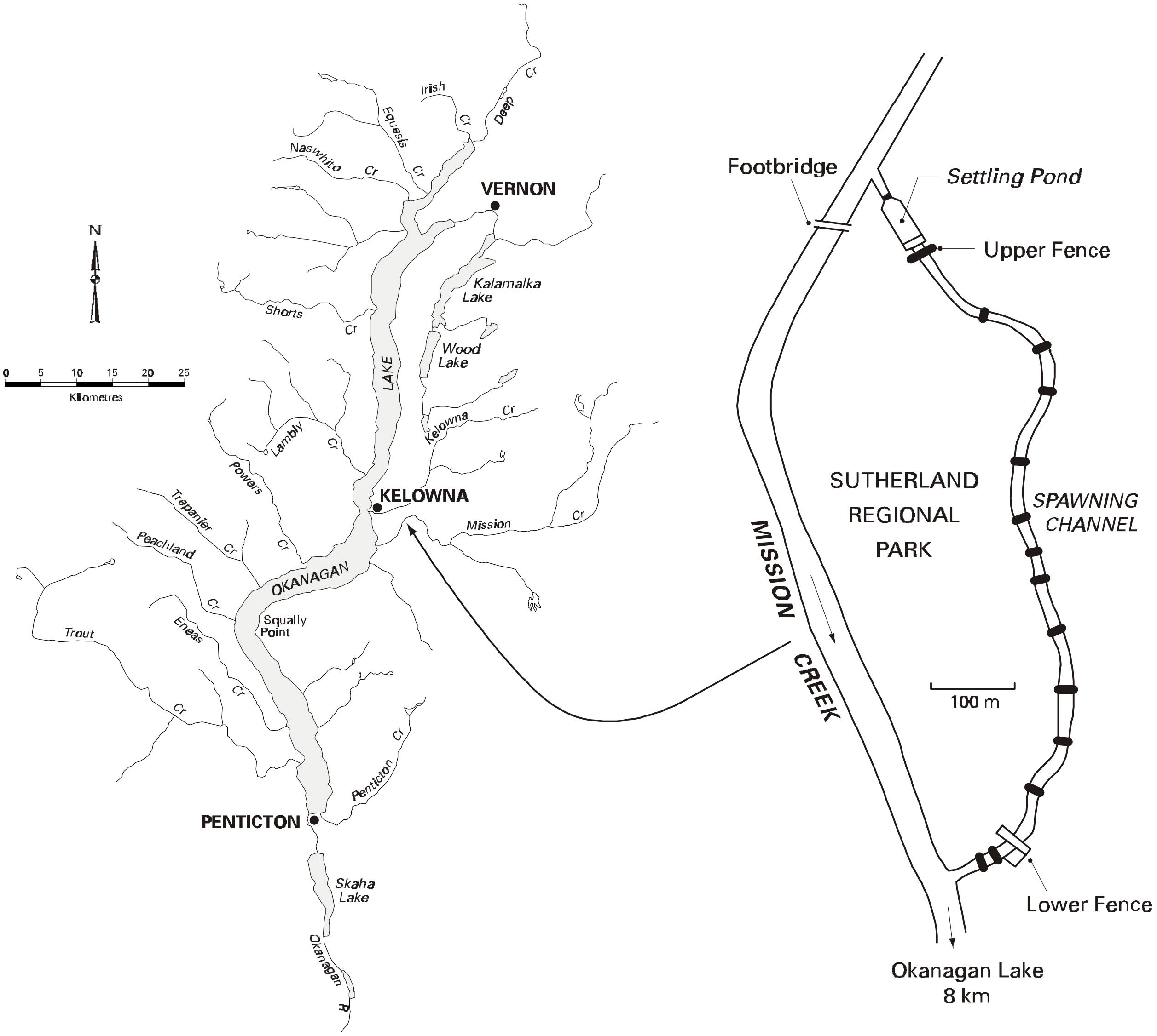

Figure 1. Okanagan Lake and Location of Mission Creek and Mission Creek Spawning Channel.

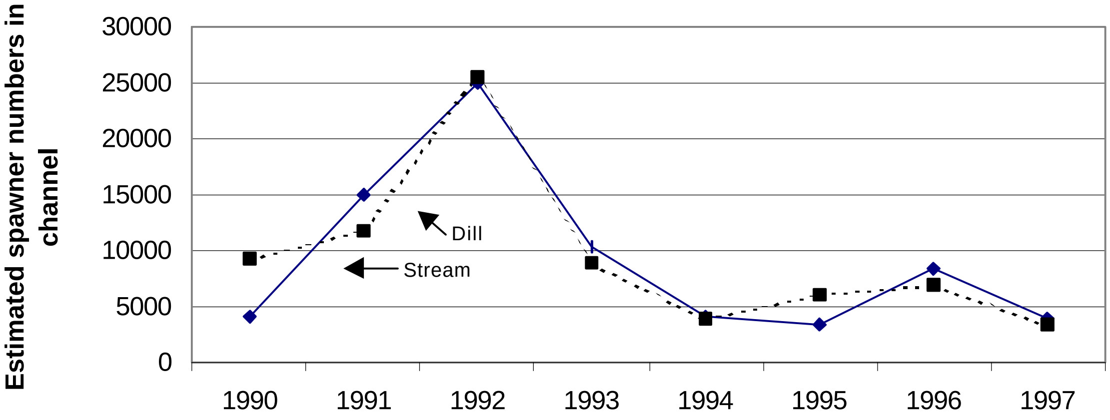

Figure 2. Estimated number of kokanee in Mission Creek spawning channel by MELP stream survey crew vs. visual estimates of Dill (1990 to 1997).

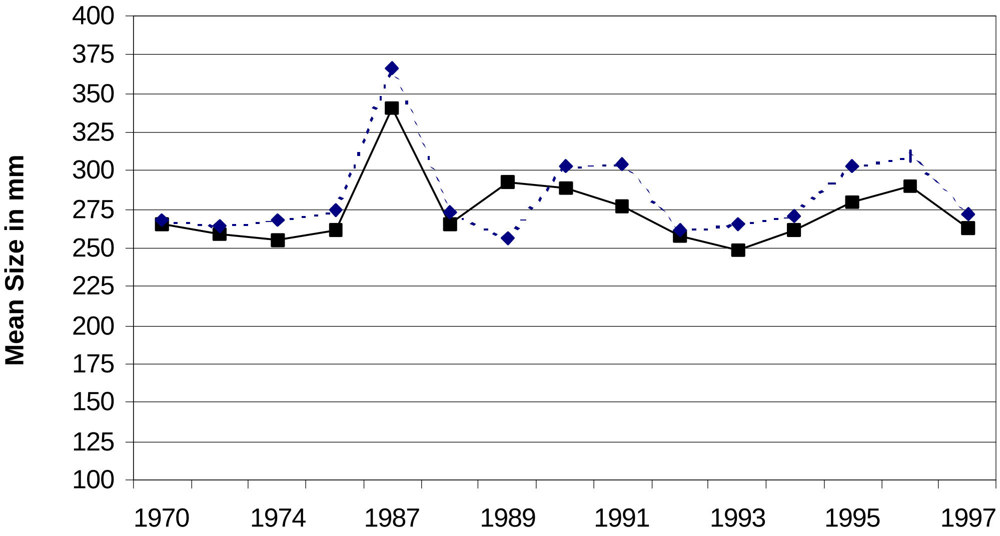

Figure 3. Mean length of male and female kokanee spawners, Mission Creek 1970 to 1997.

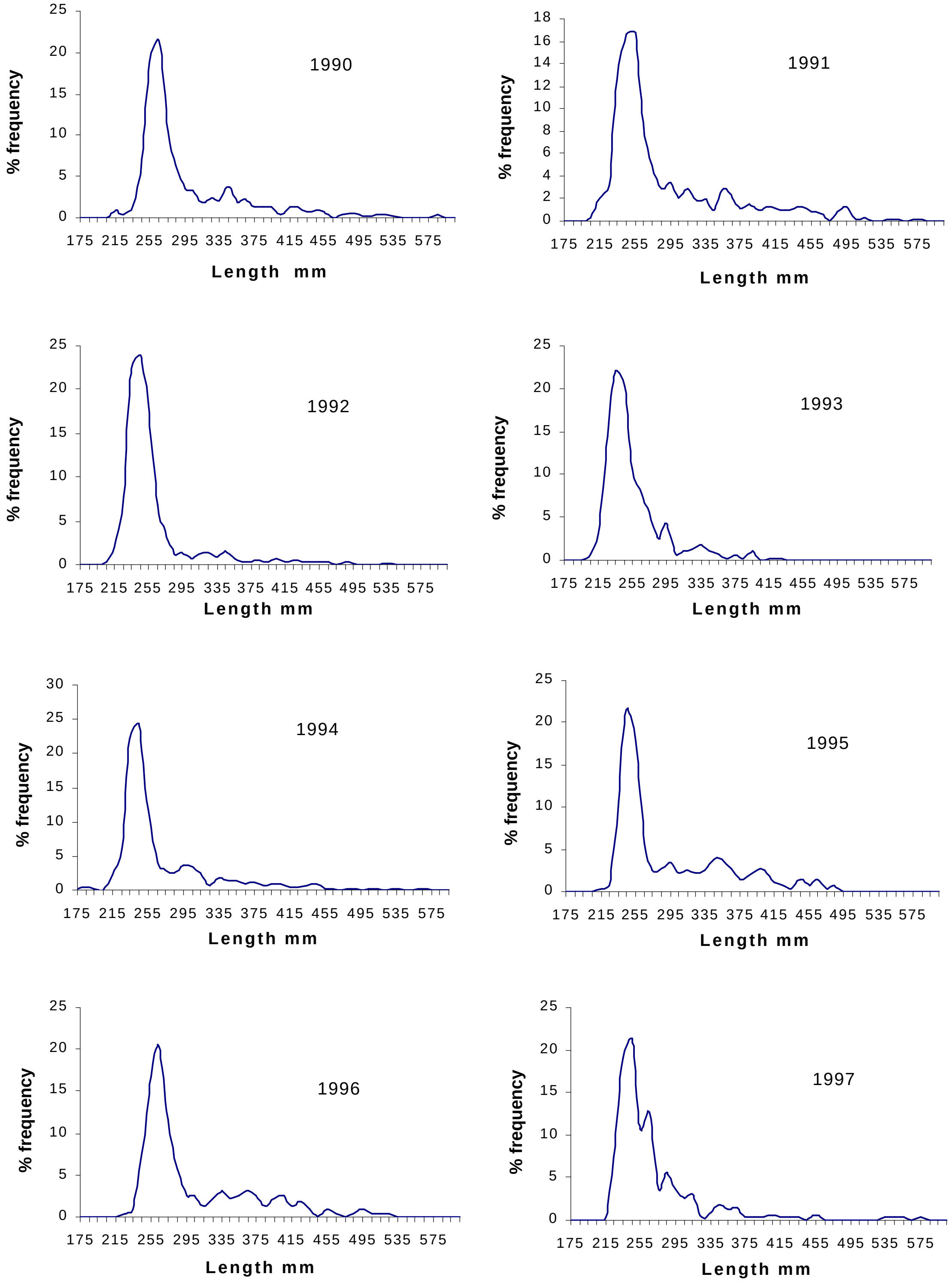

Figure 4. Length frequency of Mission Creek kokanee, 1990 to 1997.

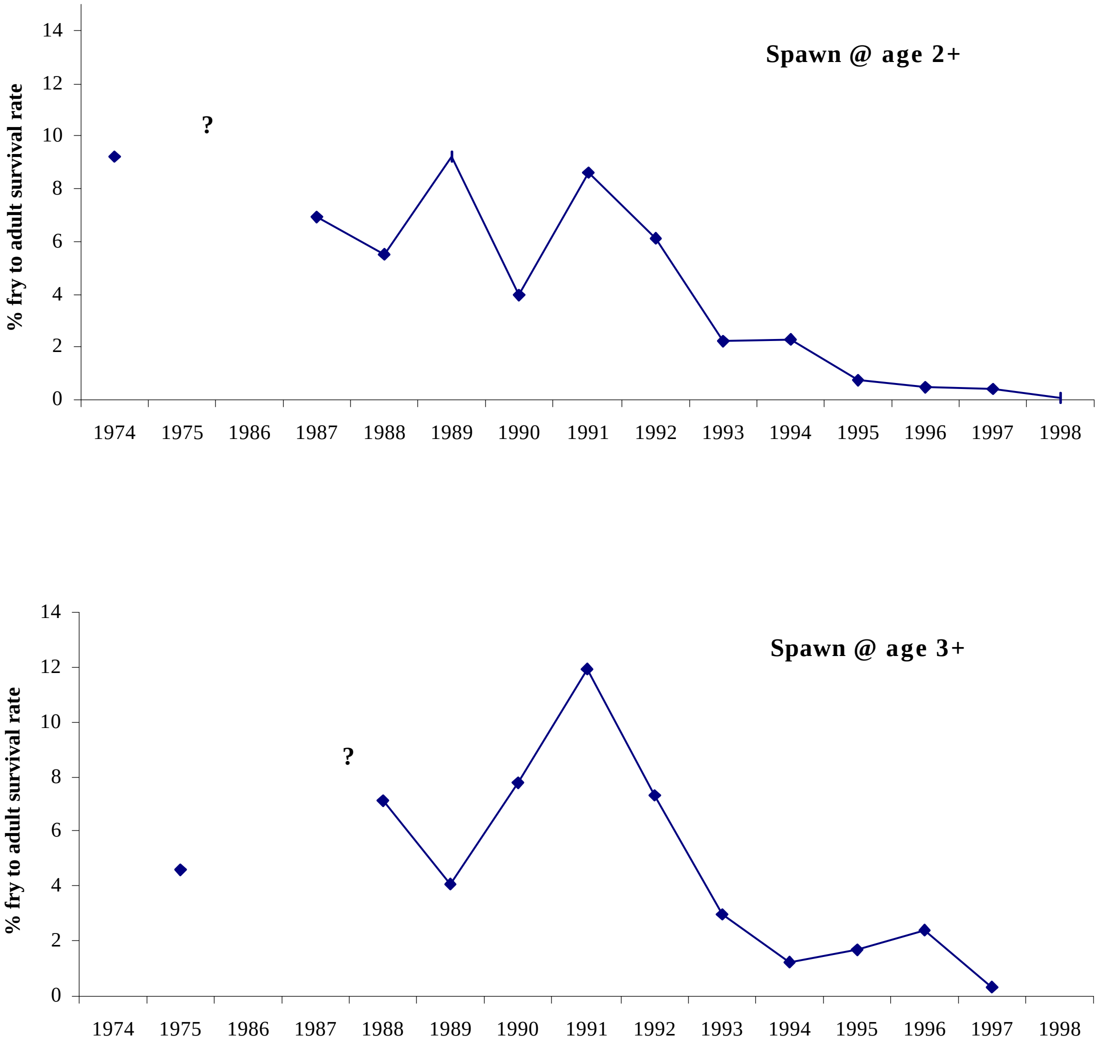

Figure 5. Mission Creek kokanee fry-to-adult survival rates derived by using spawning channel data from Dill (1991 to 1998) and assuming a) a 50:50 M:F ratio, b) 20% pre spawn mortality of females, c) mean egg retention determined from Dill, d) 5% egg-to-fry survival rate in the stream and e) 60% of all kokanee harvest estimates are stream origin and that 70% of all stream fish spawn in Mission Creek. Upper Figure assumes Mission Creek spawn at age 2+ and lower Figure assumes spawning at age 3+.

Appendix 1. Mission Creek Peak vs Total Adult Count From Dill, 1990 to 1993, 1996, Taylor and Dill 1997, MS.

Year	Peak	Total	
1991	8,000	11,765	
1992	15,341	25,541	
1993	8,812	9,003	
1994	2,300	3,881	
1995	1,919	6,021	
1996	4,598	7,030	
1997	2,187	3,422	
1998			
	43,157	66,663	1.54

Appendix 2. Estimates of kokanee fry production from Mission Creek by extrapolation of data from Mission Creek spawning channel (data from Dill 1990 to 1996; Taylor and Dill 1997, MS) and fry-to-adult survival rate estimates using harvest data from Shepherd (1994, MS).

Adult Year	Fecundity	Less Retention	Stream Egg Deposition	Fry Year	Stream Egg/Fry Survival 5%	Channel Production	Fed fry	Fry Year	Total Fry Production	Adult Year	Total Escapement	Harvest	Abundance		% Fry/Adult Survival Rate	
															3+ age spawner	2+ age spawner
1971	480	368	45,926,400	1972	2,296,320			1972	2,296,320	1974	145,391	65,000	210,391			
										1975	43,130	63,000	106,130			
1984	***526****	***414***	***13,478,350***	1985	***673,917***			1985	673,917	1984	81,391	35,700*	117,091	1974		9.2
1985	***526****	***414***	***17,395,121***	1986	***869,756***			1986	869,756	1985	105,043	33,600	138,643	1975	4.6	
1986	***526****	***414***	***7,372,843***	1987	***368,642***		20,000	1987	388,642	1986	44,522	31,500	76,022	1986		
1987	***526****	***414***	***2,879,950***	1988	***143,997***		616,456	1988	760,453	1987	17,391	29,400	46,791	1987		6.9
1988	***526****	***414***	***3,571,164***	1989	***178,558***		868,000	1989	1,046,558	***1988***	21,565	26,460	48,025	***1988***	7.1	5.5
1989	***526****	***414***	***2,303,993***	1990	***115,200***	173,000	972300	1990	1,260,500	***1989***	13,913	21,840	35,753	***1989***	4.1	9.2
1990	500	***400***	3,450,400	1991	172,520	484,324	1,053,930	1991	1,710,774	***1990***	21,565	8,820	30,385	***1990***	7.8	4.0
1991	595	***422***	13,598,022	1992	***679,901***	203,146		1992	883,047	***1991***	80,557	9,660	90,217	***1991***	11.9	8.6
1992	559	388	10,699,333	1993	***534,967***	890,361		1993	1,425,328	***1992***	68,939	7,980	76,919	***1992***	7.3	6.1
1993	377	314	4,106,618	1994	***205,331***	**328,000**		1994	533,331	***1993***	32,696	5,040	37,736	***1993***	3.0	2.2
1994	463	410	2,897,880	1995	***144,894***	**184,000**		1995	328,894	1994	17,670	2,520	20,190	1994	1.2	2.3
1995	609	524	2,303,714	1996	***115,186***	574,456		1996	689,642	1995	10,991	0	10,991	1995	1.7	0.8
1996	649	444	4,287,086	1997	***214,354***	509,873			724,227	1996	24,139	0	24,139	1996	2.4	0.5
1997	429	406	2,067,514	1998	***103,376***	45,648			149,024	1997	12,731	0	12,731	1997	0.3	0.4
1998										1998	1,000	0	1,000	1998		0.1

1. Channel egg/fry production (shown in bold) assumed to be 20% for 1994 and 1995.
2. This scenario assumes 60% of harvest is stream origin and 70% of stream origin were Mission Creek fish. Bold and italicized indicates years where data is derived using mean values from Dill (1991 to 1998, MS).
3. 1993-1994 harvest was extrapolated from last census in 1992 (Shepherd 1994, MS) and assumes a harvest level of 85,000 in 1984.
4. Bold and italicized indicates years that have been extrapolated using assumed fecundity of 526 derived from the mean fecundity determined by Dill (1990 to 1996; Taylor and Dill 1997, MS).
5. Spawner mortality assumed to be 20% for 1984 to 1989.

CHAPTER 3

COMPARATIVE ANALYSIS STUDIES

This component involves conducting specific studies that compare differences between areas of Okanagan Lake, or other lakes. These results are expected to yield valuable information applicable to stabilizing and/or rebuilding kokanee stocks in Okanagan Lake. The emphasis to date has been examination of shoreline development and differences between mysid populations in Okanagan and Kalamalka lakes.

ASSESSMENT OF LAND USE IMPACTS ON SHORE SPAWNING KOKANEE HABITAT AND FISH NUMBERS

PROGRESS REPORT

by

C. Wong[1]

INTRODUCTION

Ashley and Shepherd (1996, MS) summarized results of a technical workshop held June 1996 in Kelowna, BC to address the significant decline in Okanagan Lake kokanee abundance. Several hypotheses were proposed to explain the reductions. These included:

> "…degradation and/or loss of …spawning habitat; impoundment of streams and diversion of water for agricultural and urban development, increased angling pressure, decreased point source nutrient loading from wastewater treatment plants; introduction of exotic species (e.g., mysid shrimp, coarse fish), reduction of kokanee shorespawning habitat due to timing and extent of seasonal drawdown and shoreline habitat alteration, urban runoff, and competition between hatchery and native stocks of kokanee" (cited from Ashley and Shepherd 1996, MS).

A comprehensive interdisciplinary, long-term action plan to better understand and rebuild wild kokanee was developed in late 1995 (Ashley and Shepherd 1996, MS). The action plan was implemented in 1996 designed to gain a better understanding of whole lake biological relationships, define limiting factors and identify and implement remedial measures. Ashley et al. (1998) reported the initial two years of results from this work. Key to understanding and resolving the problems facing kokanee in Okanagan Lake is a good data set that can be used to track changes both to the stream spawning population and in-lake changes.

This current study attempts to better understand the effects of changes in land use activities on availability of shore spawning habitat, and the effect(s) of habitat availability on shore-spawning kokanee abundance. In doing so, the null hypothesis tested is that there is no correlation among changes in land use activities, shorespawning habitat and kokanee abundance.

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The study objectives are:

1. to characterize spatial and temporal trends in spawner abundance;
2. to characterize spatial and temporal trends in land use and cover within 500 m of the shoreline over the last 35 years;
3. to characterize spatial differences in spawner habitat; and
4. to examine possible cause and effect relationships between land use, spawning habitat and fish numbers.

OBJECTIVE 1 - FISH ABUNDANCE STUDY

METHODS

To characterize trends in shore spawning activity, fish enumeration data (see Shepherd in Ashley et al. 1998) collected from 1973 to 1997 by the Ministry of Environment, Lands and Parks was initially analyzed. Shore spawner counts and field notes were examined for completeness, the time period, level of effort and route of sampling, and additional data complementing count data. Spatial and temporal trends were then determined and tested for statistical significance. The number of records for each site (Map 1) varied from 1 to 6. When only one data point was reported for a site, this record represented the annual peak count for the site. If more than one count was reported, the maximum value was used to represent the annual peak count for trend analyses. Based on analysis, sites were classified into high, medium and low lake spawning segments and selected for detailed land use and habitat analysis.

RESULTS

Figure 1 illustrates lake scale spatial differences in peak counts pooled for all years for the entire lake. Counts summed over all sites were seldom greater than 10,000 fish. Counts from sites 12 to 20 in the southeast quadrant were higher than counts from sites 43 to 70 in the northeast and northwest quadrants. When all annual peak counts were averaged for each site, the highest mean occurred at site 12 (4,951 fish, sd= 8,859, n=18) in the SE quadrant while the lowest mean occurred at site 50 (38 fish, sd=75, n=4) in the NW quadrant.

The site specific distribution of spawning fish in the 1970s is illustrated in Figure 2a. Fish were observed in much higher numbers in the east half (sites 1 to 49b) of the lake, particularly the SE quadrant (sites 1 to 22a). Also remarkable were the extreme variations in fish abundance reported (range = 0-50,550). Figure 2b illustrates fish abundance in the 1980s. The large variation in fish numbers was less as were the number of spawners. Fish numbers were again higher in the SE quadrant overall, even though the maximum count of 16,575 fish was recorded in the NW quadrant (site 56). Figure 2c illustrates spawning distribution in the 1990s. Once again, fish abundance was greatest in the SE quadrant. The numbers were the lowest recorded in nearly three decades of records.

Spatial trends significant at the quadrant and site level ($p=<0.05$) supported the observation that there are spatial differences in quadrant and site abundance. There were no significant differences between peak abundance in the SE vs. NE quadrants and the NE vs. NW quadrants of the lake. However, differences between the SE and NW quadrant were significant at $p \leq 0.05$.

The classification of sites by temporal trends considered both the direction and magnitude of change for sites with at least 16 observations. All sites experienced a decrease in fish numbers since 1973. The magnitude of change among sites was trimodal (Fig. 3); modes appeared to coincide with the middle of each quadrant. Changes were particularly extreme in the SE quadrant; where the smallest and largest changes occurred. The range in levels of change that occurred in the north half of the lake were comparable; those in the NE quadrant marginally greater than those in the NW.

No significant differences were found among sites in terms of magnitude of change. Only those sites with sufficient fish data and statistically significant levels of change were used for the detailed land use and habitat evaluations (Map 2). Additional sites were selected as controls to represent areas where spawning behavior was rarely observed or reported. Sites selected are illustrated in Map 2.

DISCUSSION

The southeast quadrant demonstrated the greatest variation in fish abundance with the highest and lowest counts recorded. Abundances characterizing each quadrant were statistically distinct. Counts in the southeast and northeast quadrants were similar to one another as were abundances in the northeast and northwest quadrants. The highest fish counts were reported in 1974 while the lowest were reported in 1993. Counts were lower from 1985 to 1997 than from 1973 to 1984. Changes were particularly extreme in the SE quadrant.

OBJECTIVE 2 - LAND USE STUDY

METHODS

A base map of Okanagan Lake was created and all kokanee enumeration and study sites digitized to a distance of 500 m from the shoreline. Aerial photos for 1963, 1971, 1981, and 1994 to 1996 were classified, delineated and digitized for spatial comparisons with spawner abundance and habitat trends, as well as temporal correlations with spawner counts. Classification and subsequent delineation were performed on 2 scales: a general classification was completed for the entire lake for 1963 and 1996; more specific delineation was completed for sites where habitat sampling was conducted for all years.

RESULTS

Lake-wide classification data indicate that currently within a buffer zone of 500 m from the shoreline, sage grasslands dominate, followed by agricultural, urban developed areas and forested lands (Fig. 4a). Between 1963 and 1996, urban development increased by 9.01%, agriculture decreased by 2.53%, forested areas decreased by 3.00%, and sage and grassland areas decreased by 3.48% (Fig. 4b).

These results are not consistent with data pooled for all detailed study sites over all years (Fig. 5): forests dominated the study area, while agricultural areas outnumbered urban developed areas and sage and grasslands. Over time, forested land remained constant, agriculture and sage and grasslands diminished. These decreases appeared to be associated with increased urban development.

Site data are plotted in Figure 6a-d for land status for the years 1963, 1971, 1981 and 1996. Throughout this period, sites 1 to 20 in the southeast quadrant had negligible signs of land-based human influence. Agricultural activity was observed at site 19 until 1996, was in small patches at site 20 until 1971, and was significant at site 83 until 1981. Urban development at site 83 has encroached upon agricultural areas in recent years. In the northeast quadrant, higher levels of urban development and agriculture were observed. Urban development was apparent at sites 21, 29 and 37. Agricultural activity was noted at sites 31 to 33 and sites 37. Relatively low levels of agriculture and urban development were apparent in the northwest quadrant at sites 60, 61, 63 and 75. Higher levels of agriculture and urban development were observed in the southwest at sites 78 to 82. Mann-Whitney U-tests indicate that the percentage area of each land use type differed significantly ($\alpha \leq 0.05$) between enumeration (sites 3 to 78) and control sites (79 to 83) for all years evaluated.

Shoreline counts of rooftops and docks at study sites indicate a steady increase from 1963 to 1996, consistent with the trend of increasing urban development (Fig. 7). The distribution of rooftops and docks among sites is positively correlated with areas of urban development. However, while the percentage area of urban development differed significantly among enumeration and control sites, the number of rooftops and docks did not.

To analyze spatial and temporal trend data, historical changes in land use were calculated as the difference between land allocations in 1963 and 1996, and considered on a site specific basis. Increases in urban development occurred at site 21 in the southeast quadrant, sites 29 and 37 in the northeast quadrant, and sites 78, 79, and 82 in the southwest quadrant (Fig. 8a). Change was by far the greatest at site 29. Changes in urban area were negligible at all other sites.

Figure 8b illustrates the increase in rooftops and boat docking structures for every kilometer of shoreline at each study site. All changes generally took place at sites where urban development was greatest (Table 1). Increases in the number of rooftops along the shoreline occurred at sites 6, 7, 14, 20, and 21 in the southeast quadrant, all sites in the northeast quadrant, sites 60, 61 and 63 in the northwest quadrant, and sites 78, 79, 81, 82 and 83 in the southwest quadrant. Increases in the number of docks occurred at sites 6, 14, 19, 20 and 21 in the southeast quadrant, all sites in the northeast quadrant, site 63 in the northwest quadrant, and sites 81, 82 and 83 in the southwest quadrant. The largest increases (≥ 10 new rooftops or docks per km of shoreline) occurred at sites 29 and 79.

By applying a Spearman correlation test (Table 2) change in the area of urban development 500 m from the shoreline can be demonstrated to be positively correlated with increases in the number of rooftops and docks along the shoreline.

Table 1. Spearman correlation test for change in urban areas.

	Δ in Development	**Δ in #Roofs**	**Δ in #Docks**
Δ in Development	1.000	0.569 (α=0.002)	0.643 (α≤ 0.000)
Δ in Roofs	0.569 (α=0.002)	1.000	0.748 (α≤ 0.000)
Δ in Docks	0.643 (α≤ 0.000)	0.748 (α≤ 0.000)	1.000

Decreases in agriculture (Fig. 9) were observed at sites 31, 32 and 37 in the northeast quadrant, and sites 78 to 82 in the southwest quadrant; and increasing at sites 20 and 83. Changes at all other study sites were negligible. Decreases in agriculture appeared to be associated with increases in urban development.

Changes in the area occupied by sages and grasses are illustrated in Figure 10. Slight increasing trends were evident at site 79 and greater at site 80 in the southwest quadrant. In contrast, decreasing trends were observed at sites 29 and 33 in the northeast quadrant and sites 78, 81 and 82 in the southwest quadrant. Changes in sage grasslands were negatively associated with changes in urban development and agriculture.

Forested land experienced notable changes in all quadrants (Figure 11). Increases greater than 10% occurred at sites 81 and 82 in the southwest quadrant while less significant increases were observed at sites 31-33 in the northeast quadrant. Large decreases (>10%) occurred at site 21 in the southeast quadrant and site 29 in the northeast quadrant. Smaller decreases occurred at sites 19 and 20 in the southeast quadrant, and sites 79 and 80 in the southwest quadrant. Changes in forestry were negatively associated with changes in sage grasslands, urban development and agriculture.

DISCUSSION

Lake-wide data for 1996 revealed that the area 500 m from the shoreline was dominated by sage and grasslands and covered to a lesser degree by agriculture, followed by urban developed and forested areas. These results contrast with the assumption that urban growth has spread everywhere. In fact the proportion of urbanization in the detailed study sites is small. Overall, the land is primarily forested, while agriculture, urban development and sage and grasslands occupy disproportionately smaller areas (Fig. 12). This difference was expected because study sites were chosen specifically to characterize areas where spawning occurred historically and in recent years experienced measurable change. For example, the foreshore area of the City of Kelowna was chosen because spawning abundance was significantly higher in past years; areas near Armstrong Arm were not chosen because they have experienced little change.

Within each quadrant, land use trends also differed. Most sites in the southeast and northwest quadrants were forested areas while sites in both the northeast and southwest quadrants were more mixed with higher proportions of urban areas, agriculture and sage and grasslands. As expected changes in urban areas were positively correlated with changes in shoreline indicators of human presence, namely rooftops and docks. Increases in urban development were also weakly (not statistically significantly) correlated with changes in agriculture, sage and grasslands, and forested areas.

The current results confirm past findings that urban areas are increasing and agricultural lands are decreasing (Canadian-BC Consultative Board, 1974; Kerr et al. 1985).

OBJECTIVE 3 - FISH HABITAT STUDY

METHODS

After a review of current literature on spawning kokanee habitat preferences, field investigations were conducted in October 1997 and March 1998 to document shoreline and biological characteristics (aspect, riparian and littoral disturbances, woody debris, periphyton and macrophytes). Habitat characteristics such as slope, substrate (dimensions, angularity, sphericity, mass, and volume) and water quality (temperature and dissolved oxygen concentrations) were observed and recorded. Geographic Information System (GIS) data was used to determine shoreline lengths and the areas at the 2 m, 5 m and 10 m bathymetry lines for further analyses.

RESULTS

In general, shoreline characteristics in the SE and NW quadrants resemble one another more so than the NE and SW quadrants. While the aspect of SE and NE quadrants were similar, the degree of human disturbances evidenced by buildings, docks and bank stabilizing structures, ground cover complexity and the amount of woody debris were visibly different (Appendix 1). The SE and NW sites were characterized by lower levels of human disturbance and greater variation in riparian vegetation, ranging from clay cliffs to rocky moss covered bluffs and forest canopy.

At the study sites (Table 1) bathymetric characteristics varied significantly between enumeration and control sites ($p_{slope70} = 0.002$, $p_{area5} < 0.033$, $p_{area10} < 0.001$) and among enumeration sites ($p_{slope10} < 0.000$, $p_{slope70} < 0.000$, $p_{area2} \leq 0.000$m, $p_{area5} < 0.000$, $p_{area10} < 0.000$; Appendix 1). Tukey tests revealed that slopes in 10cm and 70cm of water were significantly greater at sites 3, 4, 9 (SE quadrant) and 75 (SW) than all other sites (Fig. 13a). Steep slopes resulted in the absence of a defined bathymetry contour of -2 m at sites 4, 8, 9, 11, 19, 33, 75, 80, 81 and 83; a contour of -5 m was absent from sites 31 and 78; and a contour of -10 was absent from sites 3, 4, 8, 9, 14, 29, 31, 31, 32, 33, 60 and 75 (Fig. 13b).

The temperature and dissolved oxygen levels of surface water and water at 1 m differed significantly among sites ($p_{temp@0m} < 0.000$, $p_{temp@1m} < 0.000$, $p_{DO} < 0.000$). Generally, air temperatures were higher in the south than the north while water temperatures decreased from the north end of the lake to the south. Water temperatures at sites 3 and 4 were the lowest (13.35 and 13.94^{o}C); temperatures at sites 29, 11, 19, 32, 31, 33, 20, 21, 14, 16 and 37 were the highest (all >15.3^{o}C); and temperatures at all other sites between 14.20 and 14.88^{o}C. Dissolved oxygen concentrations at all sites were found to be above Water Quality Guideline levels of 8.0mg/L

(Canadian Council of Ministers of the Environment, 1987) required for developmental stages of fish. Shoreline vertical profiles showed a steadily decreasing trend of rock size with depth (Appendix 1). Larger substrate rest on top of smaller substrate that gradually decrease in size with depth. Each layer of rock was statistically distinct in size from the next ($p< 0.000$) with the middle and lowest layer more similar in size distribution than the uppermost layer. Since rock sizes are associated with mass and volume, these characteristics also showed statistically significant differences with depth.

Surface rock sizes (as defined by dimensions in Boggs 1995), masses, volumes and periphyton growth were found to be statistically distinct among sites (p_{ds}, p_{dm}, p_{dl}, p_{mass}, p_{vol}, and $p_{peri}< 0.000$). Short dimensions[2] were statistically shorter at sites 7, 8, 9, 11, 14, and 20 in the southeast quadrant, site 31 in the northeast quadrant, and sites 79 and 81 in the southwest quadrant; they were statistically longer at site 3 in the southeast quadrant, sites 32 and 37 in the northeast quadrant, sites 61, 63 and 75 in the northwest quadrant, and site 80 in the southwest quadrant. Medium dimensions were statistically shorter at sites 7, 8, 14, 20 (SE), 31, 33 (NE), 79 and 81 (SW); and longer at sites 3, 19 (SE), 32, 37 (NE), 75 (NW) and 80 (SW). Long dimensions were statistically shorter at sites 7, 14 (SE), 31, 33 (NE), 79 and 81 (SW), and longer at sites 3, 6, 19 (SE), 32, 37 (NE), 75 (NW), and 80 (SW). Only angularity showed statistically significant differences between enumeration and control sites ($p= 0.016$).

Table 2 lists the habitat characteristics shown to correlate with one another and provide a complementary suite of indicators to describe each site.

Table 2. Habitat Characteristics Chosen to Represent Sites.

Index	Characteristic Indicated
Number of rooftops	Shoreline disturbance
Number of docks	Shoreline disturbance
Aspect	Exposure to wind, waves, solar radiation
Maximum depth sampled	Exposure to water movement
Slope at 10cm	Exposure to water movement
Slope at 70cm	Exposure to water movement
Water temperature at z=0m	Water quality
Water temperature at z=-1m	Water quality
Medium dimension	Protection from movement, predation, low DO
Mass	Protection from movement, predation, low DO
Volume	Predation from movement, predation, low DO, periphyton growth

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[2] Dimension as defined by Boggs (1991). Substrate characteristics from sampled sites were predominately angular with little sphericity (Fig. 14).

DISCUSSION

The data indicates that in Okanagan Lake, water temperatures were lower at sites in the south than those in the north. Dissolved oxygen levels were within criterion levels (all above 8.5mg/L O_2) for both adult and developing fish during warmer water conditions. Substrate varies within sites as well as amongst sites with larger material piled on top of smaller sized material within the vertical profile examined.

Dill (1997, MS) reported that the mean water temperature at the time of spawning at Bertram Creek Park in the southeast quadrant of Okanagan Lake was 10.8°C. This value is lower than that recorded in the current study when spawning had not yet begun. Dill (1996, MS) suggested that wave action would likely not be able to dislodge eggs and fry located below 10 to 15 cm of substrate. Suitable spawning substrate depth analyzed in this study was often found between 20 cm and 30 cm of water (initial sampling @ 10 cm of water). This suggests that at most sites, at least 10 to 20 cm of substrate would be available for the protection of eggs and developing alevins and fry.

The current study evaluates the spatial distribution of habitat resources around Okanagan Lake. To truly understand interactions among fish, land use changes and habitat alterations, a multi-year study should be undertaken to assess temporal changes in habitat characteristics. In the current study, a significant amount of substrate was removed from known kokanee spawning habitat. This has the potential to further disturb or alter spawning habitat. Because field measurements of substrate angularity and sphericity are difficult to replicate (Boggs 1995) an alternative method would be to digitally record underwater images for subsequent computer modeling of lengths, form and shape. This would increase the precision of measurements for annual comparisons.

OBJECTIVE 4 - INTEGRATIONS STUDY

a) Fish Abundance and Fish Habitat

METHODS

Indices of fish abundance compared with analyzed habitat characteristics are listed in Table 3. Habitat parameters were all measured during fall 1997 and spring 1998 to characterize the 1997 spawning and emergence conditions. These parameters were compared to a number of fish enumeration indices representing both current and historical abundances. To determine associations between Okanagan Lake shorespawning abundance and shorespawning habitat, visual interpretation of scatter plots was conducted and Spearman Rank correlation and Kruskal-Wallis significance tests applied between sites that experienced varying levels of change over time.

Table 3. Variables compared for relationships between fish abundance and habitat indices.

Fish Abundance	Fish Habitat
▪ Fish abundance in 1997	▪ Aspect
▪ Average of last 3 years of data (1995-1997)	▪ Maximum depth sampled (z_{max})
▪ Difference between means of first & last 3 years data	▪ Slope at z^1= -10 cm
▪ Average of 1990s data	▪ Slope at z= -70 cm
▪ Difference between mean of 1970s & 1990s data	▪ Water temperature at z= 0 m
	▪ Water temperature at z= -1 m
	▪ Medium dimension at z= -10 cm
	▪ Medium dimension at z_{max}
	▪ Mass at z= -10 cm
	▪ Mass at z_{max}
	▪ Volume at z= -10 cm
	▪ Volume at z_{max}

[1] Z = ZONE

RESULTS

All plots (on file) show strong associations between kokanee abundance and habitat features in the 1970s when fish counts were the highest. Aspect and the maximum depth of water in which substrate was sampled were consistently positively associated with fish abundance. During the 1970s and 1980s, spawners favored more gradual slopes while in more recent years they showed a slight favor to greater slopes. Fish of all time periods favored smaller surface substrate size, and larger sizes at the maximum subsurface substrate depth.

Kruskal-Wallis variance tests were performed to determine whether habitat features differ significantly among fish abundance classifications. All fish enumeration indices listed in Table 4 were classified according to MELP convention described in Table 4. Differences in fish abundance were also classified two other ways (Table 4). Maximum depth of substrate collected differs significantly ($p\leq 0.05$) among fish abundance classes by methods 1 and 2. Temperatures measured at the water's surface and at 1m water depth (Appendix 1) also differed significantly among classes. ($temp_{0m}$: $p_{diff1st\&last3yrs}$= 0.022 by method 2 and 0.046 by method 3; $temp_{1m}$: $p_{diff1st\&last3yrs}$= 0.017 by method 2 and 0.045 by method 3).

Table 4. Classification of Fish Abundance per Site for Significance Testing with Habitat Indices.

Class	Method 1: MELP Convention Range	Method 2: Visual Estimation Range	Method 3: Even Division Range
Very Low	0-24	≤99	≤3,508
Low	25-99	100-999	3509-7016
Medium	100-499	1000-4,999	7,017-10,525
High	≥500	>5,000	>10,526

DISCUSSION

Scatter plots of historical and current fish abundance vs habitat characteristics in 1996 (on file) suggested possible interactions with all physical, water quality and substrate features. When fish counts were high, a greater range of habitat features were used; when fish counts were low, a smaller range of characteristics were selected. Such selection is probably because competition for preferred habitat characteristics is greater with higher numbers of spawners. In recent years when fish numbers dwindled, fewer fish were marginalized with most able to access their selected (preferred) spawning sites successfully.

If possible, habitat characteristic data especially temperature and the depth of egg deposition should be collected every five years. Currently, only one year of habitat data exists, thus only spatial correlation with current fish data is truly appropriate. Nevertheless, when Kruskal-Wallis significance tests were performed, spatial associations were demonstrated between fish habitat, and temperature and depth characteristics.

b) Land Use Activities and Fish Habitat

METHODS

All recorded land use classifications were compared with specific fish habitat parameters (Table 5). To determine whether interactions exist between land use and shorespawning habitat, visual interpretation of scatter plots were generated. Spearman Rank and Kruskal-Wallis tests were applied between habitat sites that differ in the presence or absence of certain land use activities, and also with sites that experienced varying levels of change over time.

Table 5. Variables Compared for Relationships Between Land Use Activities and Habitat Indices.

Land Use Activities	Fish Habitat
▪ Area of urban development in 1996	▪ Aspect
▪ Area of agriculture in 1996	▪ Maximum depth sampled (z_{max})
▪ Area of sage and grasslands in 1996	▪ Slope at z=-10 cm
▪ Area of forested lands in 1996	▪ Slope at z=-70 cm
▪ Difference between 1963 & 1996 urban development data	▪ Water temperature at z=0 m
▪ Difference between 1963 & 1996 agricultural data	▪ Water temperature at z=-1 m
▪ Difference between 1963 & 1996 forestry data	▪ Medium dimension at z=-10 cm
▪ Difference between 1963 & 1996 forestry data	▪ Medium dimension at z_{max}
▪ Number of roofs in 1996	▪ Mass at z=-10 cm
▪ Number of docks in 1996	▪ Mass at z_{max}
▪ Difference between #roofs in 1963 & 1996	▪ Volume at z=-10 cm
▪ Difference between #roofs in 1963 & 1996	▪ Volume at z_{max}

RESULTS

Significant ($\alpha \leq 0.05$) and strong ($|rho| \geq 0.50$) Spearman correlations were calculated for habitat features with areas of agriculture and sage and grassland, and the increased number of docks. Maximum depth was negatively correlated with agriculture (rho = -0.550) and sage grasslands (rho= -0.512). The more gradual the slope beneath 70 cm of water, the more agriculture on the shoreline (rho= -0.515). Gradual slopes were also associated with the number of docks (rho = -0.608) and increase in the number of docks since 1963 (rho = -0.575).

Mann-Whitney U-test and Kruskal-Wallis variance tests were performed to determine whether habitat features differ significantly among land use classifications. Land use indices were classified on the basis of:

- presence or absence of development, agriculture, sage grasslands, and forestry, and number of rooftops and docks in 1996, or
- increasing, no, or decreasing Δ- in percent area of development, agriculture, sage and grasslands, and forestry, and number of rooftops and docks between 1963 and 1996.

The maximum depth from which substrate were collected differed significantly ($\alpha \leq 0.05$) between sites with and without agriculture (p= 0.016) and sage grasslands features (p= 0.008). Maximum depth also varied significantly between sites where urban development stayed the same or increased (p= 0.008), and among sites where agriculture (p= 0.003), sage grasslands (p= 0.003), and forestry (p=0.014) experienced various directions of change. Slopes were significantly different between sites with and without agriculture ($p_{slope@-70cm}$= 0.040) and docks ($p_{slope@-10cm}$= 0.16, $p_{slope@-70cm}$= 0.003). Slopes also differed among sites with increasing, no change or decreasing trends in agriculture ($p_{slope@-70cm}$= 0.042) and sage grasslands ($p_{slope@-70cm}$= 0.042).

DISCUSSION

Scatter plots (on file) suggested that only depths and slopes were negatively associated with development and agriculture; all other indices such as aspect, temperature, and substrate features were positively associated with development and agriculture. These trends were generally supported by Spearman rank correlations.

These results are expected. Human settlements generally favor easy access to water: urban development and agriculture are more likely to occur where the shoreline slopes gently.

c) Fish Abundance and Land Use Activities

METHODS

Table 6 lists variables compared for relationships between spawner populations and ways land is used. To determine whether interactions exist between fish abundance and land use activities, visual interpretation of scatter plots was supported by Spearman Rank correlation and Kruskal-Wallis significance tests between sites that had variable numbers of spawners and varying levels of land use.

Table 6. Variables examined for relationships between fish abundance and land use activities.

Fish Abundance	Land Use Activities
▪ Fish abundance in 1973, 83, 96	▪ Area of urban development in 1963, 71, 81, 96
▪ Average of 70s, 80s, 90s data	▪ Area of agriculture in 1961, 71, 81, 96
▪ Average of last 3 years of data (94, 95, 96)	▪ Area of sage grasslands in 1963, 71, 81, 96
▪ Difference between means of 1st & last 3 years	▪ Area of forested lands in 1963, 71, 81, 96
▪ Difference between mean of 70s & 90s data	▪ Number of roofs in 1963, 71, 81, 96
	▪ Number of docks in 1963, 71, 81, 96
	▪ Difference between 1971 & 1996 development data
	▪ Difference between 1971 & 1996 agricultural data
	▪ Difference between 1971 & 1996 sage data
	▪ Difference between 1971 & 1996 forestry data
	▪ Difference between #roofs in 1971& 1996
	▪ Difference between #docks in 1971& 1996

RESULTS

Scatter plots (on file) suggested that kokanee populations decreased with increasing areas of development, agriculture, and sage and grasslands, and the number of rooftops and docks. In contrast, kokanee numbers increased with increasing areas of forested land.

Figure 16 illustrates decreases in fish abundance vs increases in urban development. It is apparent that study sites where spawning kokanee decreased the most do not coincide with sites where urban development was greatest. This suggests that the relationship between fish counts and development 500 m from the shoreline is weak.

Figure 16 also indicates decreased fish abundance where the number of rooftops and docks per kilometer of shoreline increases between 1971 and 1996. This result was expected based on the strong positive correlation between % area of urban development and the number of rooftops and docks (Table 1). This corroborates the previous finding that the relationship between fish counts and development 500 m from the shoreline is weak.

Spearman rank correlations were calculated for all fish abundance and land use variables listed in Table 7. Fish abundance in 1996 was found to be negatively associated with agriculture as well as the number of roofs and docks in 1996. This latter finding supports the analysis that the association between fish abundance and the density of shoreline disturbances is present but weak. The mean fish abundance through the 1990s was also negatively associated with agriculture measured in 1996 (rho_{90s}= -0.511) and sage grasslands in 1996 ($rho_{1997-95}$= -0.654, rho_{90s}= -0.680). Similarly, the number of fish in 1983 and the average through the 1980s were negatively correlated with the area of sage and grasslands measured in 1981 (rho_{1983}= -0.534, rho_{80s}= -0.654). In 1973, fish counts were positively associated with the area of forested land determined in 1971 (rho= 0.763). No significant and strong correlations were found among abundance indices and the area of urban development.

Table 7. Significant ($\alpha \leq 0.05$) and strong ($|rho| \geq 0.50$) spearman rank correlations for fish abundance vs land use indices.

Land Use Indices	Fish96	Fish97-95	Fish90s	Fish83	Fish80s	Fish73
%Agriculture in 96	-0.502		-0.511			
%Sage Grasslands in 96		-0.654	-0.680			
%Sage Grasslands in 81				-0.534	-0.532	
%Forestry in 96						
%Forestry in 71						0.763
#Rooftops in 96	-0.637					
#Docks in 96	-0.625					

Kruskal-Wallis variance tests were performed to determine whether current levels of land use activities differ significantly among sites classified for fish abundance and levels of change. Fish abundance is defined in Method 1 in Table 8 and classes of change are defined by Methods 1-3 in

Table 8. From these tests, only the area of sage and grasslands was found to differ significantly among fish abundance classifications (Table 9). Among fish decrease classifications, all land uses were shown to differ significantly (Table 10).

Table 8. Classification of fish abundance for significance testing with land use indices.

Class	Method 1: MELP Convention Range	Method 2: Visual Estimation Range	Method 3: Even Division Range
Very Low	0-24	≤99	≤3,508
Low	25-99	100-999	3509-7016
Medium	100-499	1000-4,999	7,017-10,525
High	≥500	>5,000	>10,526

Table 9. Significance test results of land uses among fish abundance classes (Ho: the amount of land use is the same among all fish abundance classes defined in Table 8).

Fish Numbers	Dev96	Agr96	Sag96	For96
Last -1st 3yrs			p= 0.002	
90s			p= 0.001	
Change in Fish#s	**Dev(96-71)**	**Agr(96-71)**	**Sag(96-71)**	**For(96-71)**
Last -1st 3yrs- Method1	p= 0.022	p= 0.009	p= 0.001	p= 0.003
Last -1st 3yrs- Method2	p= 0.017	p= 0.006	p= 0.001	p= 0.002
90s- Method1	p= 0.021	p= 0.012	p= 0.001	p= 0.003
90s- Method2	p= 0.021	p= 0.016	p= 0.003	p= 0.003

Mann-Whitney U-tests and Kruskal-Wallis variance tests were also performed to determine whether fish abundance indices differ significantly among land use classes and levels of change (Table 10). Indices of current fish abundance differed significantly between sites for all land uses except forested lands (Table 11). Significant differences in the change in fish abundance were further shown for changes in all types of land use (Table 11).

Table 10. Classification of land use indices for significant testing with fish abundance.

Land Use Index	Classification
%Activity in 1996	▪ Present ▪ Absent
Δ in %Activity from 1971-96	▪ No Change ▪ Increase ▪ Decrease

Table 11. Significance test results of land uses among fish abundance classes (Ho: current fish counts and changes in fish abundance are the same among all land use classifications defined in Table 10).

Presence/Absence	Fish(last3yrs)	Fish(90s)
Development in 1996	p= 0.034	p= 0.013
Roofs in 1996		p= 0.031
Docks in 1996		p= 0.005
Agriculture in 1996		p= 0.036
Sage in 1996	p= 0.001	p= 0.001
Forested land in 1996		
No Change, Increase/ Decrease	**Fish(last-1st 3yrs)**	**Fish(90s-70s)**
Development (1971-1996)	p≤ 0.000	p= 0.001
Roofs (1971-1996)		
Docks (1971-1996)		
Agriculture (1971-1996)	p= 0.003	p= 0.005
Sage and grasslands (1971-1996)	p= 0.010	p= 0.016
Forest land (1971-1996)		p= 0.005

DISCUSSION

Plots (on file) for current and historical fish abundance and land use data suggested negative associations between fish abundance and all land uses except forest covered land. Furthermore, increases in agriculture and sage grasslands were associated with decreases in fish abundance, while decreases in forest lands were related to decreases in fish abundance. Increases in development seldom coincided with sites where significant fish decreases occurred. Spearman rank correlations supported scatter plots that fish abundance is negatively correlated with agriculture and sage and grasslands, and positively correlated with forested lands. Correlations further revealed that while the % area of development 500m from the lakeshore is not strongly correlated with fish abundance. Indicators of human disturbance such as the number of rooftops and docks along the shoreline are negatively correlated with spawning activity. This suggests that shoreline density of buildings and docks may be a more predictive measure of kokanee returns than the area of development within the 500 m buffer zone.

CONCLUSIONS

The current study objectives sought to understand the effects of changes in land use activities on the shore-spawning habitat, and the effect of habitat availability on shore spawning kokanee abundance. Results of this study indicate that while linkages among fish abundance, land use 500 m from the lakeshore, and habitat characteristics exist, these interactions are weak. Some tentative conclusions can be drawn from the work to date:

1. From the fish abundance analysis, several study sites were selected among MELP enumerations sites. One key selection criterion was that sites experienced significant declines in fish abundance over time. When these sites were compared to the entire lake, significant differences with regard to associated land use activities 500 m from the shoreline were measured.

2. Mann-Whitney U-tests between fish enumeration sites and control sites where spawners are seldom reported showed significant differences in fish abundance, land use characteristics and habitat characteristics.

3. Both fish abundance and land use indices show statistically significant and strong correlations with habitat characteristics such as water temperature, maximum depth sampled and slope.

4. Correlations of fish abundance with land use indices show statistically significant negative associations with agriculture and sage grasslands, and significant positive associations with forested lands. While correlations with the area of urban development were neither significant nor strong, shoreline indicators of development such as the number of rooftops and docks did show significant negative associations with fish abundance.

5. Current land use and changes over time were found to be statistically different among sites where high, medium, low and very low changes occurred. Similarly, fish abundance and changes over time were found to be statistically different among sites where different land uses exist and where 3 levels of change in land use have occurred.

6. Twenty-two sites used in this study represent areas in the lake where spawning kokanee have experienced significant declines. Historically, these areas supported large numbers of spawning kokanee. Since only 4 have experienced measurable urbanization, it cannot be conclusively demonstrated that urbanization is the sole cause of general decline in fish numbers. However, Spearman Correlations indicate a positive association between the increased density of shoreline disturbances and fish declines.

Interactions between land use practices and key shore spawning habitat may occur through two different mechanisms. The more obvious is physical alteration of the foreshore where kokanee spawn i.e., boat house development may result in changes to spawning habitat. The second impact of shoreline development to shore spawning habitat is less obvious. Cover removal, storm drain effluent, agricultural run-off are but a few examples of potential impacts to shore spawning habitat. These impacts are assumed to be activities associated with urban development in the

500 m zone and do not appear to be as strongly correlated to fish abundance as does measureable impacts from physical disturbance.

One assumption that is inherent in this study but difficult to test is that fish escapement is affected more so by spawning habitat availability than any other factor. That is, all other influences on kokanee abundance through their life history are constant. If this were so, then interactions among land use, fish habitat and spawner abundance may be more strongly correlated. Of course, this is not possible and one therefore concludes that another reason weak interactions found in this study is the influence of more prevalent factors such as reduced lake productivity and or overwhelming competitive pressures between kokanee fry and mysids shrimp. (Ashley et al. 1998).

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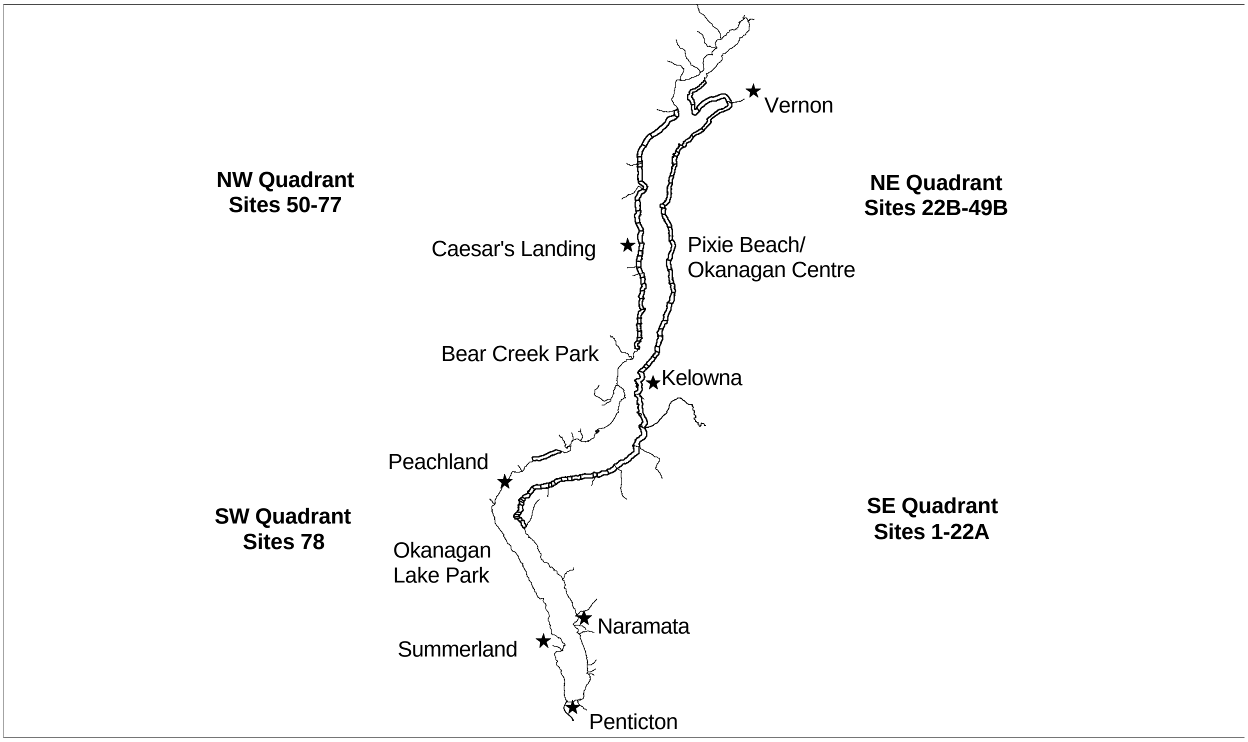
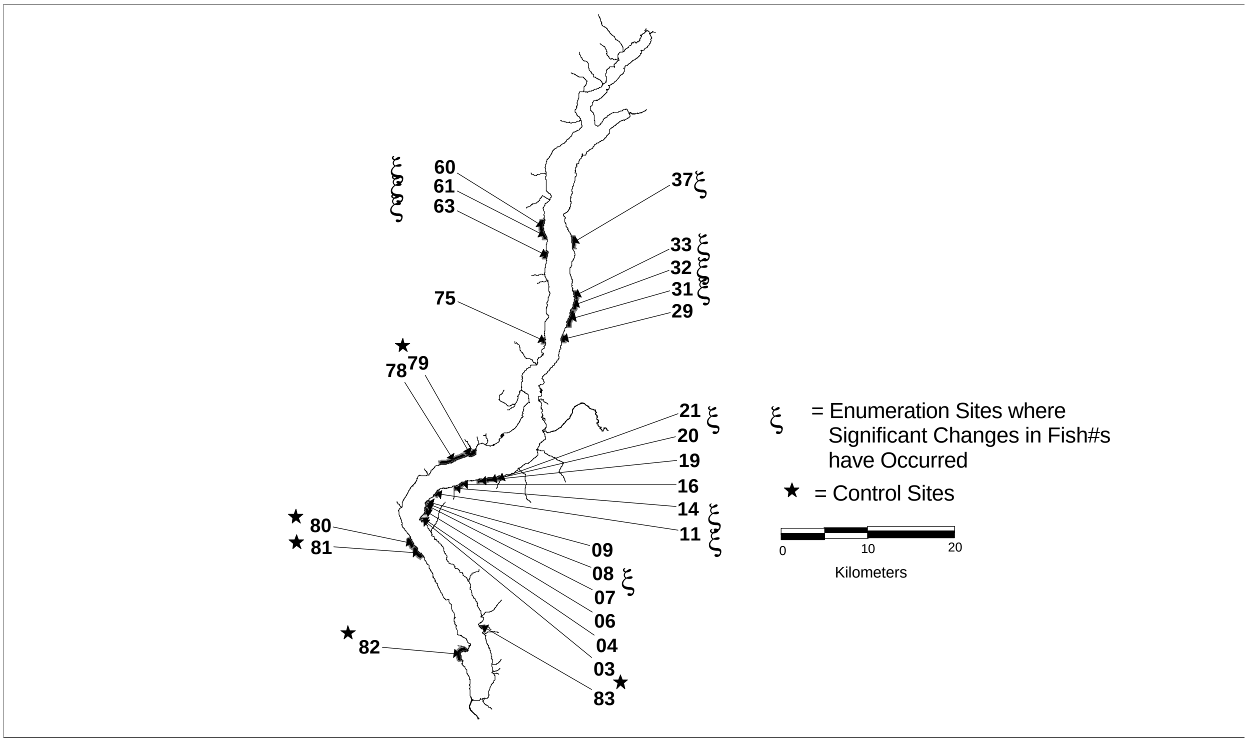


Map1. Okanagan Lake.



Map 2. Sites Selected for Detailed Land Use and Habitat Use Studies.

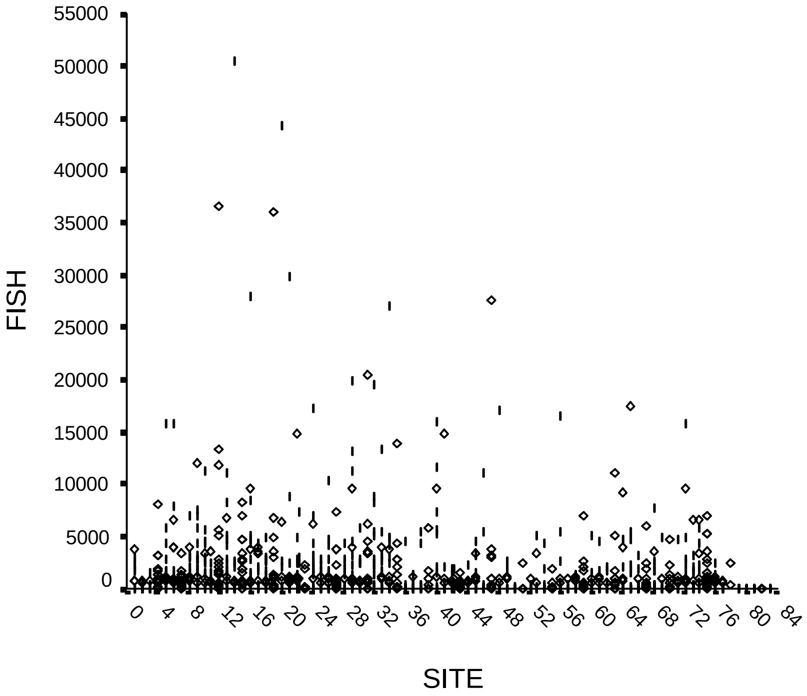


Figure 1. Lake Scale Spatial Trends in Fish Abundance.

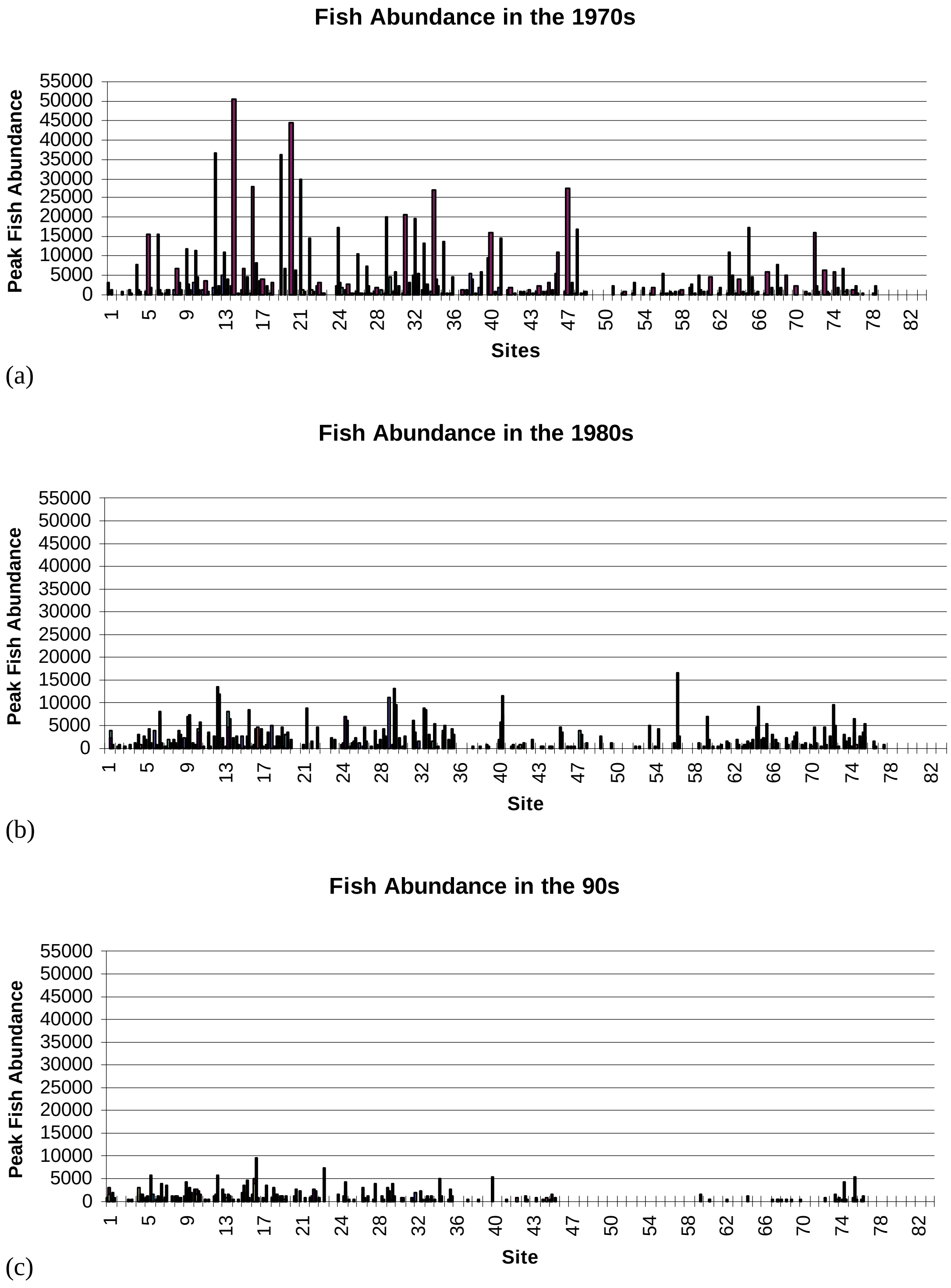


Figure 2. Site Specific Distribution of Peak Fish Abundance in the 1970s (a), 1980s (b) and 1990s (c). Scales of the three graphs are identical. Note the significant site specific trends over time.

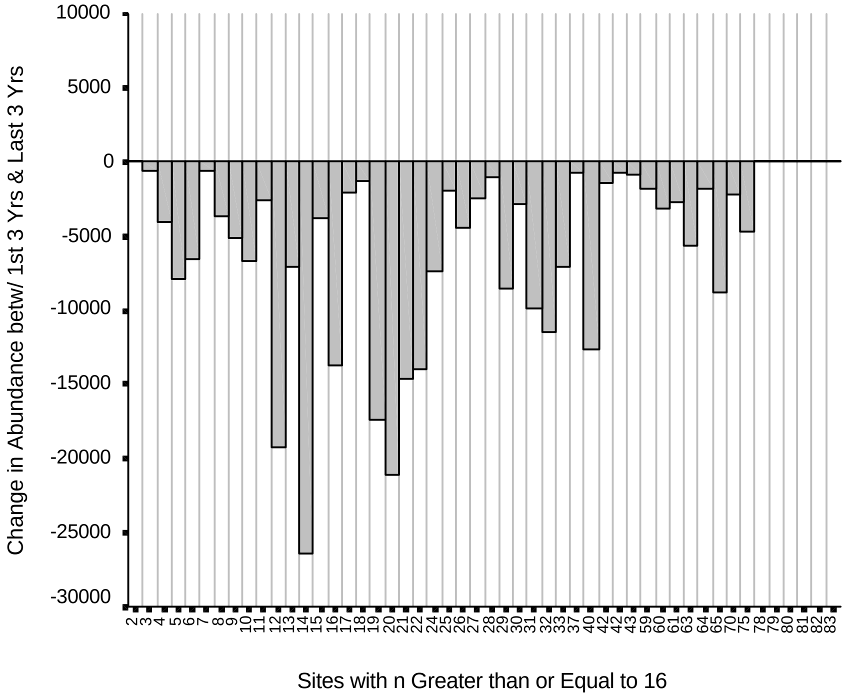
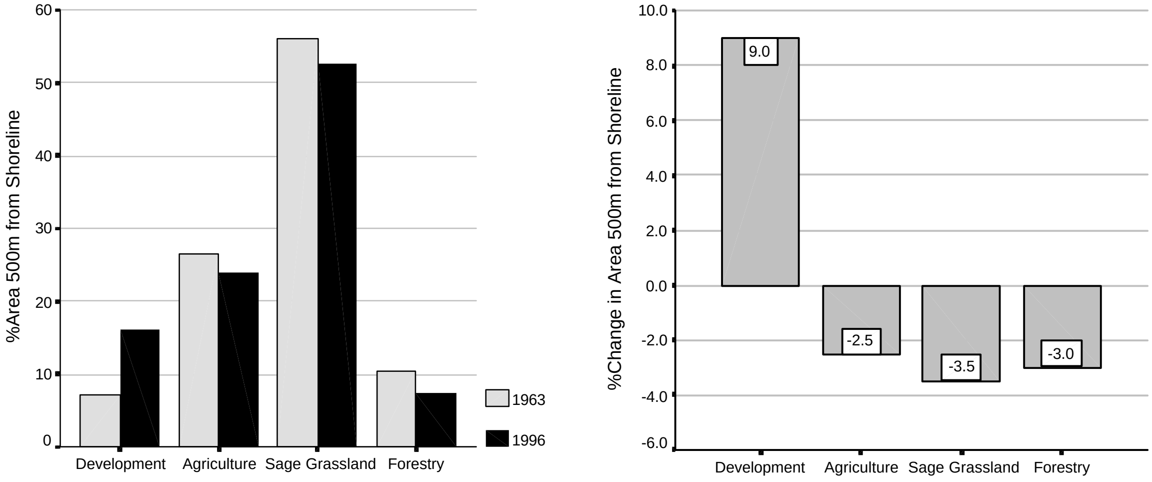


Figure 3. Changes in Fish Abundance Expressed as Difference between 1994 to 1997 and 1973 to 1975.



(a) (b)

Figure 4. Changes in Land Use Patterns Throughout Entire Lake.

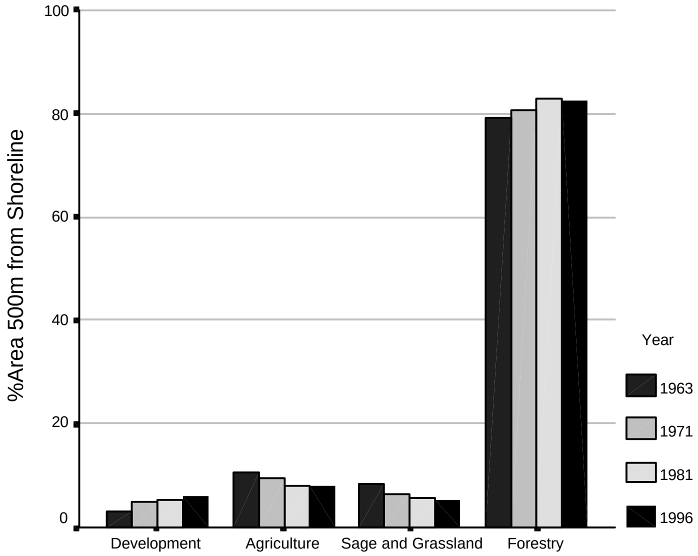


Figure 5. Changes in Land Uses Pooled from all 27 Study Sites.

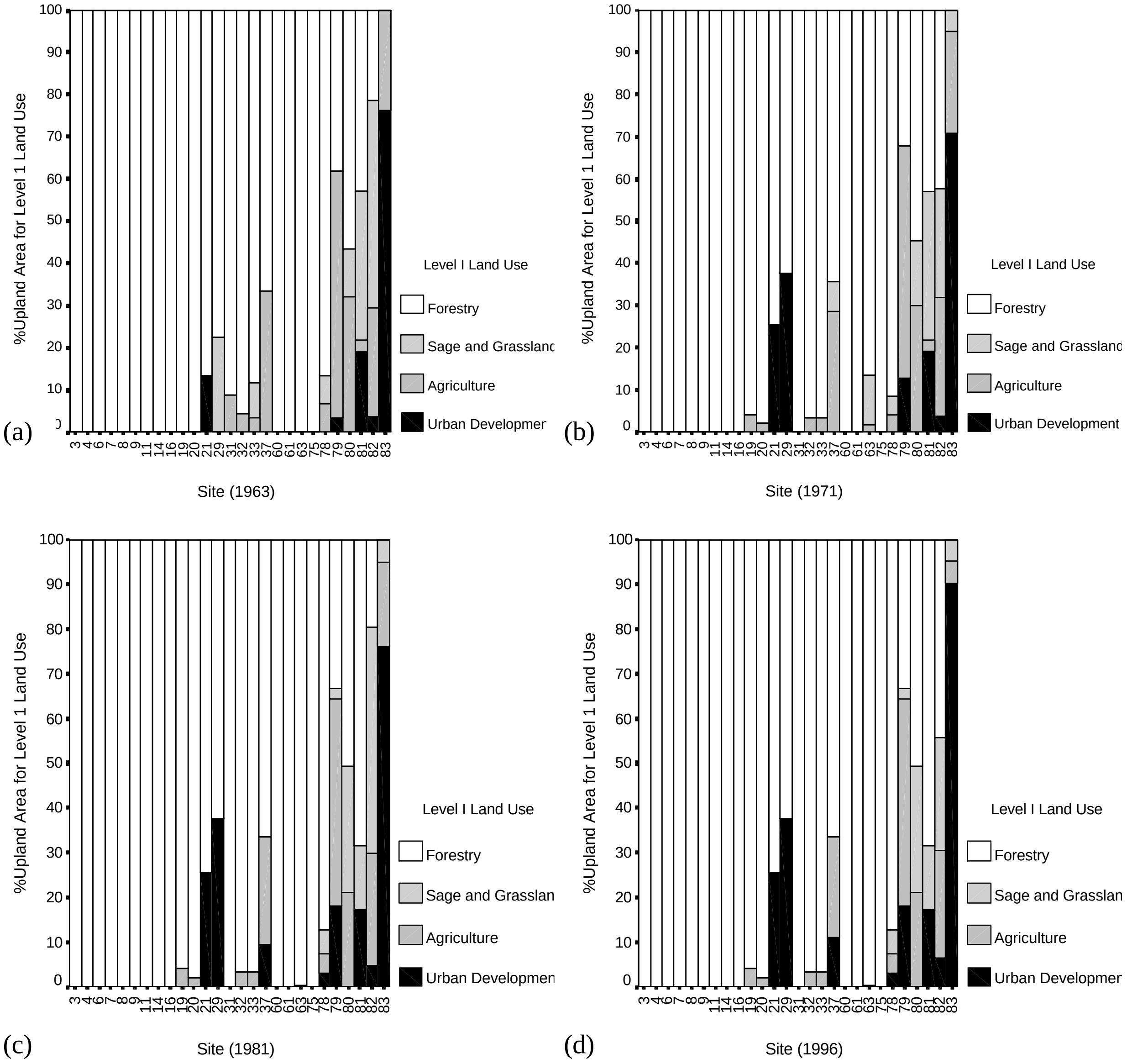


Figure 6. Spatial Trends in Land Use and Cover at Study Sites in 1963 (a), 1971 (b), 1981 (c) and 1996 (d).

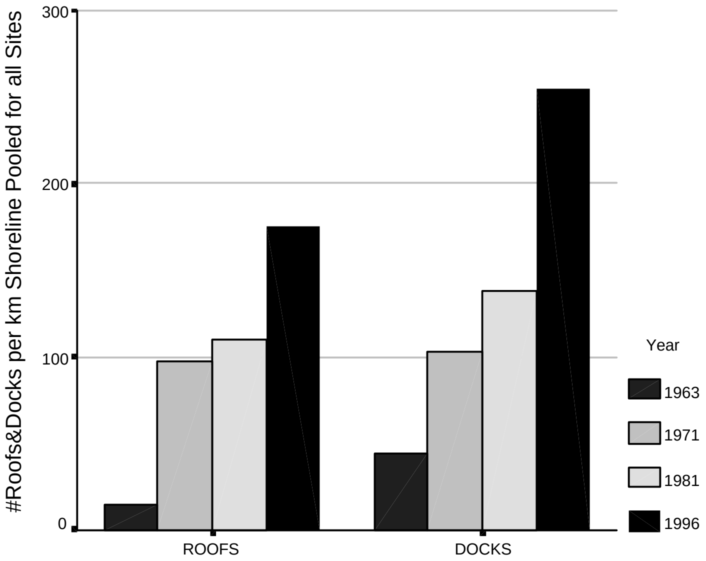


Figure 7. Number of Rooftops and Docks per Kilometer of Shoreline Between 1963 and 1996.

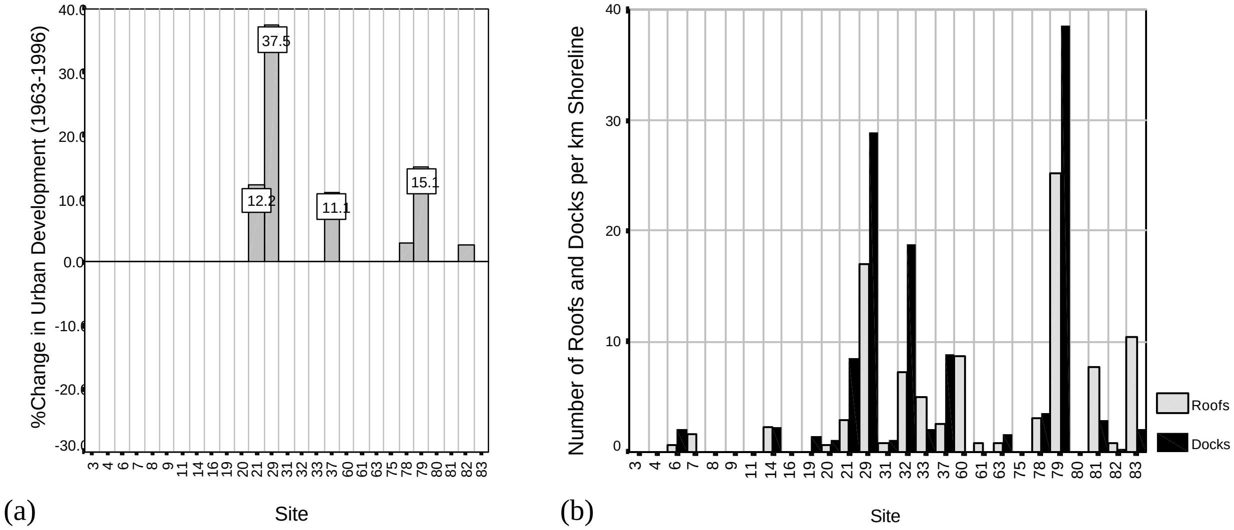


Figure 8. Increases in the Area of Urban Development (a), and the Number of Shoreline Disturbances (b).

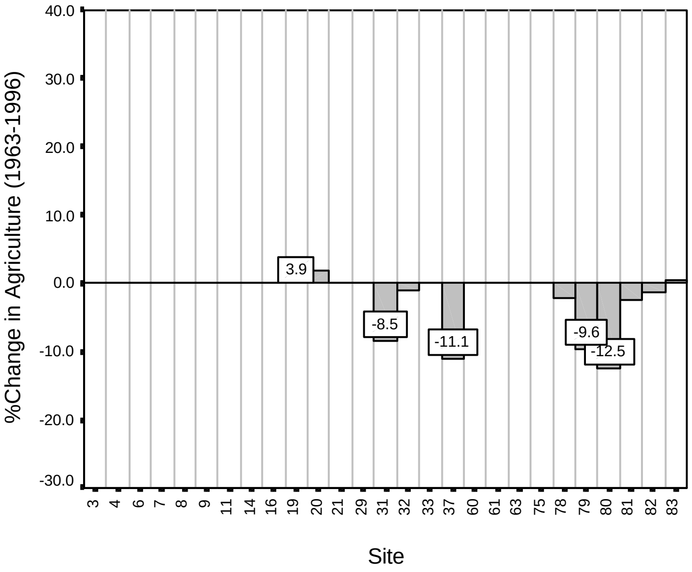


Figure 9. Changes in Area Occupied by Agriculture.

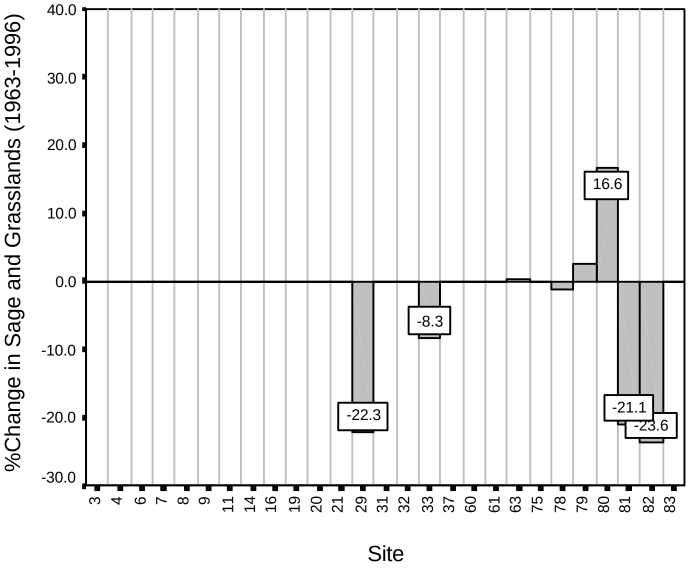


Figure 10. Change in Area Occupied by Sage Grasslands.

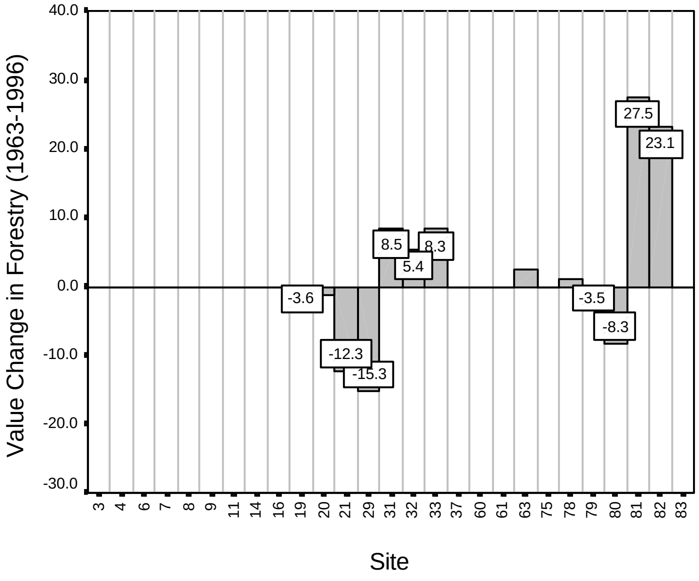


Figure 11. Changes in Area Occupied by Forestry.

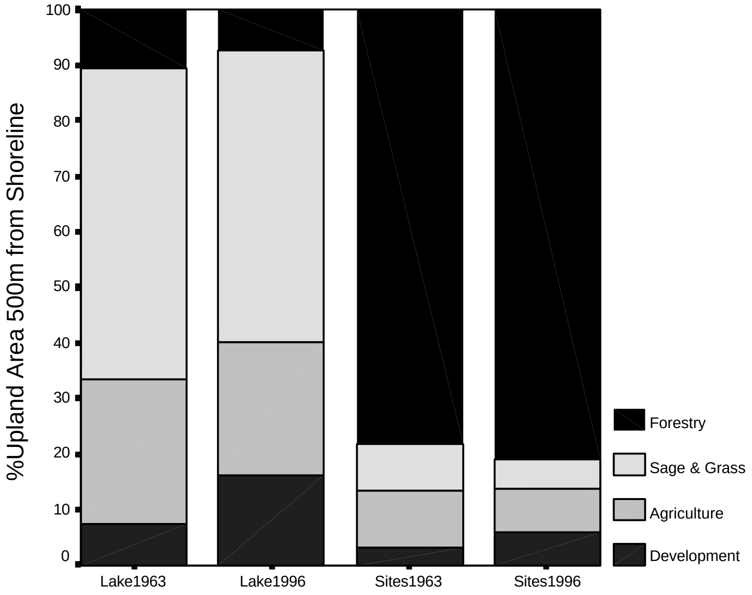


Figure 12. Comparison of Lake-wide Data to Data Pooled for all Study Sites 500 m from Shoreline.

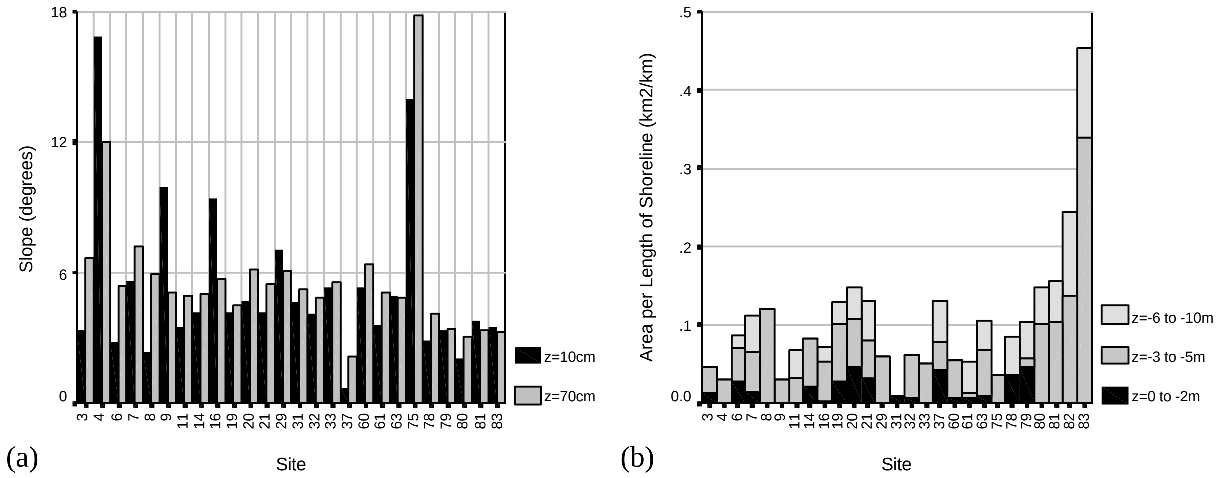


Figure 13. Bathymetric characteristics at study sites. The first figure plots the variation in slopes among sites; the second figure illustrates the area of potential habitat below 2 m, 5 m and 10 m of water at each site.

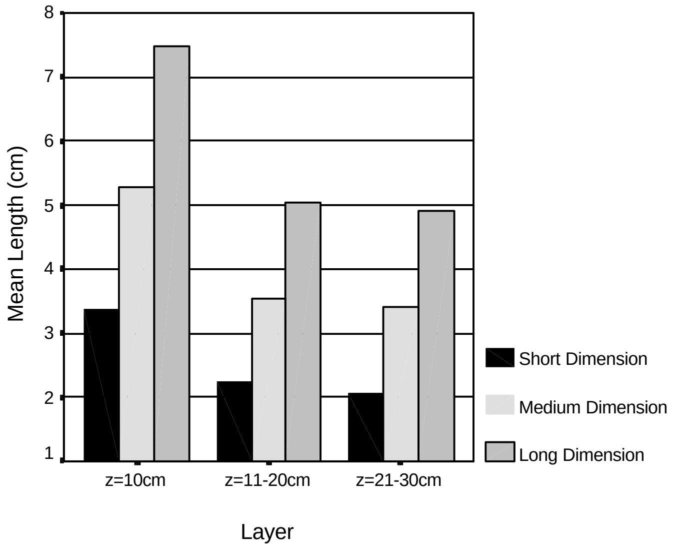


Figure 14. Substrate size decreased with depth.

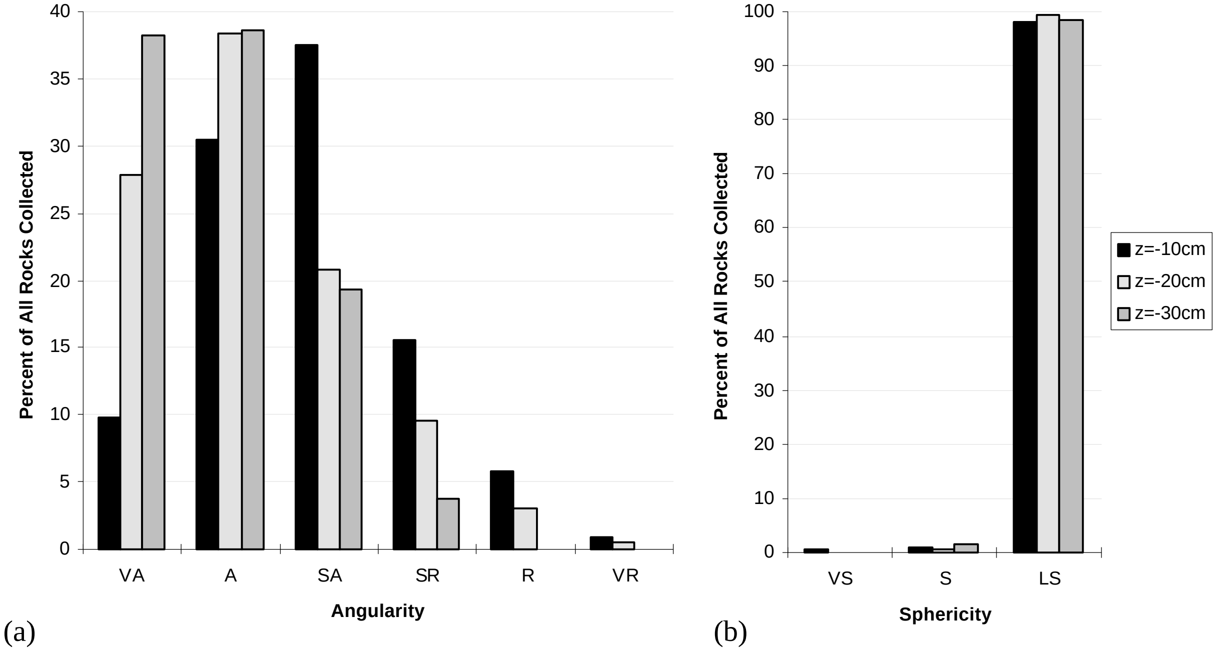


Figure 15. Substrate measured were predominantly angular and low in sphericity. Angularity increased with depth while sphericity remained constant.

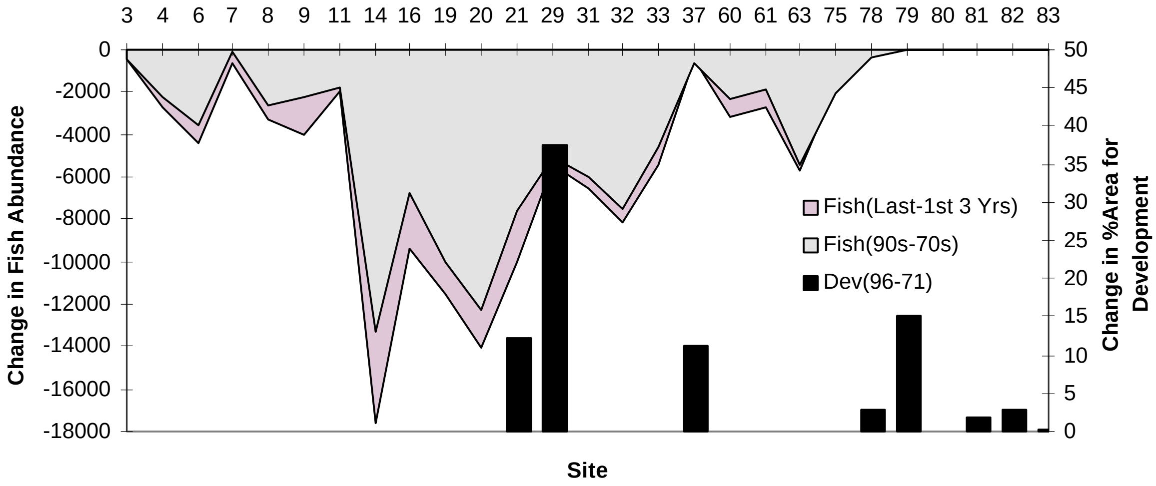


Figure 16. Spatial Comparison of Changes in Fish Abundance with Changes in Urban Development.

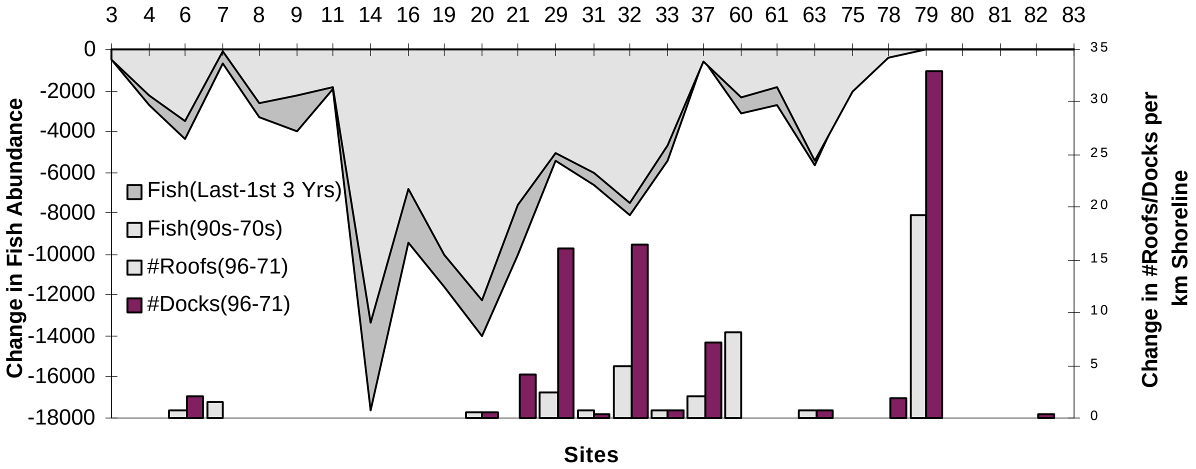


Figure 17. Spatial Comparison of Changes in Fish Abundance with Changes in #Roofs and Docks.

COMPARISON OF THE TROPHIC ROLE OF THE FRESHWATER SHRIMP *MYSIS RELICTA* IN TWO OKANAGAN VALLEY LAKES, BRITISH COLUMBIA

by

J. D. Whall[1] and D. Lasenby[1]

INTRODUCTION

The recent collapse of the Okanagan Lake kokanee (*Oncorhynchus nerka*) population instigated a research program on the freshwater opossum shrimp *Mysis relicta*, a known zooplanktivore and potential competitor with this valuable sport fish (Johannsson et al. 1994; Ashley et al. 1997). Part of this research involves comparing the distribution, abundance and bioenergetics of two populations of *Mysis relicta*. One population is in Okanagan Lake and the other in nearby Kalamalka Lake, a lake of similar morphometry and species composition which is able to support a viable kokanee population.

Three questions regarding *Mysis relicta* in Okanagan and Kalamalka lakes were asked:

1) Is there a difference in the caloric requirements of mysids between the two lakes?
2) Is there a difference in mysid impact on resident zooplankton populations in both lakes?
3) Is there a difference in mysid trophic position between lakes?

To attempt to answer these questions four separate lines of research are being pursued:

a) mysid life history characteristics will be determined for representative sites from both Okanagan and Kalamalka lakes for bioenergetic modeling;
b) mysid predation experiments on available zooplankton assemblages will be compared between both lakes;
c) mysid impact on zooplankton abundance will be modelled annually based on measured consumption rates and bioenergetically determined caloric requirements; and
d) stable isotopic tracers of ^{15}N and ^{13}C will be used to predict mysid trophic position within both lakes.

This report summarizes our progress to date.

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METHODS

The following provides a brief summary of methods outlined in the Okanagan Lake Action Plan Year 2 Report (Whall and Lasenby *in:* Ashley et al. 1998) which details field collections and experimentation from the summer of 1997. In addition we provide a description of methods and ongoing data analysis completed from November 1997 to the present.

a) Abundance and Life History Analysis

Monthly mysid collections were provided by Ministry of Environment, Lands and Parks - Fisheries for eight stations in Okanagan Lake (Map 2), and three stations in Kalamalka Lake (Stations #KA1 – KA3, Map2) for enumeration and life history analysis. At each location two hauls were taken from the deep mid-lake station and one haul from the 40 m contour on each of the western and eastern shores of the lake.

Samples for all sites have been enumerated from August 1996 to October 1998. Life history characteristics were determined for three representative sites on Okanagan Lake (Stations #OK1, OK3, OK6) and one on Kalamalka Lake (Station #KA2). Mysid total body length, sex, maturity status and brood size were analyzed for collections from August 1996 to June 1998.

b) Vertical Distribution of Mysids and Zooplankton

Temporal changes in mysid and zooplankton vertical distribution data for August 1997 (Whall and Lasenby *in:* Ashley et al. 1998) were re-analyzed to estimate the total time mysids spent in contact with their zooplankton prey for each lake. These data were then used to estimate total available time for feeding in mysid zooplankton impact calculations.

c) Cohort Analysis

The length of the mysid life cycle was determined for both Okanagan and Kalamalka lakes by following cohort development over the sampling period. Cohort structure was based on size groupings of individuals from size-frequency histograms. By tracking the average total body length of individuals within a cohort over time, it was also possible to compare mean growth rates for each cohort between stations and/or lakes. This information will provide the basis for comparison of potential differences in energetic requirements between stations and lakes.

d) Mysid Predatory Impact – Clearance Rate Experiments

Mysid clearance rates (F) of macrozooplankton (copepods and cladocerans) for Okanagan and Kalamalka lakes in June and August 1997 (Whall and Lasenby *in:* Ashley et al. 1998) were compared for significant differences between lake type, sampling month and mysid cohort using a three-way ANOVA design.

Projected impacts on zooplankton standing crop estimates from August 1996 to spring 1998 were determined for each of the four sampling stations for which mysid cohort structure was determined. Mysid abundance and cohort distributions from deep sites were used to estimate the percent abundance of different zooplankton taxa consumed per m^{2} per day.

e) Stable Isotope Collections – Mysid Trophic Positioning

Collection of various food web components for stable isotope analysis of δ^{15}N and δ^{13}C ratios were carried out in August 1997 and again in June 1998. Food web components were collected and prepared for analysis as outlined in Whall and Lasenby (*in:* Ashley et al. 1998) using a combination of the techniques described by Keough et al. (1996) and Estep and Vigg (1985). These included lake trout, whitefish, kokanee, large, medium, and small mysids, cyclopoids, calanoids, *Daphnia,* bulk plankton fractions (295 µm, 210 µm, 110 µm and 64 µm) and particulate organic matter (POM), consisting of mostly phytoplankton (1 to 64 µm fraction), clams and sediments.

The only significant change in sampling procedure for 1998 occurred in collection of sediments. Rather than using an Ekman dredge, sediments were collected using a K-B corer in approximately 70 m depth. Only cores that contained a solid sediment plug of at least 10 to 15 cm depths were used. A tygon tube flushed well with overlying water from the core was used to siphon the top 1 cm of sediment through a 500 µm mesh sieve (to remove any macrobenthos). The filtered sediment was collected in sterile 250 mL plastic bags and later filtered onto a 1 µm glass fibre filter and analyzed as per Estep and Vigg (1985). All isotope signatures of food web components were then plotted as δ^{15}N vs. δ^{13}C to delineate differences in trophic positioning (Gu et al. 1996).

Isotope samples were processed by the G.G. Hatch Isotope Laboratories at the University of Ottawa. Samples were processed on a continuous flow Finnegan Mat Delta Plus Isotope Ratio Mass Spectrometer. Isotope ratios are expressed as parts per thousand deviation from a standard (Peedee belemnite for carbon and atmospheric N_2 gas for nitrogen) as follows:

$$\delta^{13}\text{C or } \delta^{15}\text{N (‰)} = [(R_{\text{sample}}-R_{\text{standard}})/R_{\text{standard}}] * 1000$$

where R = ^{13}C/^{12}C or ^{15}N/^{14}N

RESULTS

a) Mysid Abundance and Distribution.

Seasonal peaks in mean whole-lake mysid densities occurred in July-August for Okanagan Lake in 1997 (464 m^{2}) and 1998 (509 m^{2}) (Fig. 1a). Similarly, Kalamalka Lake peak densities occurred in July 1997 (987 m^{2}; data not available for summer 1998; Fig. 1b).

Mean whole-lake mysid densities tended to increase over the course of the study (from August 1996 to October 1998) in both Okanagan and Kalamalka lakes (Figs. 1a and 1b, respectively). In Okanagan Lake, increases in 1998 densities at deep sites (relative to the same period in 1997) range from 73% in February to 19% in July. In March 1998 densities in Kalamalka Lake have shown a 274 % increase over the same period in 1997.

Average mysid abundance from August 1996 to October 1998 in deep sites at seven Okanagan Lake stations (mean ± S.E. = 300 ± 24) was significantly greater ($P \leq 1.9E-10$, paired t-test) than shallow sites (mean = 104 ± 9). Similarly, Kalamalka Lake deep site mysid densities (= 418 ± 43) were significantly greater ($P \leq 1.1E-6$; paired t-test) than shallow sites (= 225 ± 31).

With the exception of station #OK8 (which tends to be highly variable), from January to December 1997 the greatest densities of mysids were found in the southern basin of Okanagan Lake at stations #OK2 and OK3 (mean = 398 m^2) (Fig. 2). Between January and October 1998 however, the basin north of Kelowna (stations #OK6 and OK7) appeared to have the greatest densities of mysids (= 389 to 783 m^2, respectively). Station #OK4 immediately south of Kelowna has consistently had the least number of mysids present throughout the study period (mean = 178 m^2). In Kalamalka Lake there appears to be a trend of decreasing abundance from south to north (station #KA1 to KA3) in 1997, while in 1998 that trend was reversed.

Mysid abundance obtained from the 40 m depth contour does not appear to be consistently greater on either the east or west side of Okanagan Lake (Figs. 3a-h). High peaks in the late spring, early summer in near-shore mysid densities may be a result of recruitment events from newly released juveniles. In the relatively shallow Armstrong Arm (mean depth = 45 m), mysid abundance declines markedly in both shallow and deep sites in late fall (Fig. 3h), which also corresponds to periods of hypolimnetic oxygen depletion at this site (McEachern *in:* Ashley et al. 1998).

b) Vertical Distribution.

On August 12th to 13th 1997, mysids in Okanagan Lake were absent from the upper 50 m prior to 20:00 hrs and after 06:00 hrs. They began to overlap with prey at depths less than 30 m at approximately 21:00 hrs and remained in contact with them until ~05:00 hrs for a total of approximately eight hours feeding in the meta-and epilimnetic region of the lake (Fig. 4a). An estimated 84 % of the mysids time between sunset and sunrise was spent in contact with prey items.

Mysids were captured in the upper 10 m of Okanagan Lake, only at 02:00 and 04:00 hrs. (Fig. 4a). Temperatures changed rapidly from 14°C to 19.6°C between12 m and 10 m, perhaps providing a thermal barrier to the mysids, as 17°C has been suggested to be the upper tolerance level for mysids (Johannsson et al. 1994). It is possible that mysids found in the top 10 m hauls were foraging briefly in the warmer epilimninion. Between 22:00 and 04:00 hrs, the mysid population maintained a widespread distribution of all maturity classes in the top 50 m, indicating that all classes migrate on a diurnal basis.

In Kalamalka Lake, similar trends in zooplankton distribution were found (Fig. 4b), except that the majority of cladocerans were not found in the upper 10 m as was observed in Okanagan Lake. The zooplankton abundance for August in Kalamalka Lake (~3900 - ~6700 m^3) was approximately two thirds that of Okanagan Lake (~6500 - 9200 m^3) despite having similar or somewhat higher numbers of mysids than Okanagan Lake.

In Kalamalka Lake, mysids also spend ~8 hrs in contact with the zooplankton in the upper 30 m. However, more mysids were found in the top 10 m than in Okanagan Lake, even though average temperatures from 0 to 10 m in Kalamalka Lake (20.5°C) were very similar to Okanagan Lake (20.7°C). As in Okanagan Lake, all mysid maturity classes were present throughout the night in Kalamalka Lake.

c) Mysid Cohort Structure

A representative mysid size-frequency histogram for Okanagan Lake (station #OK3) shows juvenile release beginning in December and continuing until July (Fig. 5a). This pattern is also evident at stations OK1 and OK6 (not illustrated here), which show brooding females being present nearly all year round (except August and September in some cases), and juvenile release beginning as early as November and lasting as late as August. Kalamalka Lake mysids (station #KA2) however, exhibit a shorter juvenile release season, lasting from February until June (Fig. 5b). In general, the majority of juvenile release in both Okanagan and Kalamalka lakes occurs in the spring (e.g., March to May).

Mysid cohort structure was established according to age. Year zero (YR0) mysids were <365 days old, with the cohort starting at the first appearance of juveniles in the sample; Year 1 (YR1) mysids ≥365d, <730d and Year 2 (YR2) mysids ≥730d old. In general, YR0s released in December to March develop secondary sexual characteristics (Reynolds and DeGraeve 1972) at ≥ 7mm by July. By December of their first year, YR0s become immature males or females and overwinter in this stage until the start of the their second spring (now classified YR1) where they then grow into mature adults by late spring or early summer. The exception to this are immature males in Okanagan Lake, some of which may develop into mature males by the end of their first summer (Figs. 5a).

Difficulty in separating the overlap of cohorts YR1 and YR2 arises in the early spring (e.g., March to April) as it appears that the last of the YR2 animals die off and are replaced by YR1s beginning to grow again after the winter dormancy period. Mature males rarely survive past their second winter to the YR2 stage likely dying after breeding in the fall.

Mysid growth rates were estimated by tracking the average size of each previously defined cohort. The mysid cohort growth rates from February to July 1997 was used as a surrogate data set for the same period in 1996. By doing so it was possible to track the mean size of one complete mysid cohort from birth in February 1996 until mortality in March 1998 for each of the stations KA2, OK1, OK3 and OK6 (Figs. 6a-d, respectively).

In general, Okanagan Lake mysids reach up to 10 to 11 mm in length by the end of their first year. During this first year of growth, there is almost no difference in size of immature males and females (hence grouped together as YR0s). During the spring growing season of their second year immature females begin to increase in size and remain on average ~ 1.5 mm longer than the males throughout the year. Average YR1 adult and immature female length peaks at ~ 14.5 mm in Kalamalka Lake (Fig. 6a) and ~16 mm in Okanagan Lake (Figs. 6b-d). Females surviving >730 days (YR2 cohort) maintain a mean of ~15-16 mm although they may reach a maximum of ~ 19mm in Okanagan Lake.

Table 1 displays the regression equations for the linear portion of growth in the YR0 mysids from April to October 1997, which corresponds to the period of maximum growth. There was no significant difference in growth rates between stations and/or lakes (ANCOVA, $P_{slopes}= 0.411$; $P_{intercepts}= 0.705$).

Table 1. Regression equations for growth in the 1997 YR0 mysid cohorts of Okanagan Lake (Stations # OK1 – OK6) and Kalamalka Lake (Station KA2).

Station	**Regression Equation**	**R^2**
OK1	$y=0.027x - 3.124$	0.96
OK3	$y=0.032x - 4.511$	0.98
OK6	$y=0.027x - 2.978$	0.95
KA2	$y=0.032x - 4.663$	0.94

The mean body mass (dry weight) in each mysid cohort was multiplied by the average abundance of that cohort to obtain total mysid population biomass estimates from August 1996 to June 1998 (Fig. 7). For each of the sampling stations, biomass peaks tend to coincide with peaks in abundance (e.g., June to August). Total population biomass ranges from ~500 mg m^{2} in the winter to ~3000 mg m^{2} in the productive summer months (Fig. 7).

The stations ranked according to mean biomass (± S.E.) from August 1996 to June 1998 are: KA2 (=1883 ± 212 mg m^{2}) > OK3 (=1610 ± 174 mg m^{2}) > OK6 (=1229 ± 101 mg m^{2}) > OK1 (1165 ± 136.5 mg m^{2}). Generally, the biomass of YR1 males and YR1 females were similar, while the majority of biomass in the YR2 cohort was comprised of females.

Mysid Feeding and Consumption Estimates

There was no significant difference between mysid clearance rates and the date of the experiments (either June or August 1997; 3-Way ANOVA; $P \geq 0.126$). Clearance rates from both months were pooled for juveniles (YR0 cohort) and immatures and adults (YR1 and YR2 cohorts) to be used in subsequent consumption estimate modeling.

Although consumption patterns on zooplankton types are similar between juvenile and adult mysids (Figs. 8a and 8b), with clearance rates being greatest on cladocerans, the clearance rates for YR0 mysids in Kalamalka Lake are much lower than those of Okanagan Lake (Fig. 8a).

Average clearance rates on selected zooplankton groups (Figs. 8a, b) were used with mean deep-site mysid densities and estimated feeding times to calculate the potential mysid population impact on zooplankton abundance over time. To express mysid impact in terms of percentage of zooplankton population removed, it was necessary to assume that all zooplankton in the lake were in the upper 45 m corresponding to depth of zooplankton hauls (McEachern *in:* Ashley et al. 1998).). Total numbers of zooplankters consumed were then divided by the total number available to obtain the percentage of zooplankton population removed.

Mysid impact on zooplankton abundance (expressed as % of zooplankton population removed per day) follows the seasonal mysid population trend, with the greatest % of prey populations removed during the summer and early fall for all stations modelled (station #OK1, OK3, OK6: Fig. 9a to c; and KA2: Fig. 9d). The order of predation pressure follows that of clearance rates, with *Diaphanasoma* > *Daphnia* > cyclopoids > calanoids. With the exception of *Diaphanasoma*, daily impact by the mysid population is generally ≤ 1.0 % of the prey population removed (Figs. 9a to d). These estimates do not include other potential zooplankton prey such as copepod nauplii or *Bosmina*, which may serve as an important food source to the mysids.

d) Food Web Relationships

Preliminary analysis of $\delta^{15}N$ and $\delta^{13}C$ signatures for Kalamalka and Okanagan lakes for August 1997 and June 1998 suggests that there is no substantial difference in the base of the food web (POM, Figs 10a-d). Although the mean mysid $\delta^{15}N$ signatures between the two lakes appear to be different, the August 1997 and June 1998 signatures within each lake are relatively similar (Okanagan Lake 7.7 ‰ and 7.3 ‰ respectively; Kalamalka Lake 10.2 ‰ and 10.1 ‰ respectively). The mysids in Kalamalka Lake appear to occupy a somewhat elevated trophic level relative to those in Okanagan Lake as they were approximately 2.5 ‰ enriched with $\delta^{15}N$.

With the exception of the August 1997 data for Okanagan Lake, large mysids were enriched approximately 2 ‰ relative to small mysids in both lakes.

In general, in both Okanagan and Kalamalka lakes, mysid $\delta^{15}N$ signatures were similar to or slightly depleted relative to copepods, while being enriched over *Daphnia* and POM. For example, in August 1997, mean Okanagan Lake mysid $\delta^{15}N$ signatures (7.7 ‰) were between those of copepods (9.7 ‰) and *Daphnia* (6.4 ‰) and greater than POM (3.2 ‰). Okanagan Lake kokanee nitrogen isotope signatures are on average enriched over mysids by 2.9 ‰ in 1997 and by 3.0 ‰ in 1998.

Okanagan Lake mysid $\delta^{13}C$ values (–30.8 ‰ to –29.3 ‰ in August 1997 and –29.8 ‰ to -28.2 ‰ in June 1998), are similar to those for Kalamalka Lake mysids (–32.6 ‰ to -30.6 ‰ and –32.1 ‰ to –29.7 ‰ for the same months). In turn, these signatures are similar to, or slightly enriched, over other pelagic zooplankton and POM, while being more depleted than the sediments (-26.9 ‰ to –25.6 ‰, Okanagan Lake only; Figs. 10a to d). Analytical problems prevented carbon isotope signatures being determined for Kalamalka Lake sediments. For presentation of $\delta^{15}N$ values for Kalamalka Lake sediments, $\delta^{13}C$ signatures have been assumed to be the same as Okanagan Lake sediment samples (Figs. 10b and d).

The fish analyzed from Okanagan Lake are spatially separated from the pelagic zooplankton by both their $\delta^{15}N$ and $\delta^{13}C$ signatures (Figs. 10a, c). Kokanee $\delta^{15}N$ is on average 2.0 ‰ and 3.4 ‰ enriched over the zooplankton sampled in August and in June respectively. Kokanee $\delta^{13}C$ is on average 4.1 ‰ and 4.9 ‰ enriched over zooplankton in August and June as well.

DISCUSSION

For the two years sampling, mysid densities in Okanagan Lake appear to be increasing, with the yearly whole-lake averages (± S.E.) increasing from 284 (±86) in 1997 to 374 (±37) in 1998. However, it has been shown in other systems that mysid abundance can fluctuate greatly from year to year (Lasenby et al. 1996) and therefore only long-term population monitoring will be able to detect significant trends (see McEachern in this report).

With the exception of the 1998 data from Vernon Outfall (Station #OK7), peak mysid abundance in Okanagan Lake generally appears to coincide with the deeper stations (e.g., OK2, OK3, O6). Stations with lower abundances (e.g., OK1 and OK4) correspond to the shallower shelf-regions in the basin (see Map 2).

The significant dependence of mysid density with depth in Okanagan Lake has also been shown for Kootenay Lake, British Columbia and Lake Ontario mysid populations (Smokorowski 1998; Johannsson 1995). Johannsson (1995) speculated that larger mysids may gain an energetic benefit by remaining in deeper water as they would expend less energy avoiding predators and may consequently have more time to feed on high-quality zooplankton food sources.

The lack of mysids in the upper 10 m in Okanagan Lake is coincident with a sharp increase in temperature to 19.6°C (the lower limit of the epilimnion). Smokorowski (1998) reports a potential for mysid avoidance of temperatures > 17°C. This creates a potential for an epilimnetic refuge for cladocerans from mysid predation, as has been noted in other systems (Rieman and Falter 1981; Lehman et al. 1990). However, analysis of data from Okanagan and Kalamalka lakes suggests that mysids are not completely excluded from waters warmer than 17°C but may be limited to brief foraging periods in the epilimnion.

When comparing mysid growth and cohort structure between lakes from 1996 to 1998, several differences become apparent. Juvenile release is nearly continuous in Okanagan Lake beginning in November continuing until August and September. However, in Kalamalka Lake, juvenile release begins in February and ceases by June or July. Also, mysids appear to reach a greater total body length in Okanagan Lake (up to ~19 mm) versus Kalamalka Lake (up to ~16 mm) which may translate into a difference in energetic requirements of the larger cohort.

The 1997 YR0 growth rates ranged from 0.027 to 0.032 mm per day for Okanagan and Kalamalka lakes. These values are comparable to those found for first year mysids in Lake Ontario at 0.035 mm per day (Johannsson 1992). Comparison of growth rates revealed that there were no significant differences between station or lake, suggesting that the energetic requirements of mysids throughout their first year of life is similar in both lakes.

Common to both Okanagan and Kalamalka lakes is a 2-year life cycle for mysids. A juvenile mysid released in the winter or spring of 1996 will reach an immature sexual stage by summer 1996 (with males possibly maturing in their first year), and overwintering in this pre-adult stage. Beginning in spring 1997, immature mysids became mature by the end of their second summer. If they survive past their breeding season in the fall of 1997, they will overwinter and survive until the spring of 1998, for a total life expectancy of ~750 days (for mature females).

Johannsson (1992) also describes a 2-year life cycle for the mysid population in Lake Ontario. In Lake Ontario the greatest number of cohorts occur in the spring when the newly released cohort is present with the immature 1-year old mysids (and those that are reproductively spent) and the larger 2-year old mysids.

Mysid clearance rates on selected zooplankton species range from ~75 mL/mysid/hour for copepods to ~460 mL/mysid/hr for *Diaphanasoma*. Clearance rates on copepods are similar to those found in Kootenay Lake (50 to 120 mL/mysid/hr) (Smokorowski 1998) and oligotrophic central-Ontario lakes (42 to 110 mL/mysid/hr) (Nero and Sprules 1986). Clearance rates on *Daphnia* and *Diaphanasoma spp*. in this study (146 to 460 mL/mysid/hr) are much lower than those found by Nero and Sprules (1986) (390 to 1019 mL/mysid/hr), but higher than those in neighbouring Kootenay Lake (10 to 232 mL/mysid/hr). These results support the contention that mysids search, secure and ingest their prey on a lake-specific basis and research should be based accordingly (Nero and Sprules 1986; Smokorowski 1998).

Mysid impact on abundance of prey populations appears to be relatively similar in both Okanagan and Kalamalka lakes. For all prey groups modelled, other than *Diaphanasoma*, total mysid impact is ~≤ 1 % of that group's population removed per day. These levels of consumption are similar to Kootenay Lake mysids which removed between 2 to 4 % of the total available zooplankton standing crop per day (Smokorowski 1998) and in Lake Michigan, where *Daphnia* mortality due to mysid predation was generally < 1 % per day (Lehman *et al*. 1990). Lehman et al. (1990) determined that with a mean estimated *Daphnia* birth rate of ~ 10 % d^{1}, this level of mysid predation would be insufficient to control a daphnia population.

The greater percentage of the *Diaphanasoma* population removed compared to other zooplankton types is a result of the relatively high mysid clearance rate estimates for this group. As only one of the six predation trials from Kalamalka Lake contained *Diaphanasoma*, the clearance rate estimate used to model mysid impact for this lake should be used with caution. Although higher than Okanagan Lake the estimates for *Diaphanasoma* in Kalamalka Lake are within the range found by Nero and Sprules (1986).

These mysid impact calculations do not take into account zooplankton productivity, which will define how quickly they are able to replace their biomass. As zooplankton productivity estimates for Okanagan and Kalamalka lakes do not exist, they will have to be inferred using biomass estimates from the Kootenay Lake zooplankton population (Thompson and Ashley 1997). These biomass estimates can then be applied to published P/B ratios to infer production estimates for the zooplankton in both Okanagan and Kalamalka Lakes (Stockwell and Johannsson 1997; Shuter and Ing 1997).

Preliminary analysis of the stable isotope results suggests that mysids receive the majority of their energy from planktonic, rather than benthic food sources. Although researchers have reported that mysids may obtain a portion of their energy from sediments during the day (Parker 1980; Johannsson et al. 1994), it appears that in Okanagan and Kalamalka lakes, they do not assimilate a great deal of energy from this source.

There appears to be some evidence that mysids may be feeding on different food sources according to their stage in life. With the exception of Okanagan Lake in August 1997, large mysids appear to be enriched in $\delta^{15}N$ relative to small mysids by ~2 ‰. Although not yet quantified, if this nitrogen isotope enrichment is a result of a greater input of energy from more enriched zooplankton (relative to POM), then this would correspond to the greater clearance rates on zooplankton found in large mysids in this study. In addition, small mysid $\delta^{13}C$ values were more enriched than larger mysids (up to ~3.5 ‰), which suggests a greater proportion of more enriched carbon sources in their diet (such as organic matter in the sediments).

The lack of increase in $\delta^{15}N$ signatures in mysids relative to copepods is puzzling, as the mysids have been shown to readily consume this prey in experimental chambers and in gut content analysis in this study. As stable isotopes offer a measure of the assimilated (not just ingested) diet (Peterson and Fry 1987), it may be possible that they are consuming the copepods, but not assimilating them to the same degree as either cladocerans or phytoplankton. Toda and Wada (1990) also found that mysid $\delta^{15}N$ signatures were on average ~1‰ lower than the zooplankton in the lake and ~3.7‰ enriched over POM (mostly phytoplankton). They found that zooplankton did not constitute a major source to mysid diet, but rather that mysid $\delta^{15}N$ signatures tracked the seasonal changes in POM more closely.

While $\delta^{15}N$ provides an estimate of trophic level, $\delta^{13}C$ values reflect the food source of an organism, with the consumer often exhibiting little (~1‰) or no enrichment relative to their food source (Peterson and Fry 1987). Mysids exhibit a range in $\delta^{13}C$ values (from ~ –32 to –28‰), but on average reflect a planktonic food source rather than the more enriched $\delta^{13}C$ source found in sediments (~ -26‰). As a result, it is unlikely that mysids are incorporating much of the detrital organic material from the sediments into their tissues. This is consistent with ^{15}N data.

The elevated nitrogen isotope signature in the kokanee relative to mysids indicates that they may occupy a higher trophic level (Gu et al. 1996). Additionally the kokanee $\delta^{13}C$ values relative to the zooplankton sampled are much greater than the proposed 1‰ enrichment value between consumer and prey (Peterson and Fry 1987). This would seem indicates that the kokanee that are primarily planktivorous (Foerster 1968) and may be utilizing a food source that is distinct from the pelagic zooplankton used by the mysids. Keough et al. (1996) found the $\delta^{13}C$ signature of Lake Superior alewife (*Alosa pseudoharengus*) was more closely linked with the enriched carbon isotopes found in the shallow wetland ecosystem than the more ^{13}C depleted pelagic system. This suggested that alewife may have spent more time feeding in the shallower regions of the lake. In Okanagan Lake, there may be more separation in the trophic and feeding relationships between the deep-water mysids and kokanee than previously thought. Food habits of Okanagan Lake kokanee should be examined to better understand their feeding behaviour.

Any interpretation of results of trophic positioning and food source using stable isotopes needs to consider the possibility of seasonal variation in isotope signatures. This may be particularly important for organisms at the base of the food web (e.g., phyto- and zooplankton) which turnover their biomass more often than larger organisms such as fish. For example, Gu et al. (1994) report that $\delta^{15}N$ can vary seasonally in *Daphnia middendorfia*, which exhibit ~0.5 ‰ decrease in June and July relative to August. If this type of relationship exists for Okanagan Lake *Daphnia*, then the level of $\delta^{15}N$ fractionation we see in August may be overestimating the signature which mysids would have been consuming in June and July (which may be retained in the August collection of mysid tissues). This in turn could underestimate the importance of the food source to the mysids. Future studies using this technique could follow a seasonal regime as described by Leggett (1998) who recommended monthly collections for mysids and bi-weekly collections for plankton.

The next step in the analysis of the isotope data is to determine whether it is possible to use a mixing model (e.g., Gu et al. 1996) to determine the % contribution of zooplankton to the mysid’s diet.

SUMMARY

- Mysid populations in Okanagan and Kalamalka lakes increased from 1997 to 1998.
- Most recently, the greatest abundance of mysids in Okanagan Lake. Appears to occur north of Kelowna (stations #OK5 to 7).
- The greatest numbers of mysids are found in the deep, mid-lake locations.
- There is no substantial difference in mysid abundance in east or west shallow sites in Okanagan Lake.
- Based on summer distributions, mysids spend ~84 % of the time post sunset and pre-sunrise feeding in the metalimnion.
- Okanagan Lake has a more continuous juvenile release season (November/December to August/September) than Kalamalka Lake (January/February to June).
- In both lakes, the greatest period of juvenile recruitment is March to April.
- Mysids have a 2-year life cycle with some of the larger females surviving up to ~27 months.
- According to average mysid abundance estimates and clearance rate estimates, the mysid population is unable to consume more than ~1 % of zooplankton abundance on a daily basis (with exception of *Diaphanasoma*).
- For Okanagan Lake, stable isotope data suggest that mysids may utilize pelagic food sources to a greater degree than sediment/detrital organic sources.
- From stable isotope data kokanee and deep-water mysids do not appear to share the same trophic level in Okanagan Lake.

ACKNOWLEDGEMENTS

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Fig. 1a

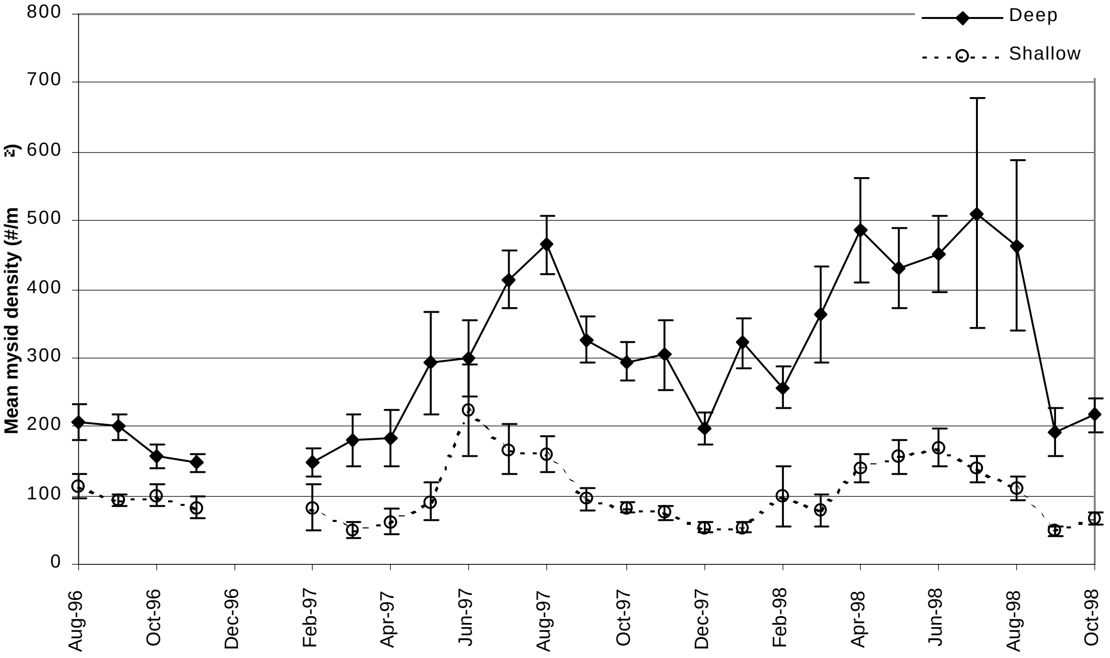
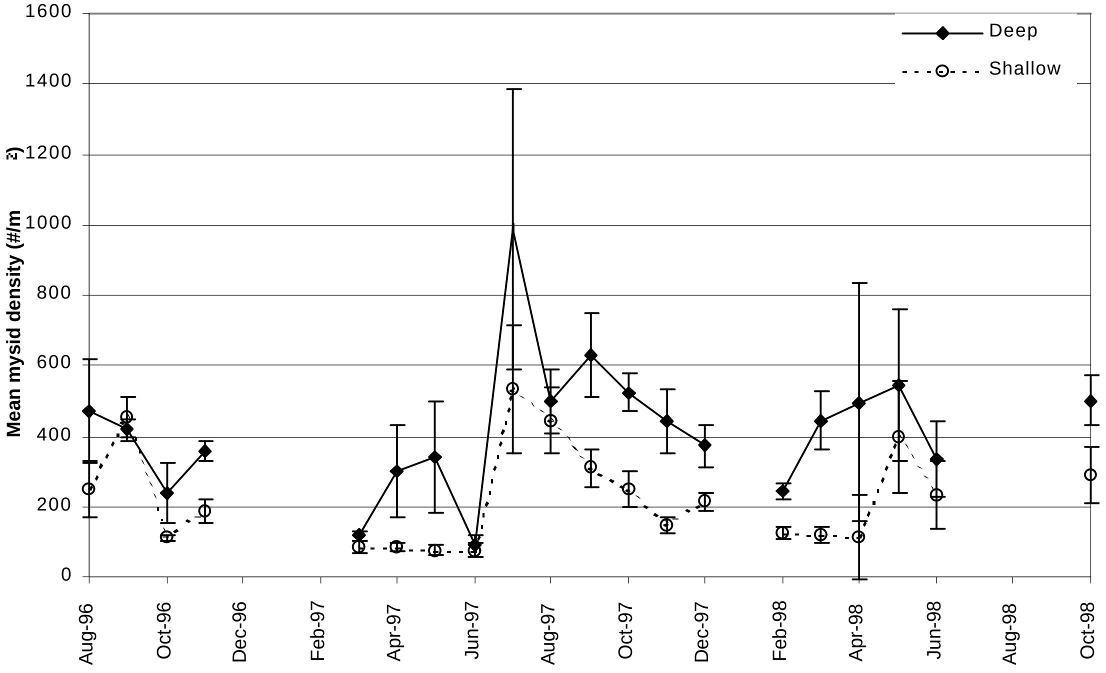


Fig. 1b



Figures 1a,b. Whole-lake mean mysid densities for a) Okanagan L. (Station #OK8 excl.; n=7 stations) and b) Kalamalka L. (n=2-3 stations) (bars rep. +/- 1 S.E.).

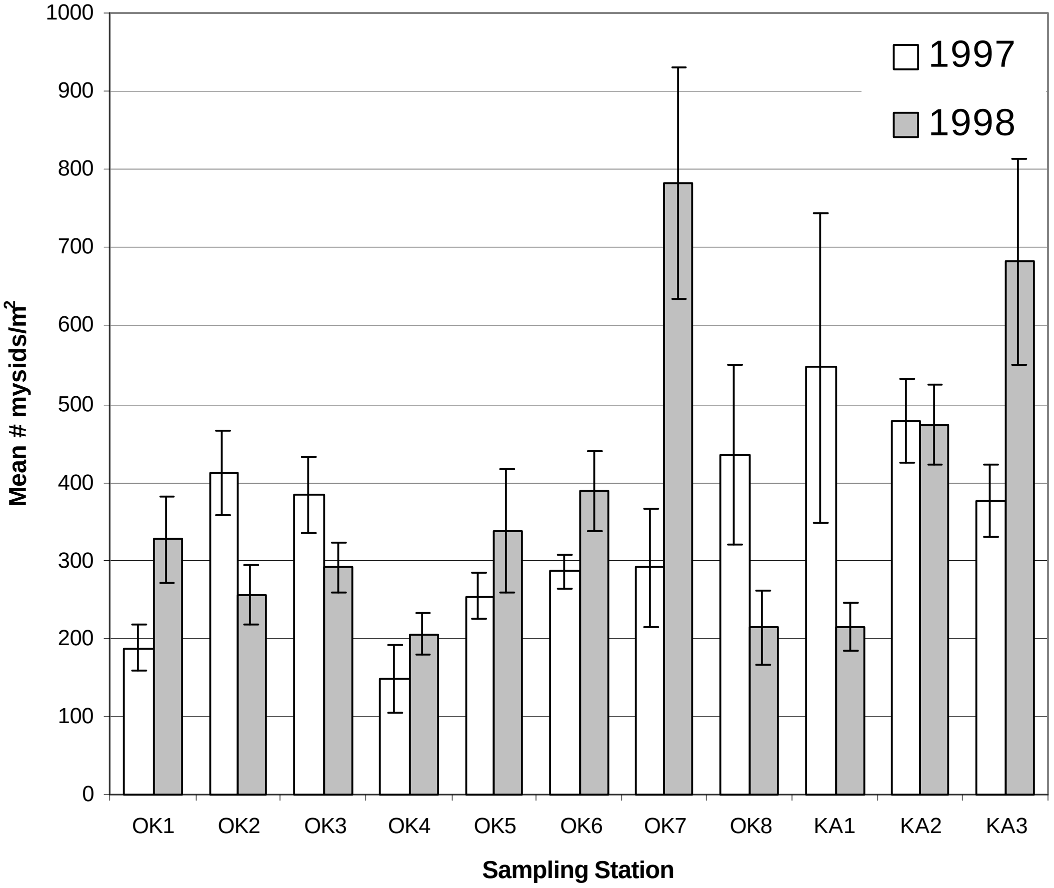


Figure 2. Mean annual mysid distribution by station for Okanagan Lake (Station #OK1-8) and Kalamalka Lake (Station #KA1-3) (bars rep. +/- 1 S.E.; Note: 1997 - January to December inclusive, 1998 - January to October only).

Fig. 3a

Station # OK1

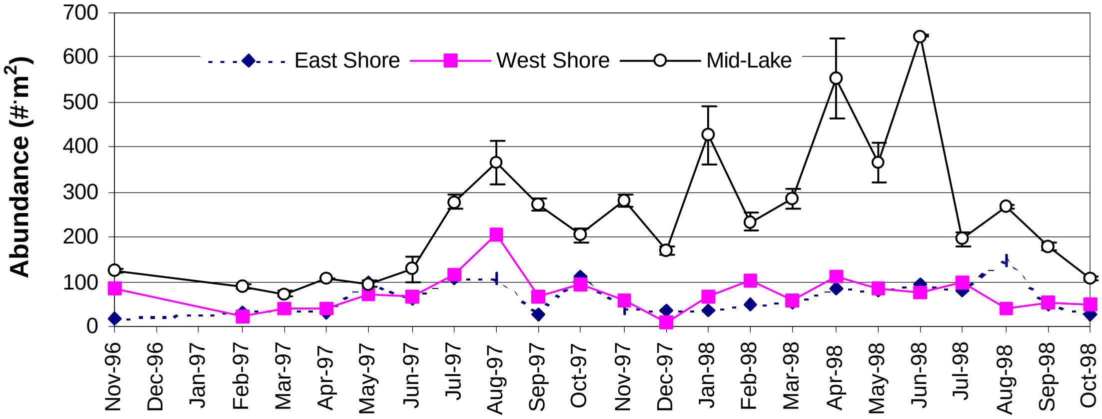


Fig. 3b

Station # OK2

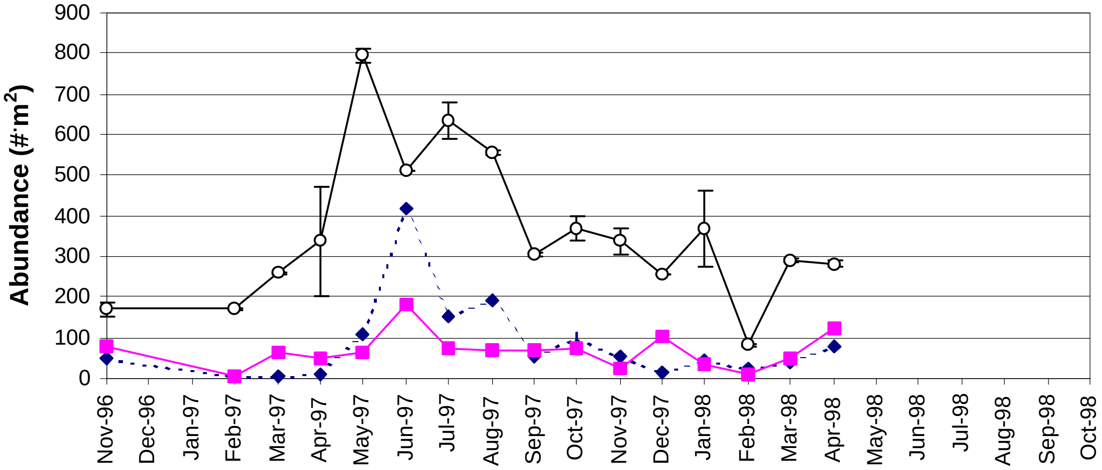
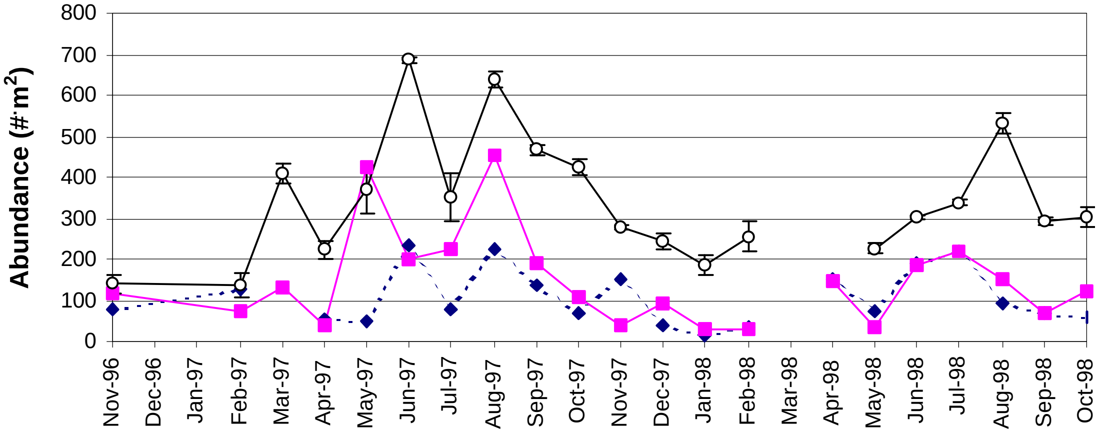


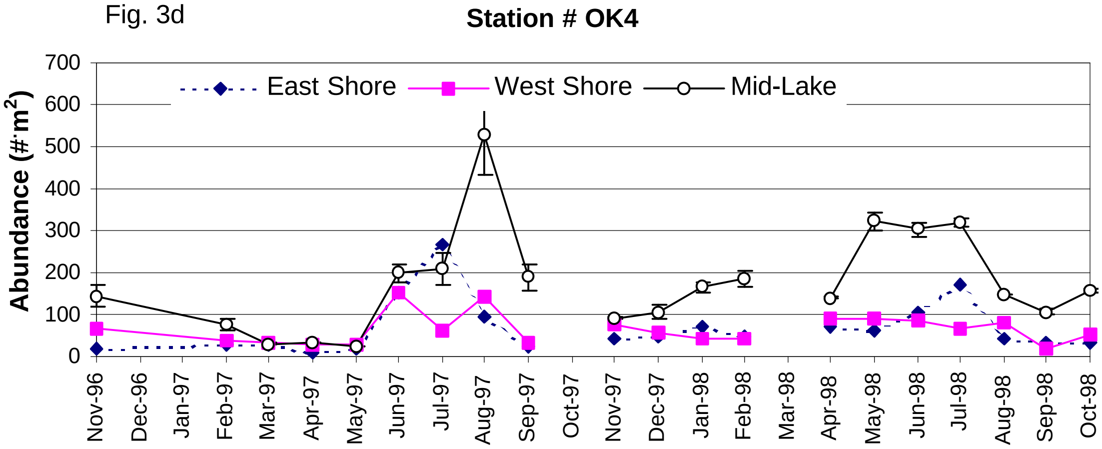
Fig. 3c

Station # OK3



Figures 3a-c. Monthly distribution of mysids across Okanagan Lake by sampling station (bars rep. +/- 1 S.E. on two mid-lake hauls).

Fig. 3d


Station # OK4
Abundance (#·m^2)
East Shore
West Shore
Mid-Lake
0
100
200
300
400
500
600
700
Nov-96
Dec-96
Jan-97
Feb-97
Mar-97
Apr-97
May-97
Jun-97
Jul-97
Aug-97
Sep-97
Oct-97
Nov-97
Dec-97
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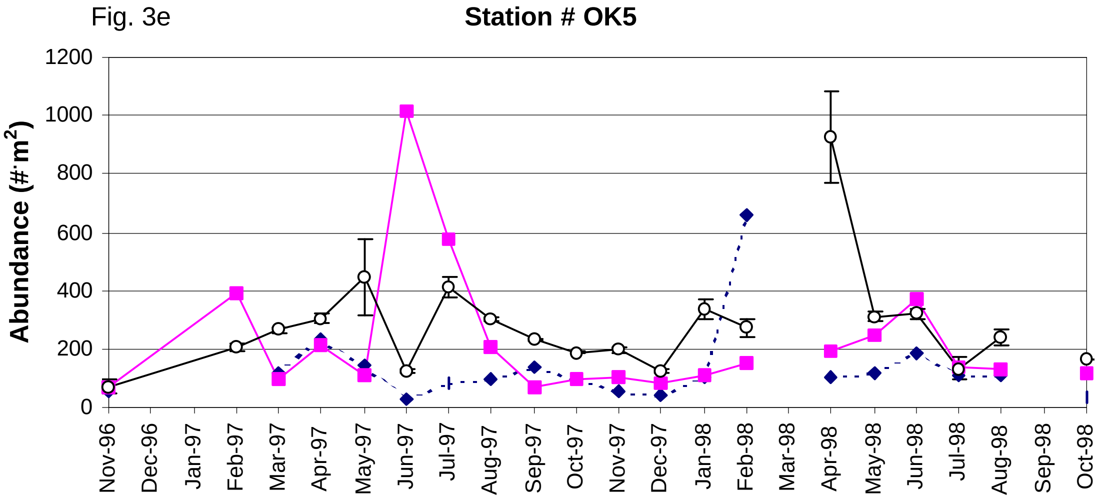
Mar-98
Apr-98
May-98
Jun-98
Jul-98
Aug-98
Sep-98
Oct-98

Fig. 3e


Station # OK5
Abundance (#·m^2)
0
200
400
600
800
1000
1200
Nov-96
Dec-96
Jan-97
Feb-97
Mar-97
Apr-97
May-97
Jun-97
Jul-97
Aug-97
Sep-97
Oct-97
Nov-97
Dec-97
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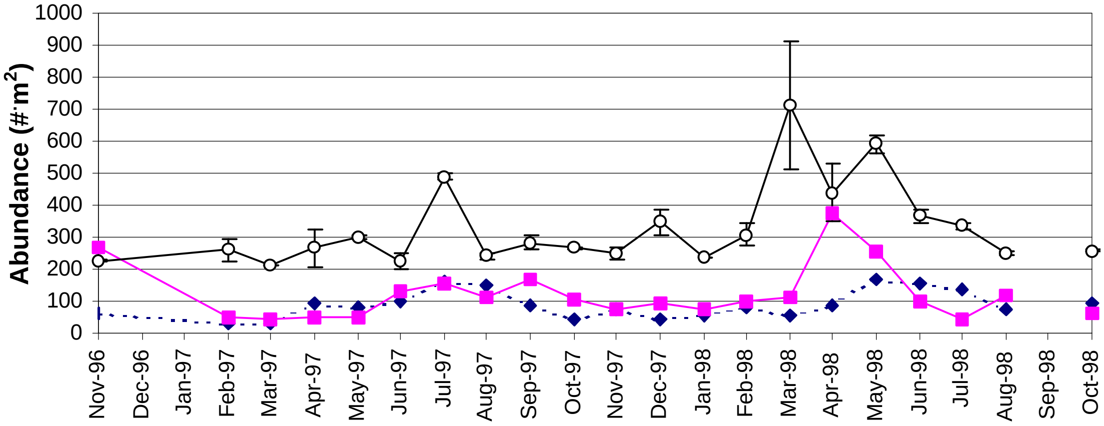
Jul-98
Aug-98
Sep-98
Oct-98

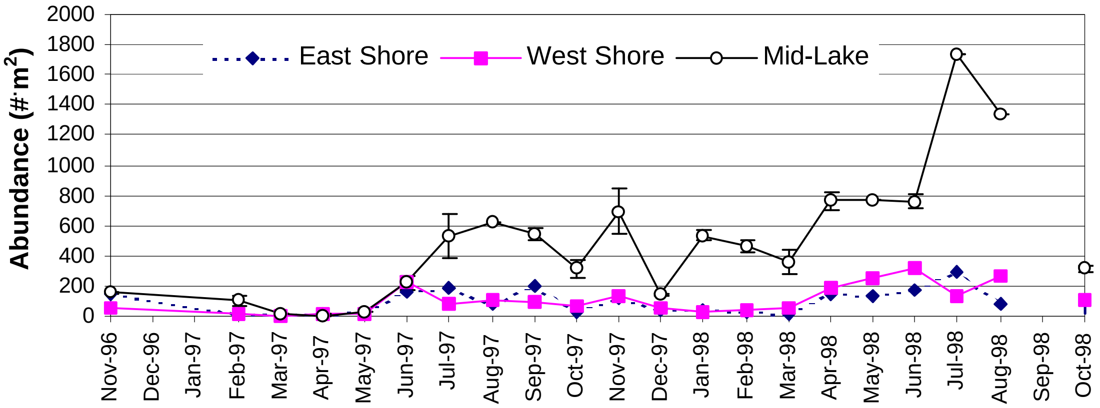
Fig. 3f



Station # OK6

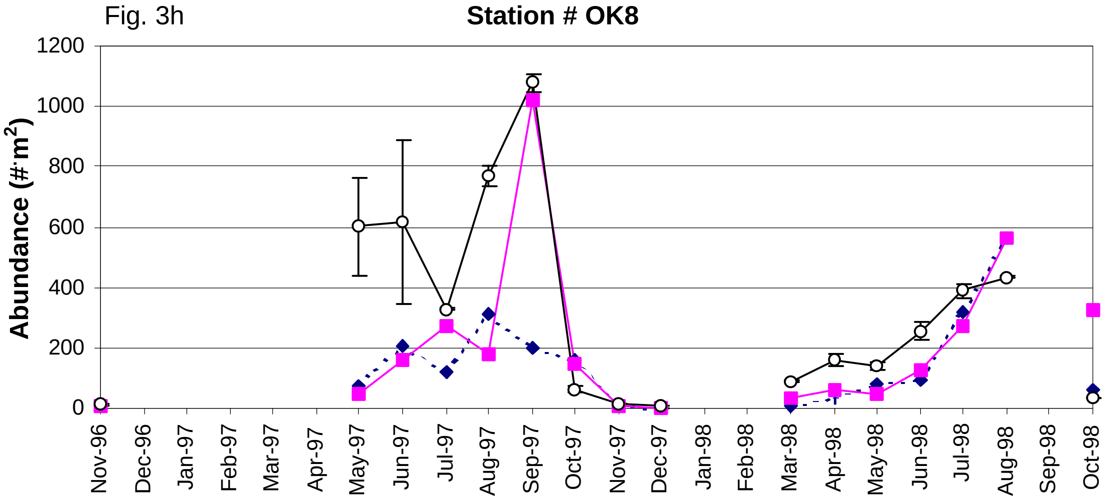
Figures 3d-f. Monthly distribution of mysids across Okanagan Lake by sampling station (bars rep. +/- 1 S.E. on two mid-lake hauls).

Fig. 3g



Station # OK7

Fig. 3h



Figures 3g,h. Monthly distribution of mysids across Okanagan Lake by sampling station (bars rep. +/- 1 S.E. on two mid-lake hauls).

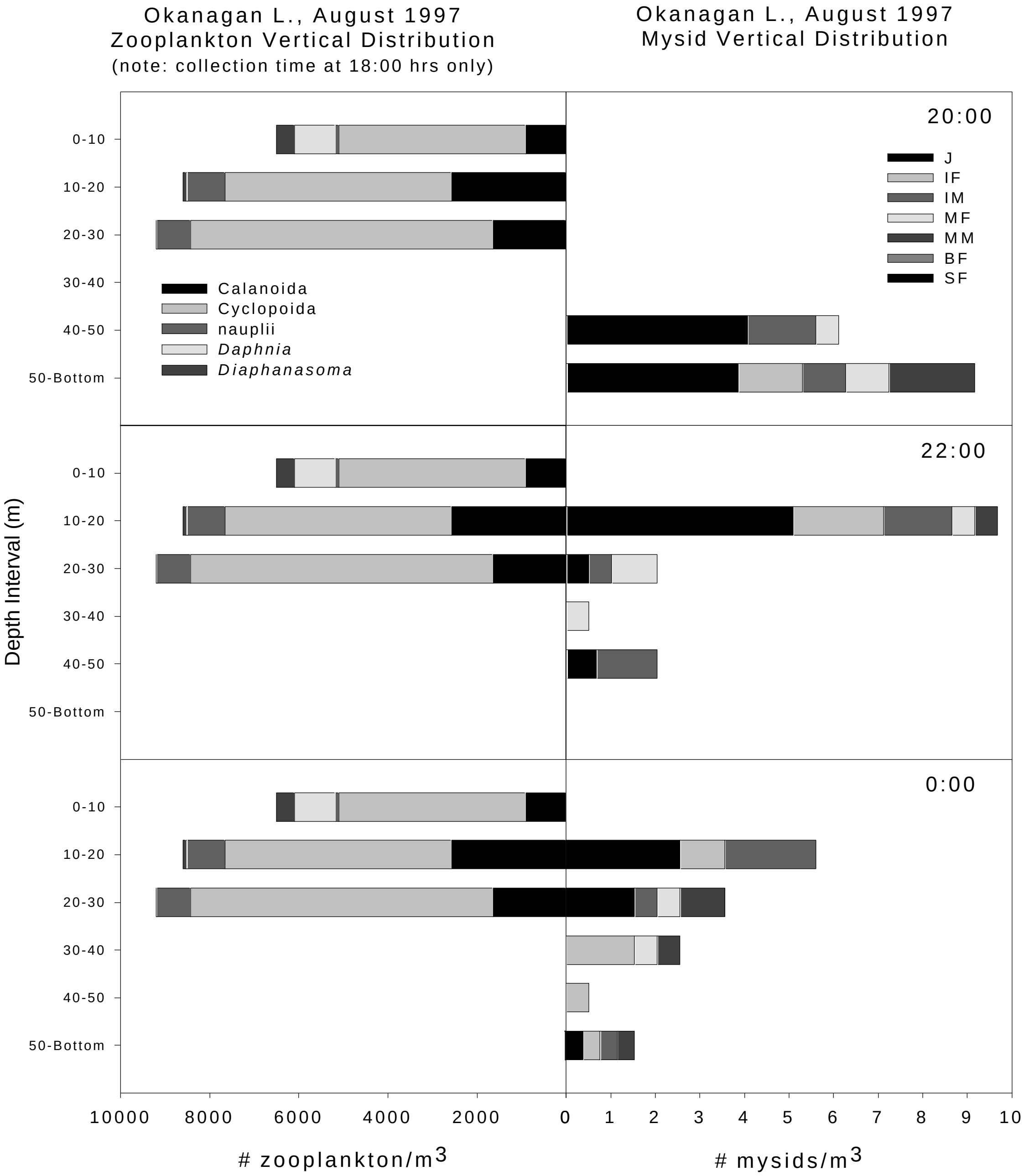


Figure 4a. Vertical distribution of mysid age classes in the water column between 20:00 and 06:00 hrs relative to their zooplankton prey for August 1997 in Okanagan Lake (J=juvenile, IF=immature female, IM=immature male, MF=mature female, MM=mature male, BF=brooding female, SF=spent female).

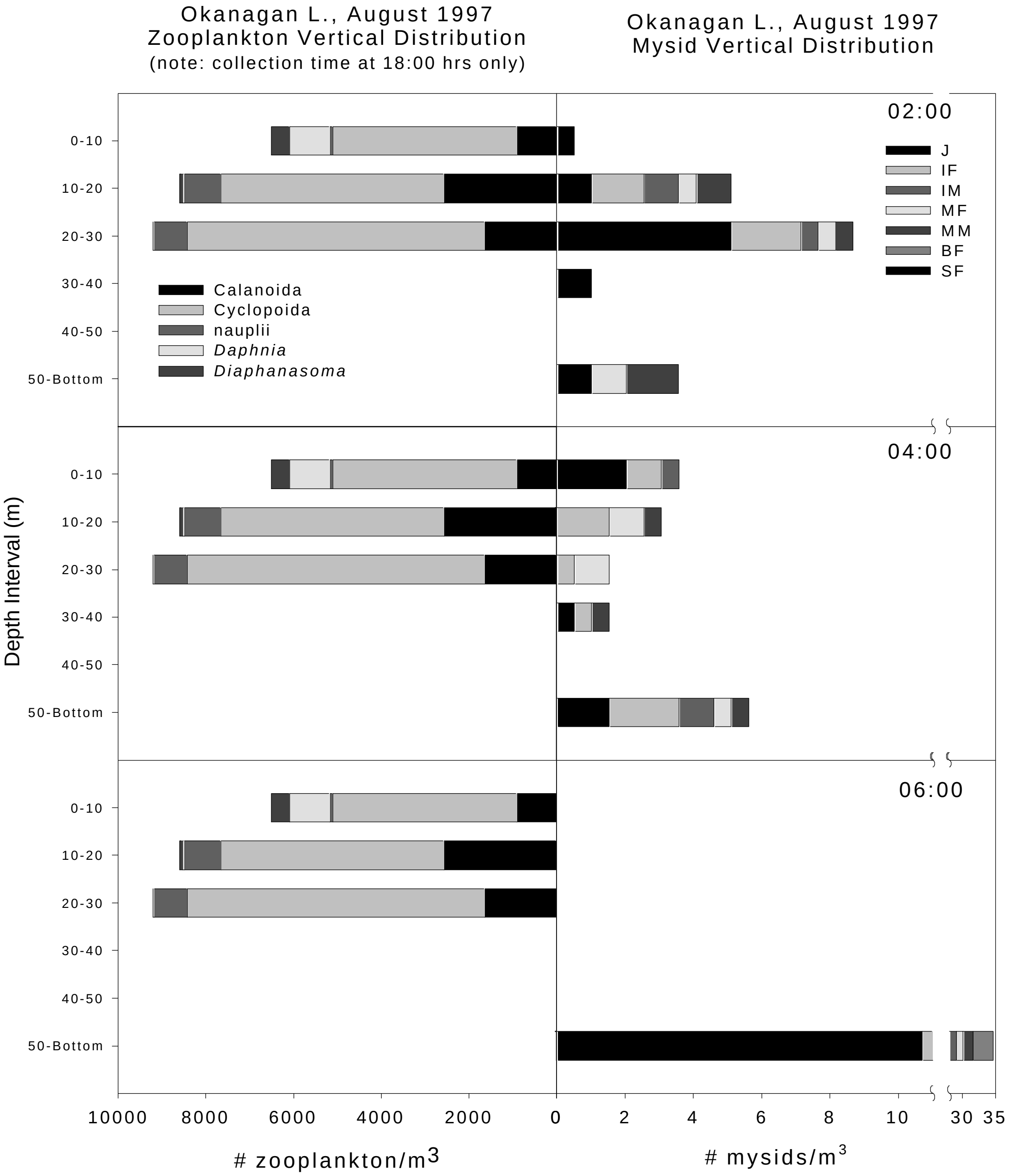


Figure 4a (cont'd). Vertical distribution of mysid age classes in the water column between 20:00 and 06:00 hrs relative to their zooplankton prey for August 1997 in Okanagan Lake.

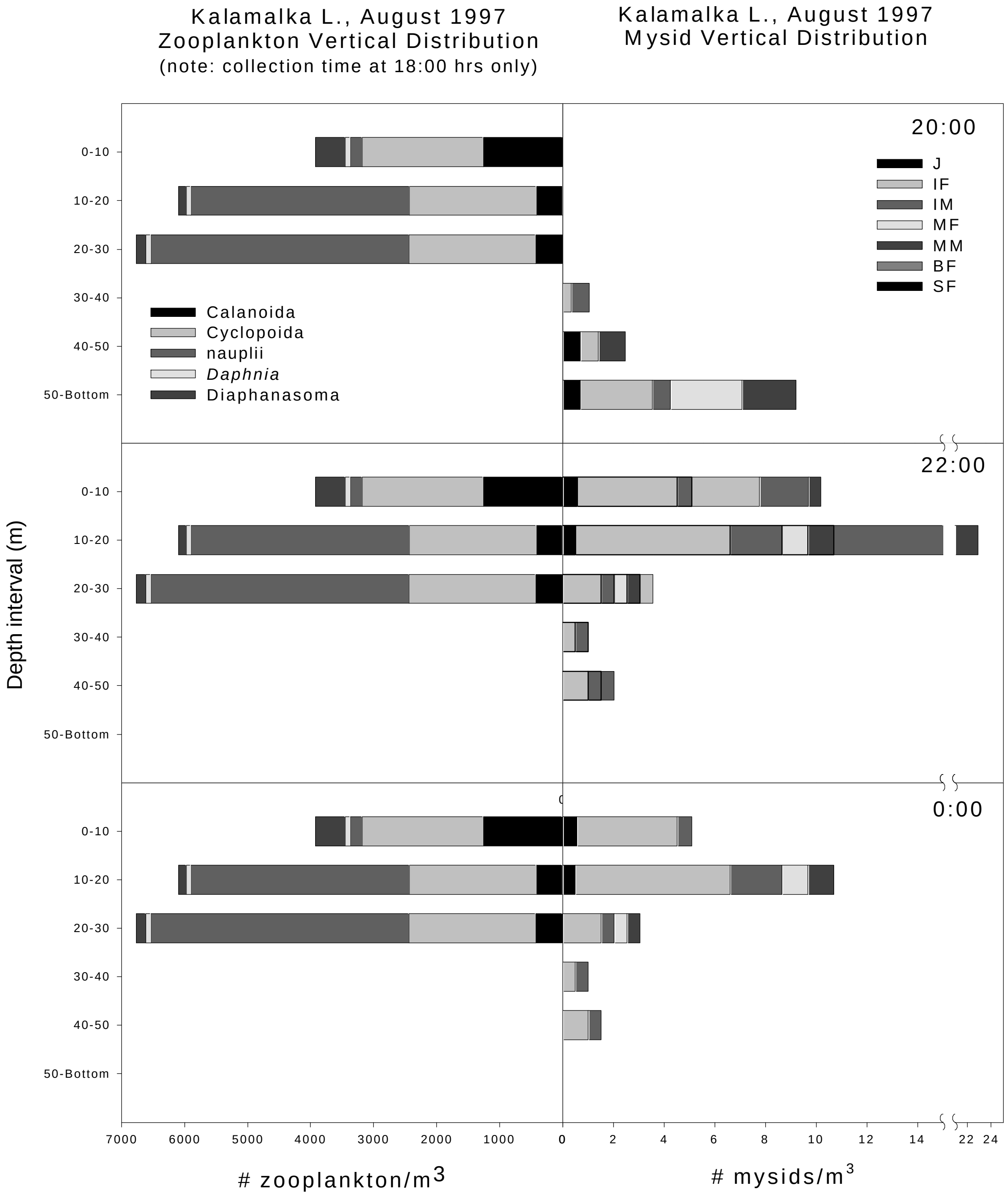


Figure 4b. Vertical distribution of mysid age classes in the water column between 20:00 and 06:00 hrs relative to their zooplankton prey for August 1997 in Kalamalka Lake.

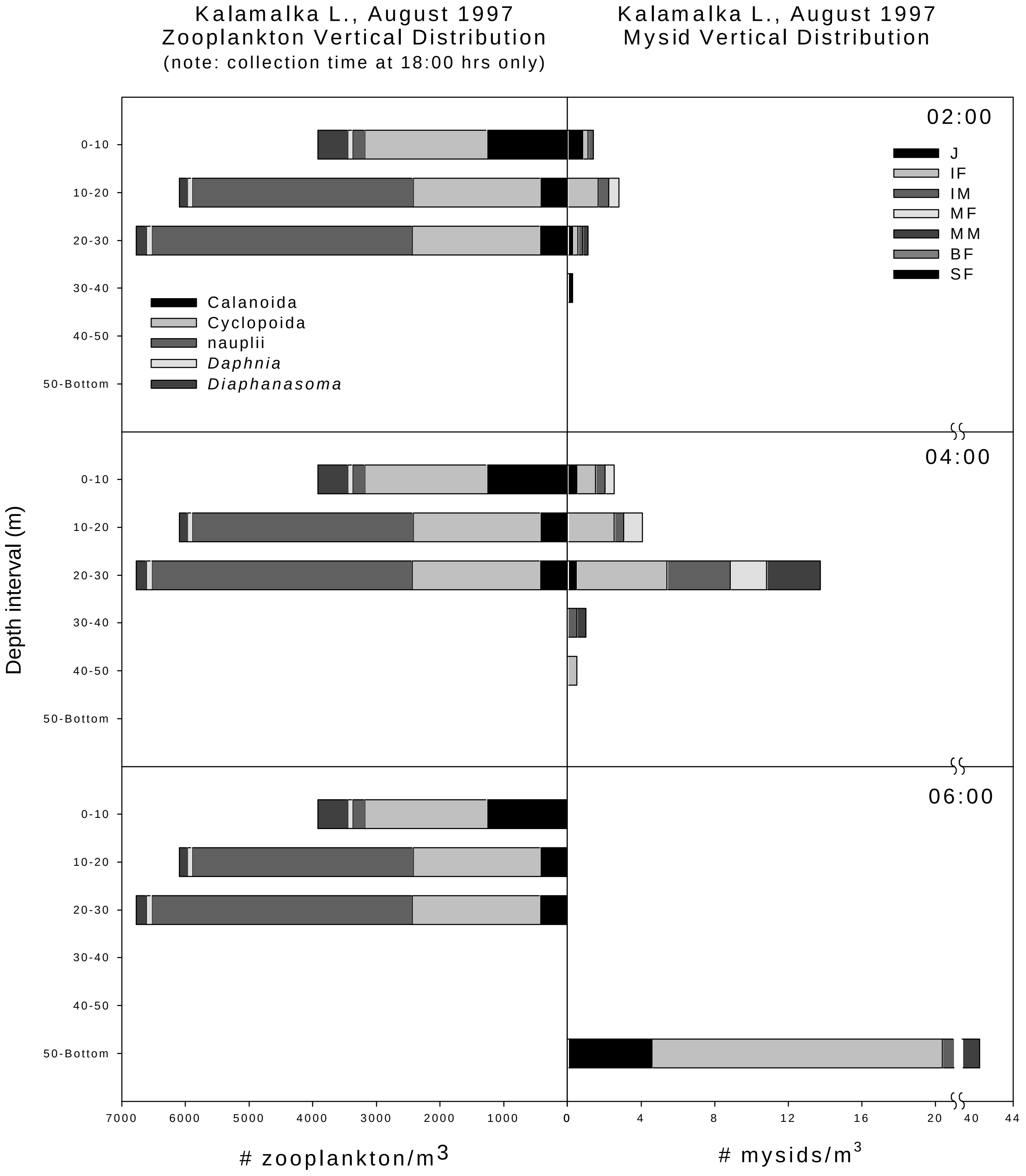


Figure 4b (cont'd). Vertical distribution of mysid age classes in the water column between 20:00 and 06:00 hrs relative to their zooplankton prey for August 1997 in Kalamalka Lake.

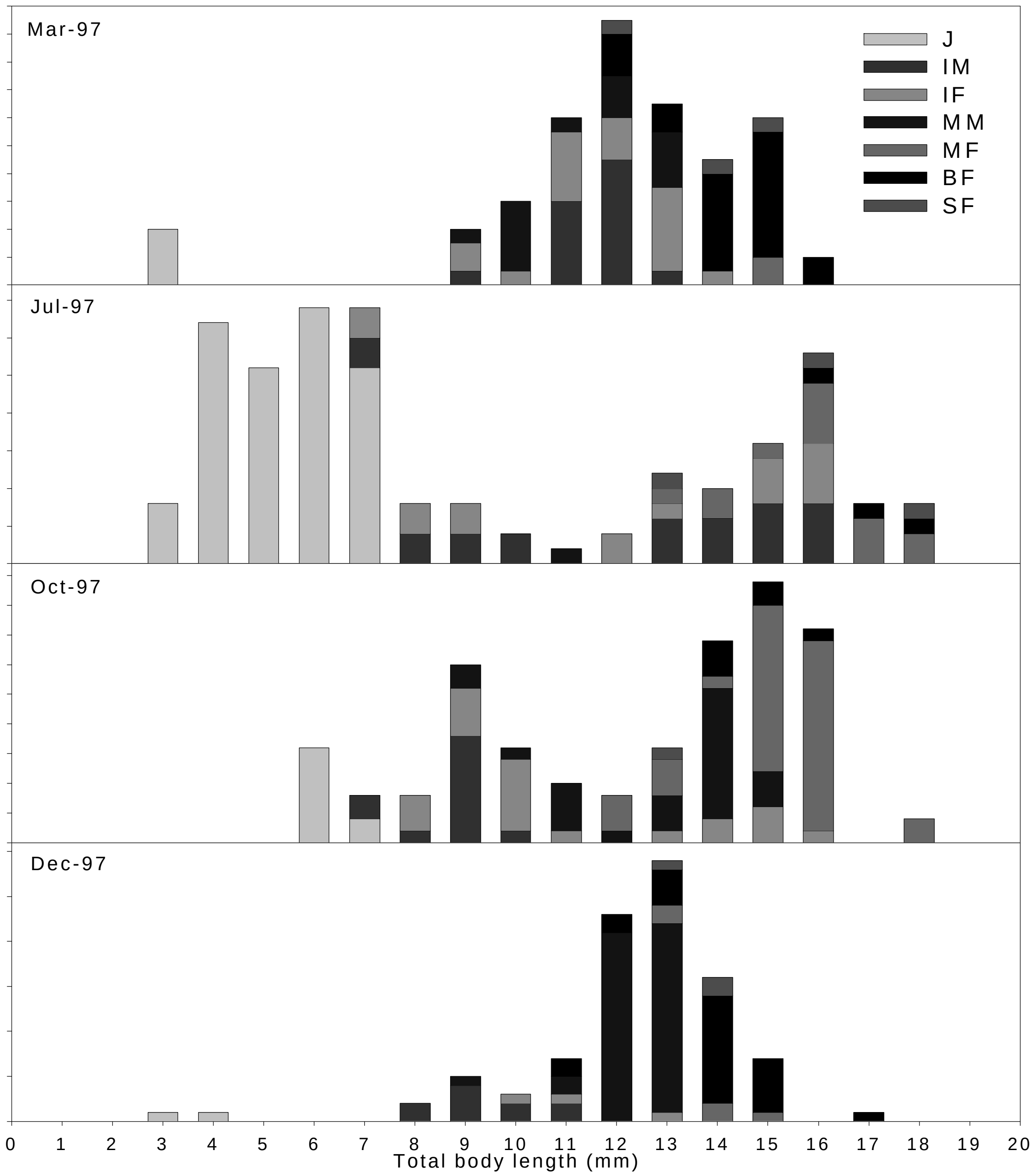


Figure 5a. Representative mysid size-frequency histograms for age classes at Station #1, Okanagan Lake.

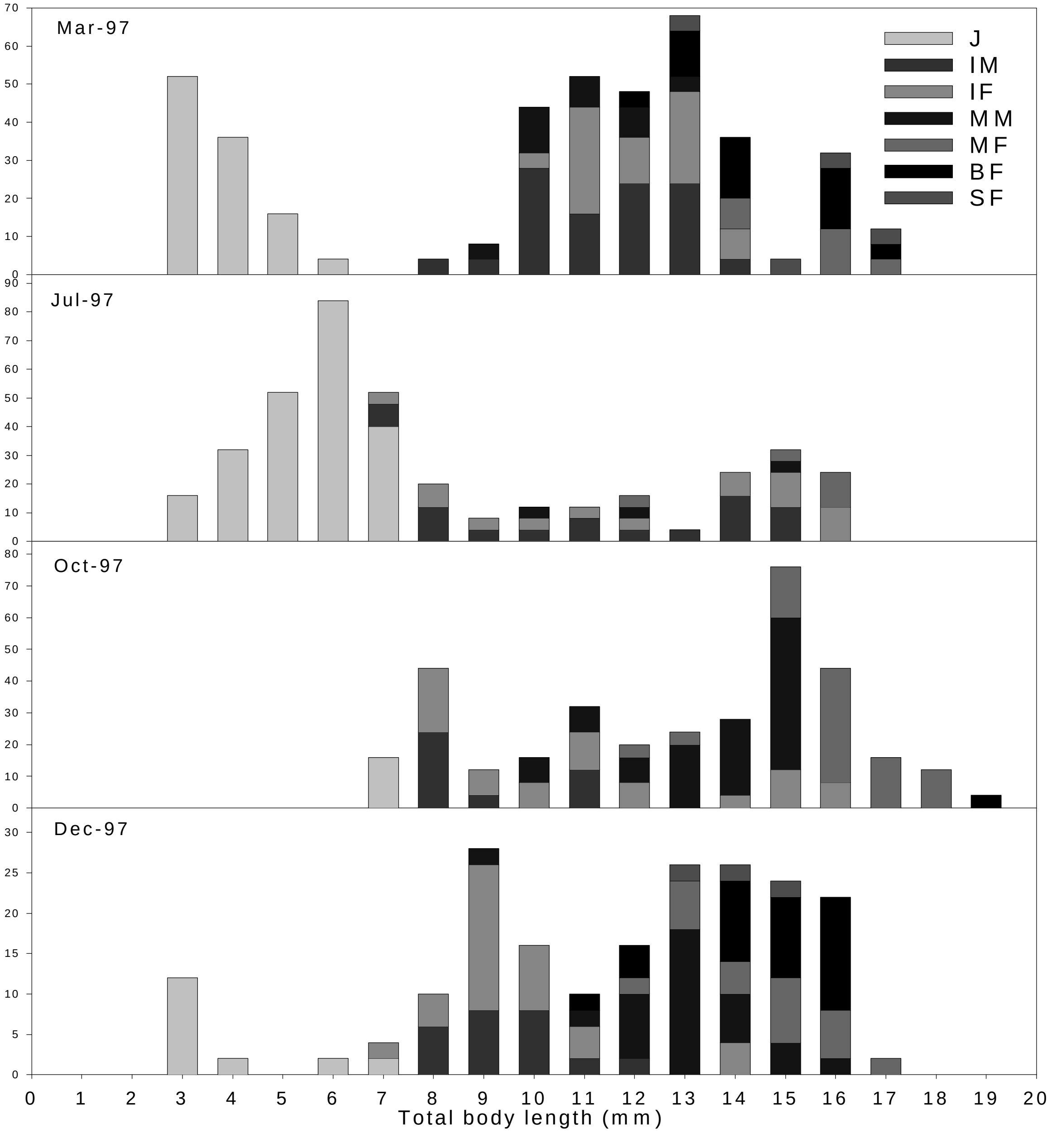


Figure 5b. Representative mysid size-frequency histograms for age classes at Station #3, Okanagan Lake.

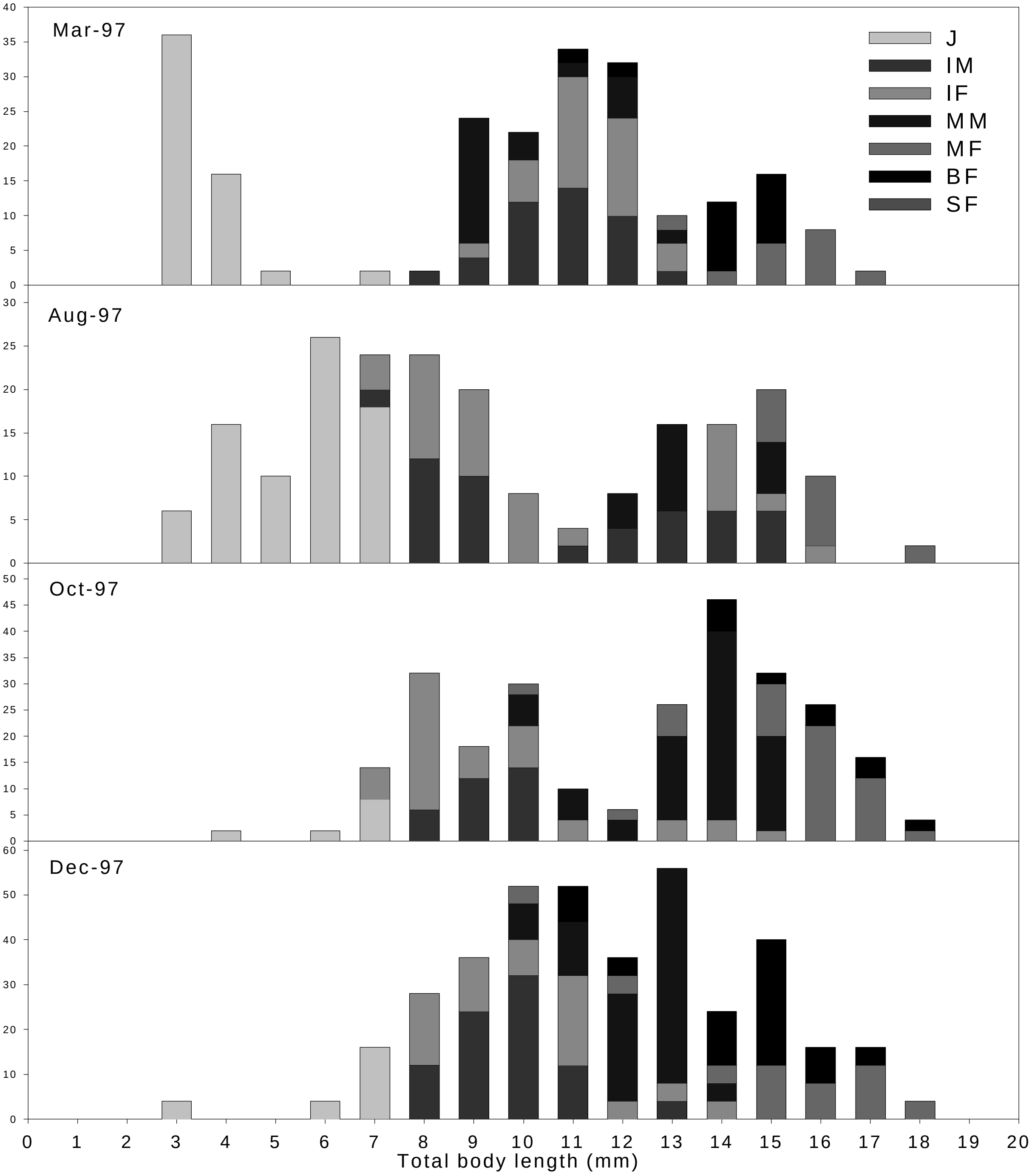


Figure 5c. Representative mysid size-frequency histograms for age classes at Station #6, Okanagan Lake.

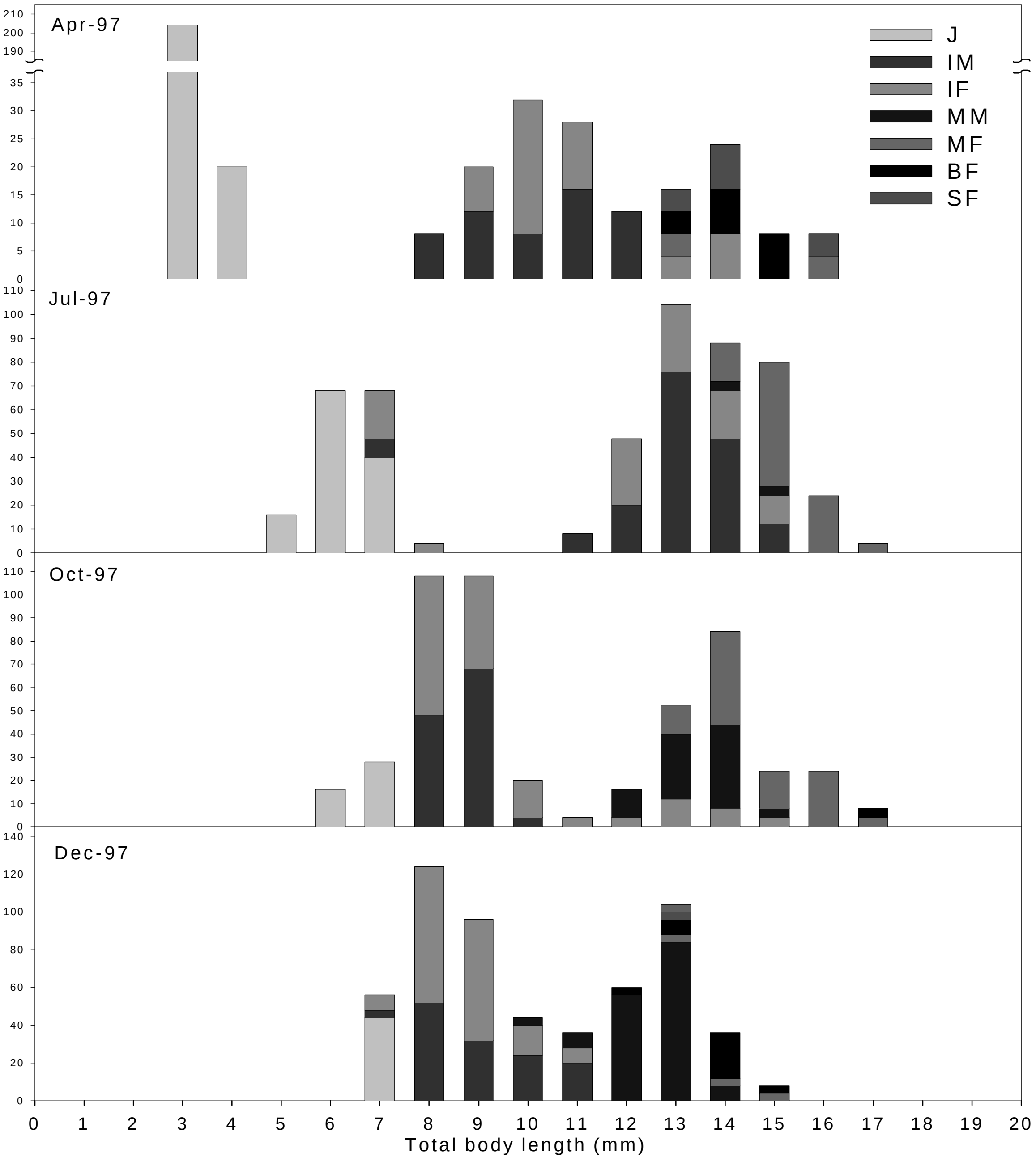
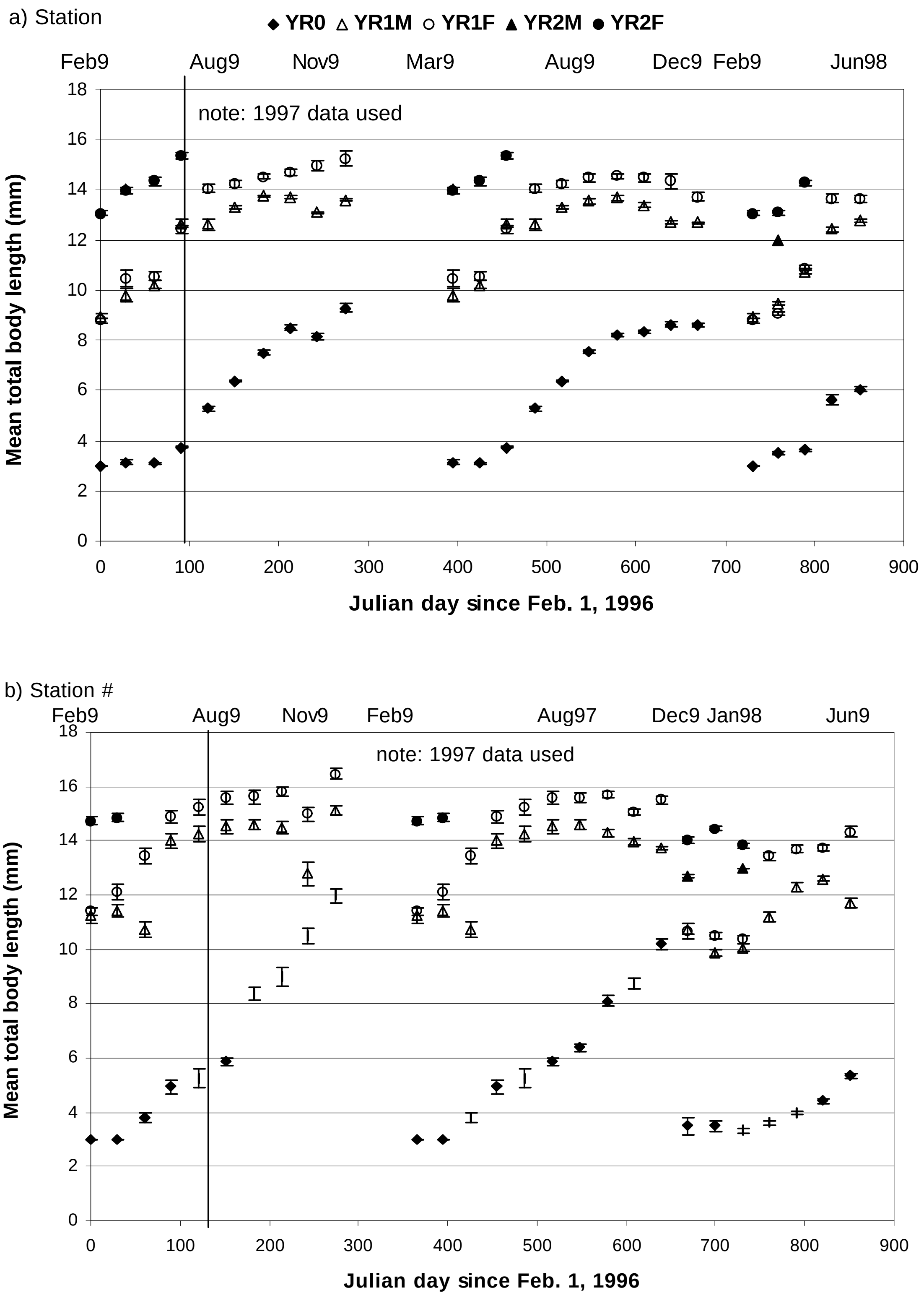
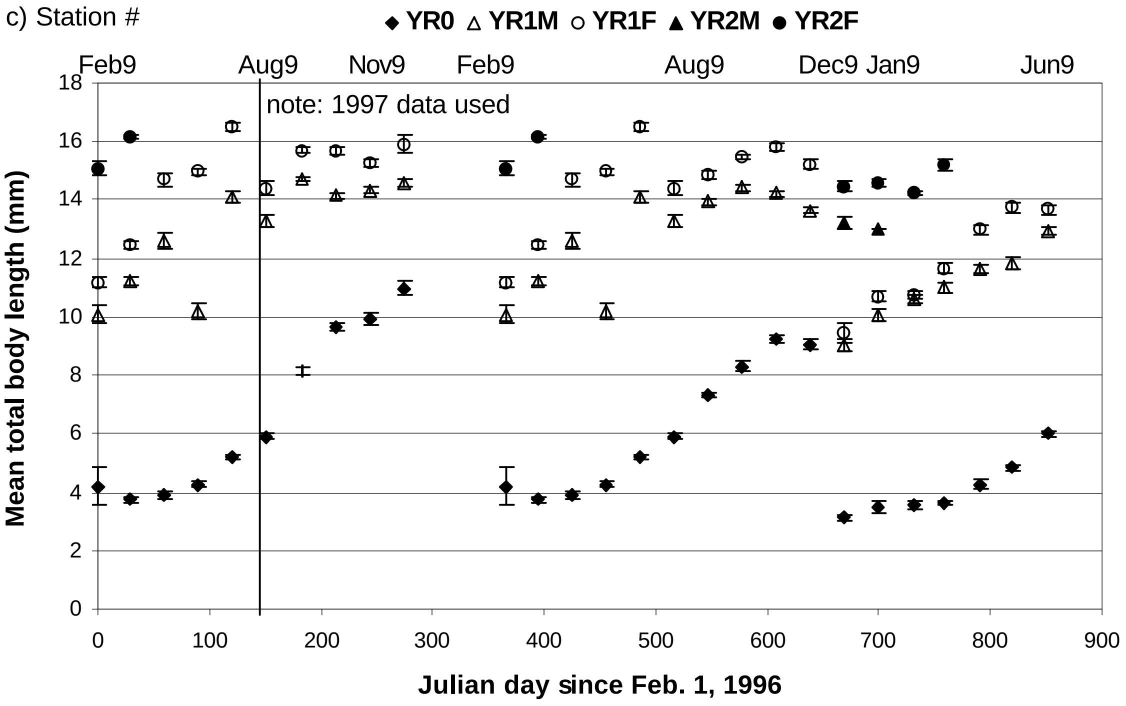


Figure 5d. Representative mysid size-frequency histograms for age classes at Station #KA2, Kalamalka Lake.



Figures 6a,b. Average size of mysid cohorts in a) Station #KA2, Kalamalka L. and b) Station # OK1, Okanagan L. since brood release in Feb. 1996 (bars rep. +/- 1Std. Dev.)



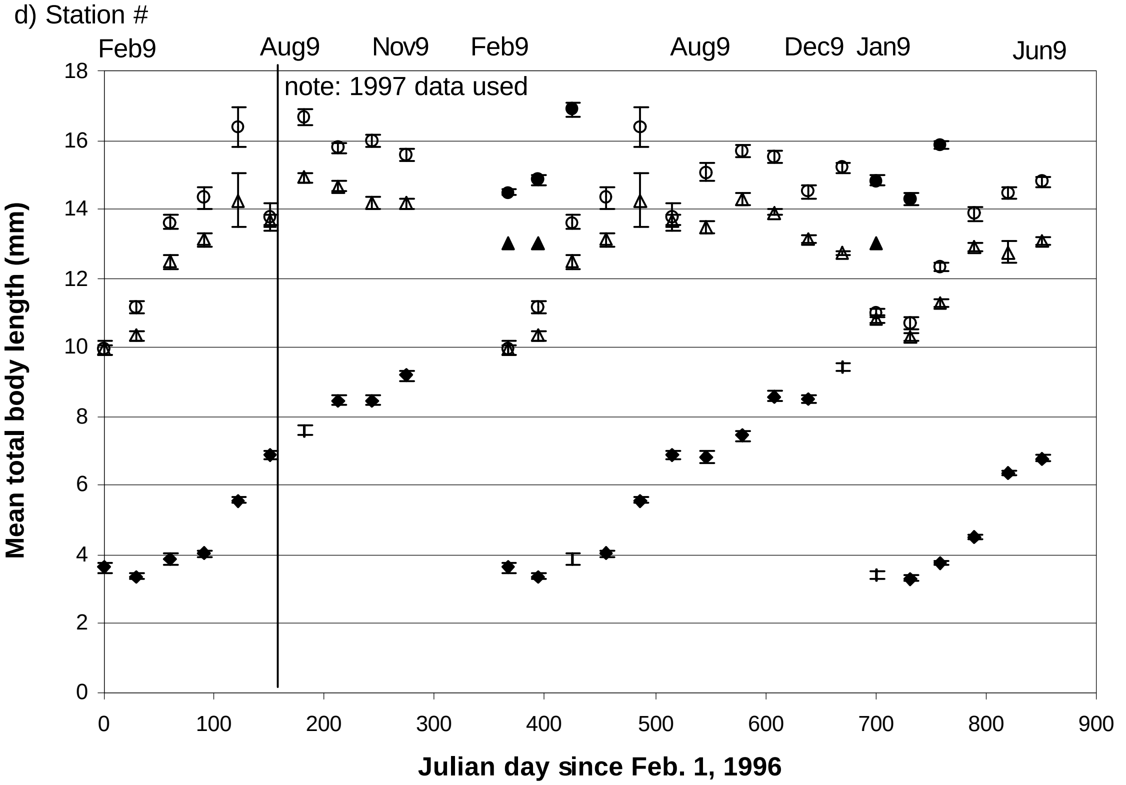


Figure 6c,d. Average size of mysid cohorts in c) Station #OK3 and d) Station #OK6, Okanagan Lake since brood release in Feb. 1996 (bars rep. +/- 1Std. Dev.).

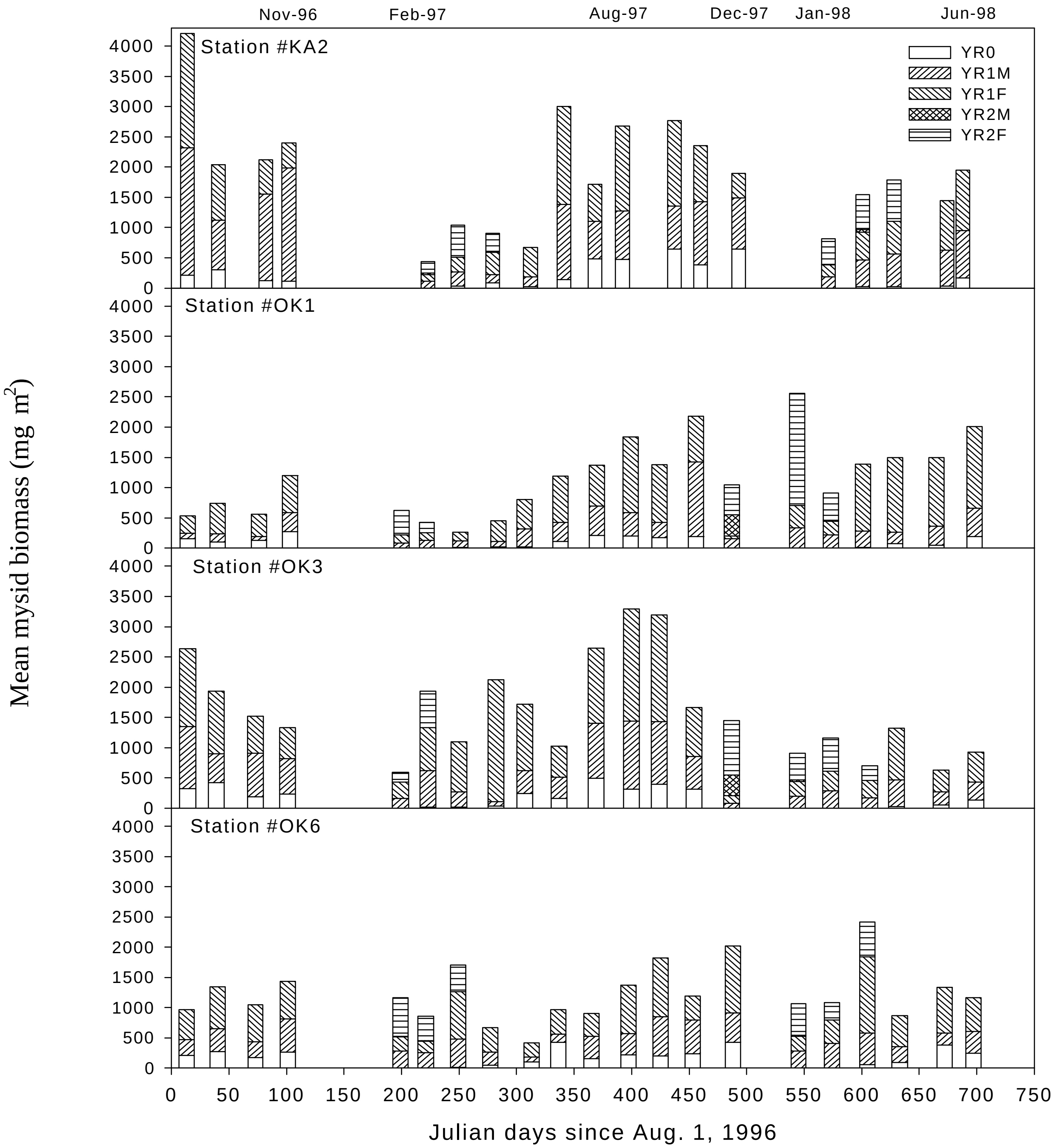


Figure 7. Mean biomass estimates for mysid cohorts at deep sites in Kalamalka and Okanagan Lakes (stations KA2 and OK1, OK3, OK6, respectively).

Fig. 8a

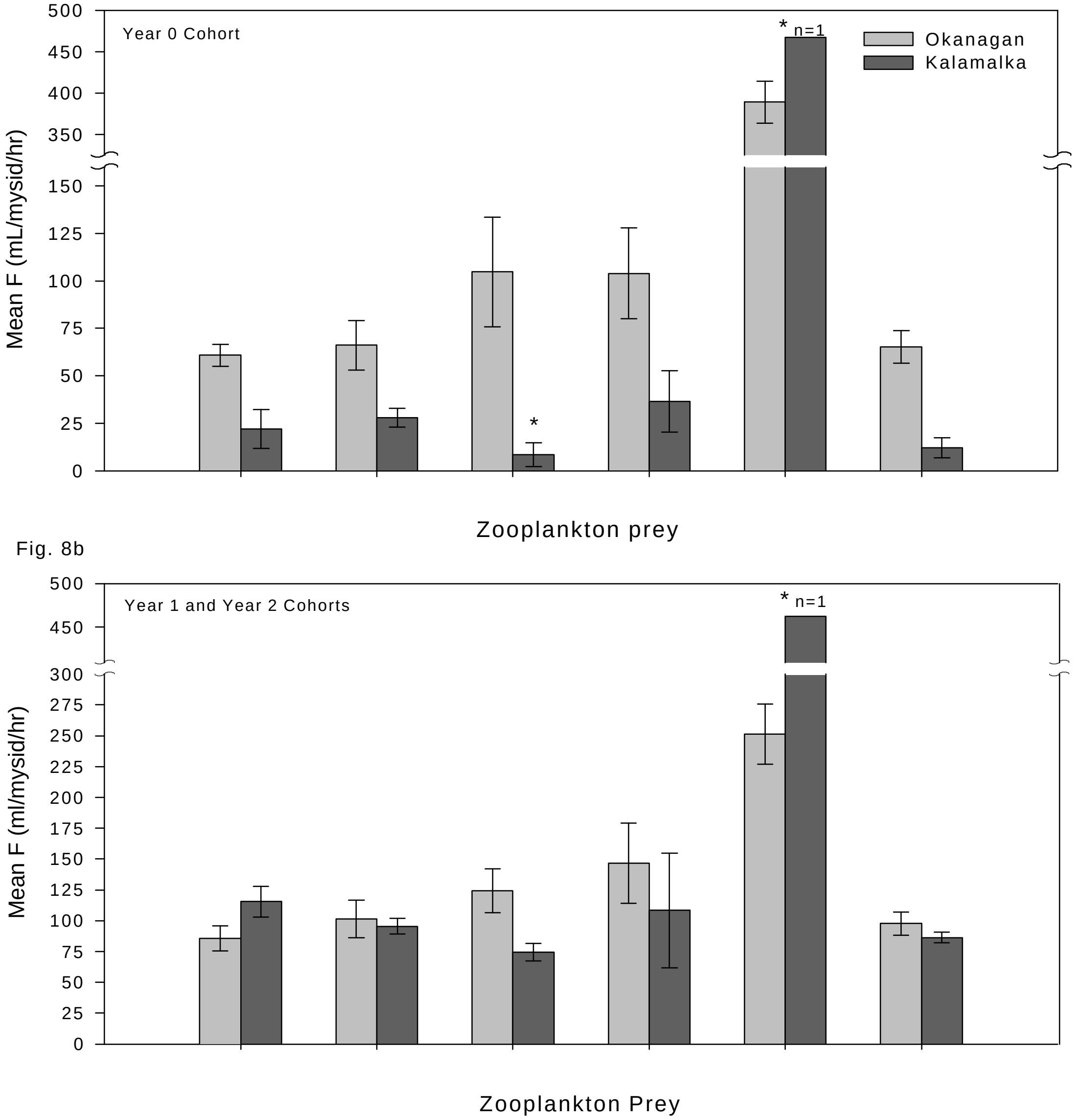


Figure 8a,b. Mean mysid clearance rates on selected zooplankton prey in Okanagan and Kalamalka Lakes for the juvenile (YR0) cohort (Fig. 8a) and immature to adult (YR1 and YR2) cohorts (Fig. 8b) (n=6 trials; bars rep. ± 1 S.E.; *represents F-values not significantly >0; t-0test, P>0.05; one-tailed test).

Fig. 9a

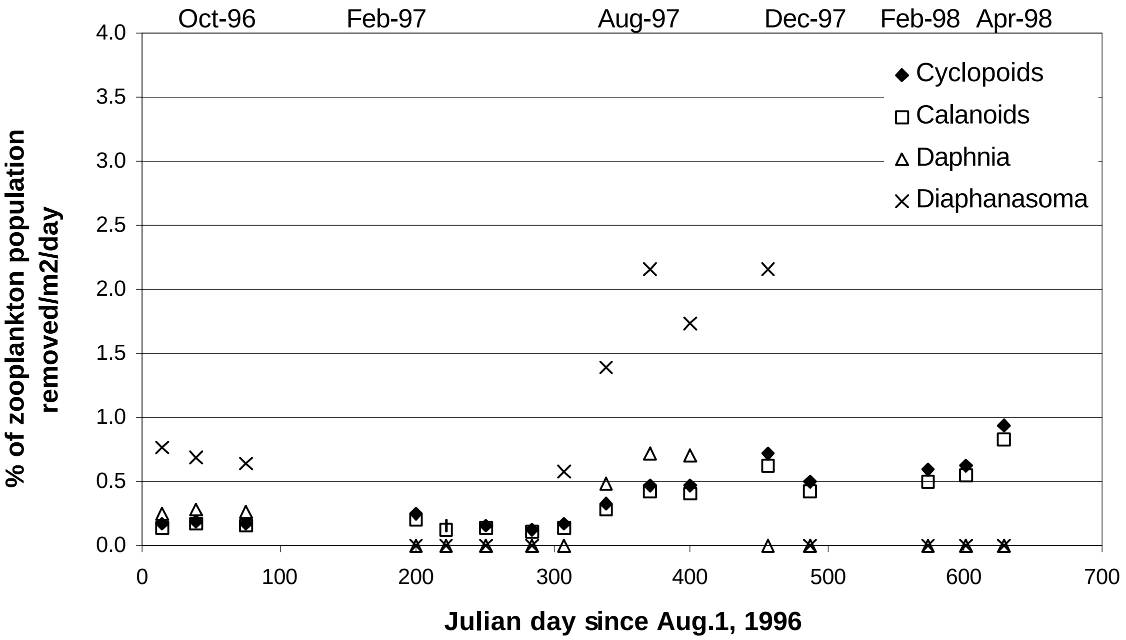


Fig. 9b

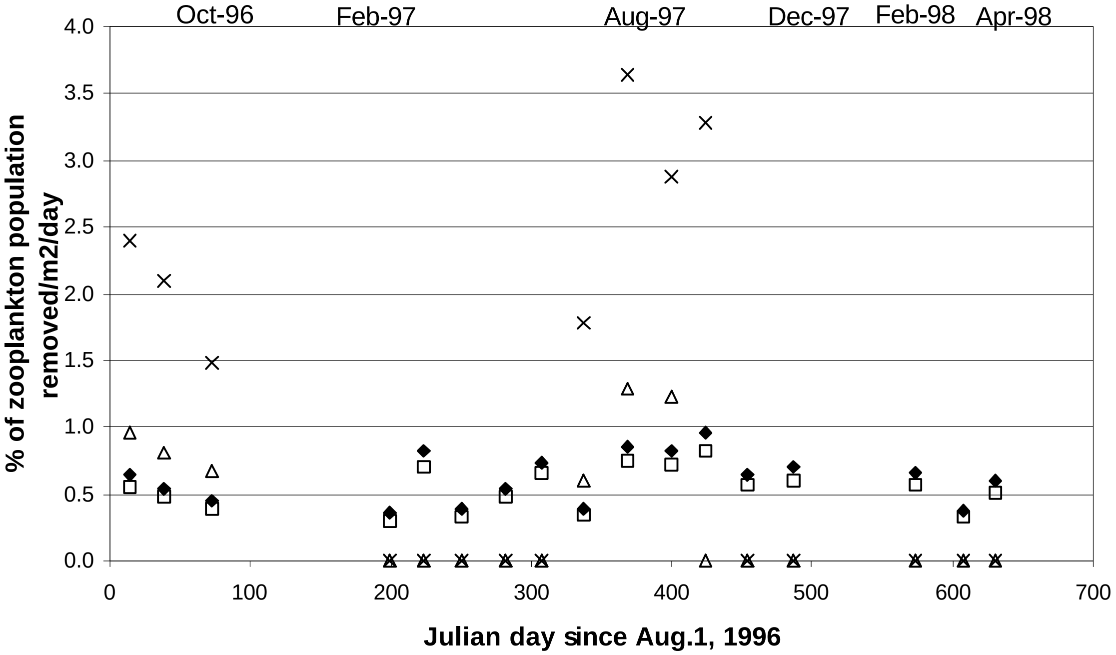


Figure 9a,b. Percentage of selected zooplankton populations removed per m^2 per day by the mysid population as determined from clearance rates at the deep sites of Stations #OK1 and #OK3 Okanagan Lake (Figs. 9a and b, respectively).

Fig. 9c

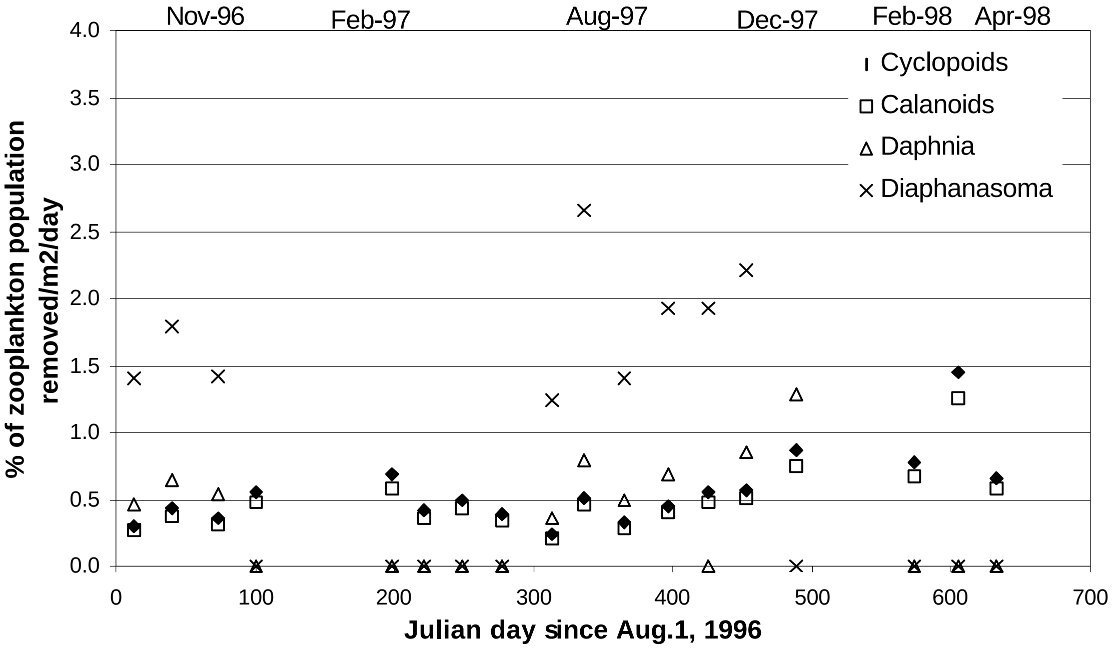


Fig. 9d

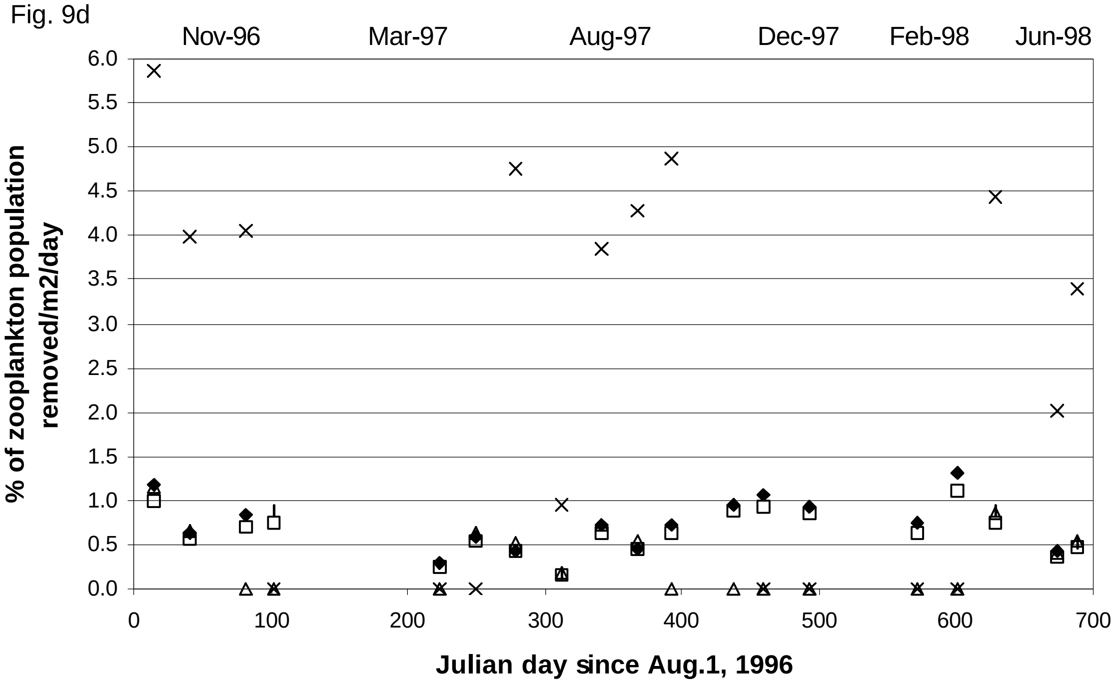


Figure 9c, d. Percentage of selected zooplankton populations removed per m2 per day by the mysid population as determined from clearance rates at the deep sites of Stations #OK6 Okanagan L. and #KA2 Kalamalka L. (Figs. 9c and d, respectively).

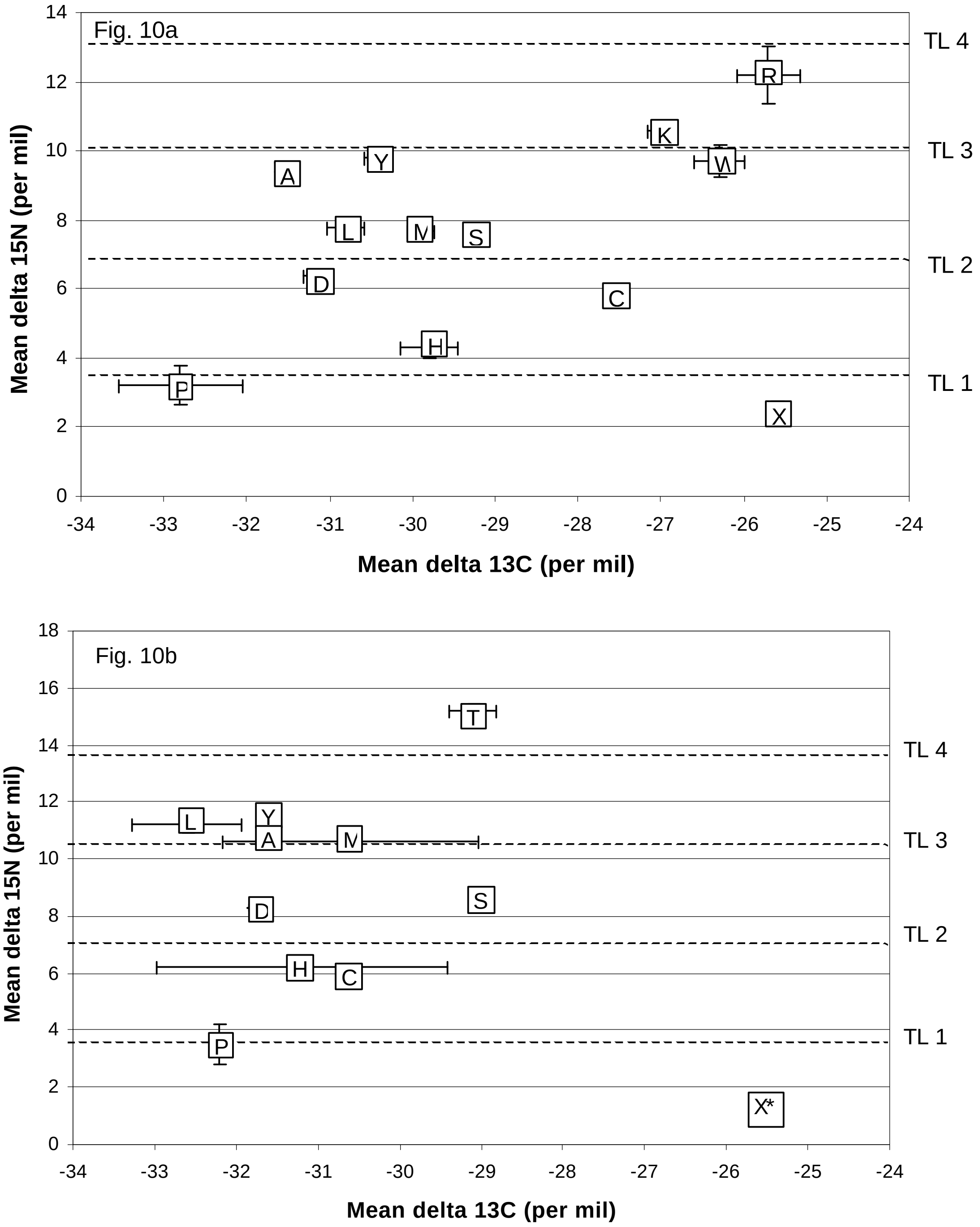


Figure 10a,b. Aug-97 food web composition of Okanagan Lake (Fig. 10a) and Kalamalka L. (Fig. 10b) using dual isotopes of delta 15N and delta 13C (visible bars rep.+/- 1 S.E.; ' X=sediment, C=clams, H=chironomids, P=phytoplankton, D=Daphnia, Y=cyclopoids 'A=calanoids, S=small mysids, M=medium mysids, L=large mysids, W=whitefish 'R=rainbow trout, T=lake trout; TL = trophic level; note: * Kalamalka L. sediment 13C assumed to be the same as Okanagan L. sediment signature).

PALEOLIMNOLOGY OF OKANAGAN LAKE

PROGRESS REPORT

by

Lidija Vidmanic[1] and Ken Ashley[2]

INTRODUCTION

Sediment cores were collected from Okanagan Lake in 1996 and 1997 as part of the Okanagan Lake Action Plan. Stratigraphic variations in major nutrients (i.e., N, P and C) and abundance and species composition of diatoms and cladoceran fossil assemblages are associated with vegetational and climatic changes within a lake's watershed. Such changes are connected to changes in the aquatic environment and therefore, it is possible to infer historic oscillations in water chemistry and lake trophic status using paleolimnological analyses.

The best available reconstruction of the developmental history of a lake and its watershed is achieved by a combination of sediment geochemistry, diatom and cladoceran microfossil analyses and sediment dating. In such studies, a sediment core from the aquatic environment is examined to determine the trophic history of lakes, rivers, ponds etc. Pioneering studies in this area included Mesjatsev (1924) studying cladoceran remains in lake sediments, and Conger (1939) studying diatoms microfossils. In the following decades many scientists working in this field made significant contributions to the development of paleolimnology including Frey (1955, 1958, 1960 and 1962); Pennington (1943); Nygaard (1956); Round (1961); Goulden (1966); De Costa (1968) and Deevey (1969). Intensive studies of microfossils in sediments took place in the 1970s and 1980s and have continued to the present. As a result of data obtained by paleolimnological studies in lake sediments, scientists have succeeded in reconstructing past trophic conditions and identifying changes, which took place throughout a lake's history.

Therefore, according to the distribution and succession of microfossils in lake sediments, it is possible to document the developmental history of lakes including their past conditions and identifiable changes in the lake environment. The purpose of this study is:

a) to identify major nutrient (N, P and C) stratigraphy and diatom and cladocera composition in sediments from Okanagan Lake;
b) to provide historical perspectives to environmental changes; and
c) to determine a connection between human impacts in the watershed and within the lake during past century (e.g., lake level regulation, cultural eutrophication and oligotrophication, introduction of new species etc.) and changes in the plankton composition.

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MATERIAL AND METHODS

Site Description

Okanagan Lake is situated in south-central area of British Columbia. Okanagan Lake has a surface area of 351 km^2, is located in Okanagan Valley, and is surrounded by forest, grassland and rapidly urbanizing areas. Industrial development in the watershed is associated with the agriculture, fruit and vegetable growing industries, dairy farming, cattle and ungulate grazing as well as timber production. The majority of inflow water to the lake comes by tributary systems during April to June, while from July to November most small streambeds are dry, due primarily to upstream storage and irrigation demands. About 15% of the main annual surface runoff to Okanagan Lake is used for irrigation. Okanagan Lake is presently oligo-mesotrophic and chemically stratified.

A modified KB corer (deep water release mechanism) was used to collect two sets of short sediment cores (300 to 350 mm) from Okanagan Lake. In 1996, a trial core was taken from the lake at 49^o 32' 141" N/119^o 36' 387" W at depth of 62 m to determine if it was possible to obtain cores from a deep lake using a modified shallow water coring device, and to develop expertise in the identification of the various diatom and zooplankton fossil remains in Okanagan Lake. Upon developing expertise in deep water coring and plankton identification, a second set of cores was collected in 1997. On June 2, 1997, a set of 3 cores was collected from the north basin of Okanagan Lake at 50^o 01' 234-390"/119^o 28' 282-356" at depths of 190 to 193 m. On June 2 and September 24, 1997, a set of three cores were collected from the south basin of Okanagan Lake at 49^o 47' 299-320"/119^o 38' 609-808" at depths of 192 to 201 m.

The 1996 cores (300 to 350 mm) were extruded and sectioned at 10 mm intervals immediately after sampling. The 1997 cores (300 mm) were extruded a few weeks after collection, and were sectioned at 5 mm intervals from 0 to 150 mm, and 10 mm intervals from 150 to 300 mm. The sediments were stored in plastic vials and returned to the laboratory for further examination of organic matter, cladocera and diatom remains.

Each sample was mixed and 1 ml weighed and oven-dried at 95^oC for 24 hours, and the water content of the sediment was calculated. These samples were further heated in a muffle furnace at 500^o C for 4 hours, cooled to room temperature, and reweighed. Organic content was measured in terms of loss on ignition as a percentage of dry weight.

For the study of cladocera remains, 1 ml samples (known weight) were heated for 30 minutes in 10% KOH with gentle agitation to defloculate the organic material. Defloculated sediment was then rinsed with distilled water and sieved through a 25 µm screen. The residue from each sieve was stored in 5 ml of 4% solution of formaldehyde. A known volume of suspension (0.05 ml per coverslip) was flooded with 1 ml distilled water and dried overnight. Permanent slides were mounted in Permount, and cladocera remains were determined and counted under 125x and 600x magnification. The most common parts were head shields, carapaces, claws and postabdomens. All recognizable exuviae were counted, and expressed as number of individuals per gram of dry weight of sediment, according to Frey (1986).

For diatom analysis, 1 ml of sample (known weight) was digested by boiling in 30% H_2O_2 for 4 hours in presence of few drops of ethanol, to prevent foaming and violent reaction. The samples were than filled with distilled water, and stored in a refrigerator for 2 days for sedimentation. Samples were slightly shaken few times during first day to release gas bubbles from the walls. Supernatant was removed by Pasteur pipette. The samples were diluted with distilled water to 200 to 500 ml to provide a concentration of 100 frustules in microscope field transect. Each sample was stirred and left to stand 30 seconds for larger sediment particles to settle out. 0.05 to 0.1 ml aliquots were taken with automatic pipette, placed onto a coverslip, flooded with 1 ml of distilled water and dried overnight. Permanent slides were made with Permount medium. Counts from slides were counted to total number of frustule per 1 ml of sample (Stockner and Castella 1980). The final results are expressed as a number of cells per gram of dry weight of sediment.

Sub-samples of core sections, or replicate core samples were sent to the Pacific Environment Science Centre in North Vancouver for geochemical analysis. Core section dating was performed on the 1996 core by Flett Research Ltd. (Winnipeg, Manitoba) using Pb-210 isotope dating techniques. MyCore Scientific Ltd. in Ontario is currently processing the 1997 north and south basin cores for Pb-210 dating and N15 stable isotope analysis.

RESULTS

The results and preliminary analysis of the 1996 and 1997 diatom and zooplankton cores were presented in Ashley et al. (1998). Unfortunately, the processing of the cores for Pb-210 dating and N^{15} stable isotope analysis has taken longer than expected, and the results will not be available until February to March 1999. A full analysis of the coring study will be presented in the Year 4 Okanagan Lake Action Plan report (i.e., 1999/2000).

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CHAPTER 4

LONG-TERM APPLIED RESEARCH

This component of the Action Plan involves original research that may or may not result in long-term solutions for restoring kokanee. There is an unknown chance of success with research but the possible outcome(s) dictate that the work is well worth pursuing. In 1998, the research emphasis was directed towards feasibility of mysis harvest and genetic techniques for distinguishing between shore and stream spawning kokanee.

BEHAVIOURAL EFFECTS OF NON-VISUAL COMMUNICATION IN THE OPPOSSUM SHRIMP *MYSIS RELICTA*

by

Janice Quirt[1] and David Lasenby[1]

INTRODUCTION

Chemical communication is often used to convey different kinds of information to conspecifics of varying species. For example, sex pheromones are used by a number of crustacean species to stimulate attraction between males and females and to facilitate breeding (Dunham 1978). Sex pheromones of a variety of pest species have been investigated and characterized for use in traps designed to capture significant numbers of the pest species (Karg and Sauer 1997). Sex pheromones that have been used for the control of insect pest species have also been identified in marine mysids (Wittman 1982). Epideictic, or spacing pheromones, have also been identified in a number of invertebrates and they have the ability to affect a number of changes. Some are known to deter ovi-position from already colonized areas and instigate the dispersal of larvae or adults, and are being considered as a novel form of anti-congregation control (Gabel and Thiery 1992, Poirier and Borden 1995, Turchin and Thoeny 1993).

Allelochemicals are chemical compounds that are similar to pheromones but are released by other species, such as predators, and affect another species, such as the prey (Dodson et al. 1994). When the information is conveyed from the predator to the advantage of the prey, the term kairomone is employed. Fish kairomones can inhibit and decrease the vertical migration of the larvae of the midge *Chaoborus,* thus mimicking the effects of intra-specific spacing pheromones (Dawidowicz et al. 1990).

This project investigates the possibility of non-visual communication by the opossum shrimp *Mysis relicta*. There may be a number of ways of utilizing non-visual communication as a means to modify mysid behaviour, which may subsequently be used to control mysid numbers and predatory impact. For example, dispersal pheromones may play a role in determining variable distribution of age classes. It is known that juvenile and immature mysids have been found to reside higher in the water column of the pelagic zone than mature mysids. In addition, some juvenile and immature mysids migrate horizontally towards the shallower water near shore (Morgan and Threlkeld 1982, Moen and Langeland 1989). A study of potential control mechanisms in mysids requires an in-depth knowledge of their distribution and abundance. For example, information obtained on the horizontal and vertical distribution of mysids should assist in commercial trawling for mysids and could be applied to the studies of non-visual communication for biological control.

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The following is a description of the progress to date on determining both the possible existence of non-visual communication in the form of sexual attractants and interaction of juvenile and adult mysids. Laboratory studies have been supplemented with field sampling to confirm the distribution and abundance of varying age classes of mysids in a range of depths in Okanagan Lake.

METHODS

In-lake Distribution and Abundance

Sampling to determine the distribution and abundance of mysids was performed at seven depths at three sites on Okanagan Lake. Station locations are shown in Map 2 and include OK 2 (Rattlesnake Point), OK 5 (north of the Kelowna sewage treatment plant) and site OK 6 (North Okanagan Lake). Samples were taken on December 1, 1997, April 1, 1998, and July 1, 1998, and were collected at night by the BC Ministry of Fisheries as described in McEachern (in this report 1999). The depths sampled ranged from the shallows immediately adjacent to each shore to the deepest site in the middle of the lake, with two intermediate sites in between. The density of mysids (# per m^2) and life history characteristics including length, sex, and maturity were determined for each depth. The densities of each age class could then be compared across the seven varying depths at each site as well as between three seasons.

Laboratory Studies: Olfactometer Trials

Seasonal collections of mysids for laboratory studies were performed on Crystal Lake in southern Ontario from September 1997 and throughout 1998. Mysids were caught during the day using a benthic trawl and were cultured in the laboratory at 8°C. Collections of mysids from the south part of Okanagan Lake for use in laboratory experiments took place in 1998 on June 15th, June 20th, and November 23rd at night using a vertical haul mysid net. Okanagan Lake mysids were cultured in lake water held in darkness at 8°C. Collections from Okanagan Lake in June yielded high numbers of juveniles, but the catch also contained a quantity of immature mysids and mature female mysids. The November catch yielded mostly adult mysids, of which the majority of males were mature and the majority of females already possessing a brood. Small processing numbers of non-brooding female mysids, approximately 5% of the total, were also captured.

A two-choice test apparatus (an olfactometer) was used to determine the effects of non-visual communication on the behaviour of mysids. This apparatus is designed in an Y-tube, providing 10 test mysids (termed “travelling” mysids) with two options once they have left the compartment in which they were initially placed (the departure bottle). If the mysids do leave this departure bottle, the tube divides into two tunnels. Each of these tunnels leads to a treatment reservoir, in which either the treatment organisms (10 mysids) or a control (blank water) is housed. Water is constantly pumped at 30 ml per minute through these treatments down the tunnels and into the departure bottle. Thus, the water conditioned by the treatment animals is carried to the travelling organisms. The travelling mysids are denied entry to the treatments by a mesh. Receiving chambers are placed close to the treatment chambers for the travelling mysids once they have travelled down either tunnel. Trials were conducted in 8°C water in the dark to avoid visual stimuli. Each trial lasted for four hours, and was replicated eight times.

All of the age classes (juveniles, immatures, and adults) were used as travelling mysids. They were each exposed to the following combinations of treatments: juveniles and blank water, immatures and blank water, adults and blank water, and two treatments of blank water. Each of the combinations represented a distinct trial. Since it has been determined that when travelling mysids are exposed to two treatments of blank water they orient themselves randomly between the two receiving chambers, any deviation from this expected distribution would be considered to be a result of the treatment. For each trial (consisting of one class of travelling mysids exposed to 2 treatments, replicated 8 times) the data were tested for homogeneity using heterogeneity Chi-square analysis. If this analysis determined that the data were homogenous, the eight replicates were pooled and a Chi-square test was performed on the total numbers ($\alpha = 0.05$) to determine if the observed numbers differed significantly from the expected random distribution.

In the fall (breeding season), mature male and female mysids were used as travelling organisms and exposed to the following treatments: mature males and blank water, mature females and blank water, and two blank water treatments. The intent was to use non-brooding females because in marine mysids it is the sexually mature, non-brooding female that releases a pheromone that is attractive to males (Wittman 1982). However, all combinations were tested so as not to preclude the possibility that it is the male that could release a pheromone that is attractive to females. In addition, travelling mysids were exposed to water conditioned by the same sex of mysid to determine if attraction or avoidance was sex specific. If similar responses were noted for each sex of treatment, the response could have been the result of food-seeking or aggregation behaviour.

The Crystal Lake mysids were exposed to treatments of mysids of the opposite sex twice, once in mid-October and the second in mid to late November (eight replicates each). Female and male mysids from Okanagan Lake were exposed to treatments of the opposite sex and blank water in late November. However, due to time constraints imposed by weather conditions, only 5 replicates of the Okanagan trials could be conducted. In addition, owing to the paucity of non-brooding female mysids available at that time of year, brooding females comprised the majority of the female mysids used in these experiments.

From these experiments, the activity of the travelling mysids exposed to the treatments could also be determined by noting the average number of mysids that left the departure bottle. Activity for each age class travelling mysid (e.g., juvenile) was compared between the varying treatments to which it was exposed (i.e., two blanks, juvenile and blank, immatures and blank, adults and blank). Mean of activity for all experiments conducted using the same travelling organism and the varying treatments were compared. Because travelling mysids exposed to two treatments of blank water had been conducted, the effect of the other treatments could be compared not only to each other, but also to a standard level of activity that could not have been caused by chemical stimuli. Any variation between the mean activity was compared using a one-way ANOVA ($\alpha = 0.05$). If the ANOVA revealed significant differences, a Newman-Keuls test was performed to determine between which pairs of means the differences existed ($\alpha = 0.10$).

This analysis assisted in determining if certain treatments caused an increase or decrease in the activity of the travelling mysid compared to the other treatments.

RESULTS

In-lake Samples

Distribution and abundance of age classes

In general, mysid numbers increased with depth at the three sites sampled in Okanagan Lake (Fig. 1). The three different linear trends show varying numbers in winter spring and summer. The numbers in winter (December 1st) were lower at all depths than those in spring and summer, between which there is little difference.

The lower numbers of mysids found in the shallower sites are comprised mainly of juveniles and immatures (Figs. 2 to 10); juv = juvenile, IF = immature female, IM = immature male, MM = mature male, MF = mature female, BF = brooding female, SF = spent female. Few large mysids were found in the shallow waters, with none being found above 40 m (Figs. 11 to 13). Of these mature mysids, mature females were found at shallower depths than mature males. Brooding females and spent females were confined to deep sites. The number of mysid age classes represented increased with increasing depth. In the shallows, only three age classes were usually present (juv, IF, IM), while all seven classes were found in the deep samples.

Juveniles were not very abundant in the December samples but their numbers increased dramatically in the April samples, following their release from the brooding females. Mature males were most abundant in the December samples, which correlates with the time when the majority of mysids breed in Okanagan Lake. The number of immature mysids peak in the July samples, likely because some of the early release juveniles have reached immature status at this time.

Laboratory Experiments

Olfactometer trials

In the olfactometer experiments, a designation of “no response” was assigned to trials in which the numbers of travelling mysids in each of the two treatment receiving chambers did not significantly differ from a random distribution (see Tables 1 and 2). Of the combinations of travelling mysids and treatments offered only three scenarios resulted in a significant reaction from both Crystal and Okanagan Lake mysids. When juveniles from Okanagan Lake were exposed to water conditioned by Okanagan Lake adult mysids and blank water, significantly more travelling juveniles were found in the blank receiving chamber than the adult receiving chamber (Fig. 14, $\chi^2_{cl} = 5.94$, $P < 0.025$). When juveniles from Crystal Lake were exposed to water conditioned by adults from Crystal Lake and blank water, significantly more travelling juveniles were found in the blank receiving tunnel than in the adult reservoir (Fig.14, $\chi^2_{cl} = 7.6$, $P < 0.01$). When immature travelling mysids were exposed to water conditioned by Crystal Lake adults and blank water, significantly more immatures were found in the blank receiving chamber than the adult one (χ^2_{cl} = 4.5, P< 0.05). There was no evidence to suggest that sexually mature mysids were attracted to each other.

Table 1. Olfactometer trials conducted using juveniles, immatures, and adults from both Crystal Lake and Okanagan Lake (0 = no response observed, x = avoidance of treatment organism, * = attraction towards treatment organism, - = trial not performed).

Traveller	**Treatment Organism**[1]				
	Juv_C	**Juv_O**	**Adult_C**	**Adult_O**	**Immature**
Juv_C	0	-	x	-	0
Juv_O	-	-	-	x	-
Adult_C	0	0	0	-	0
Adult_O	-	0	-	-	-
Immature	0	-	x	-	0

[1] C= Crystal Lake, O= Okanagan Lake

Table 2. Olfactometer trials using mature males and females from Crystal Lake and Okanagan Lake as travellers and as treatments; included in treatments are macerated mysids (Macer) and 24 hour trials (0 = no response observed, x = avoidance of treatment organism, * = attraction towards organism, - = trial not performed).

Traveller	**Treatment Organism**[1]						
	Male_C	**Female_C**	**Male_O**	**Female_O**	**Male 24**	**Female 24**	**Macer**
Male_C	0	0	-	-	x	x	x
Female_C	0	0	-	-	x	x	x
Male_O	-	-	-	0	-	-	-
Female_O	-	-	0	-	-	-	-

[1] C= Crystal Lake, O= Okanagan Lake

Activity analyses

In the olfactometer experiments activity was determined as the mean number of mysids leaving the departure bottle (based on results for 8 replicates of the same treatment). These analyses revealed that there was a significant difference in the means of the activity of juvenile mysids. When juveniles were exposed to adults they exhibited higher activity than when they were exposed to other juveniles or immatures (Fig.15a, ANOVA one way, P < 0.025). Their activity when exposed to two blanks (no chemical stimuli) was midway between the adult and juveniles/immatures. The higher activity of the juveniles in the presence of conditioned water from the adults was consistent with their preference of the blank treatment over the adult treatment. When adult mysids were exposed to juveniles and two blanks their activity was higher than when they were exposed to immatures only (Fig.15b, ANOVA P < 0.05). There was no significant difference in the travelling mysids' activity when exposed to other adults and the other treatments. There was a significantly lower level of activity of immature mysids exposed to adult conditioned water than when exposed to either juvenile or immature conditioned water (Fig. 15c, ANOVA, P < 0.025).

DISCUSSION

In-lake Distribution and Abundance

The observed relationships between numbers, age class, depth and season could be used to predict when the maximum abundance of a particular age class could be caught at a particular depth. For example, the 1997 results suggest that the best strategy to capture brooding females would be to sample at depths greater than 40 m in December at all three stations.

The vertical migration of *Mysis relicta* has been well-documented (Beeton 1960, and others). Fewer studies have been done on horizontal distribution. As in Okanagan Lake, Morgan and Threlkeld (1982) found brooding females in deep water in Lake Tahoe. They hypothesized that it was only the juvenile and immature mysids that migrate horizontally to shallower water about a month after having been released from the brood pouch of adult female mysids in deep water. In Lake Tahoe, the juvenile density increased in the shallows from May until June (similar to the increase of juveniles in shallow waters in Okanagan Lake). From July onward their numbers decreased in shallow waters and increased in the deeper water as they grew larger. Morgan and Threlkeld (1982) suggest the horizontal migration of small mysids is related to the lower sensitivity to light and temperature compared to that of adult mysids as observed by Beeton (1959, 1960). They speculated that juveniles remain close to the bottom to benefit nutritionally and energetically, and to avoid predators. Similarly, small mysids in Okanagan Lake may migrate to shallow depths to access the lake sediments while still being within the limits of their light sensitivity. Elsewhere a different pattern has been found with brooding females migrating to shallow water, releasing their juveniles, and then migrating back to the depths (Moen and Langeland 1989, Reynolds and Degraeve 1972).

Other studies have found that younger age groups remain spatially separated from the adults by residing higher in the water column during the day (Daley et al. 1981, Moen and Langeland 1989, Hakala 1978, Beeton 1960). Spatial segregation is disrupted in the night-time waters of Okanagan Lake, when the majority of mysids vertically migrate just below the epilimnion to feed upon zooplankton. However, because juveniles seem to migrate earlier than the mature mysids and descend later, they do spend part of the nocturnal hours separated from the matures (Daley et al. 1981). Therefore juveniles spend the majority of the diel cycle separated from the adults, with mixing of the age classes occurring only for a few hours at night while feeding. In addition, there may be factors other than light and substrate availability that influence spatial segregation of adults and juveniles and immatures. The possible effect of a dispersal pheromone should also be considered, given that results from this study indicate that juvenile and immature mysids preferentially select blank water when exposed to water conditioned by mature mysids. All these factors may work in concert, producing the spatial separation observed in Okanagan Lake.

Laboratory Experiments

Olfactometer experiments

The results obtained suggest that the water conditioned by the adults causes an avoidance or dispersal reaction in juvenile and immature mysids. Many invertebrates utilize epideictic, or spacing pheromones to direct the distribution within a species. In some cases, mature females of the European grapevine moth (*Lobesia botrana Den. Et Schiff*) produce a spacing pheromone that covers the eggs that lay on grapevine flowers and berries. This pheromone deters ovi-position by conspecific females, resulting in a spacing of ovi-position (Gabel and Thiery 1992). Larval eastern and western spruce budworms (*Choristoneura fumiferan* and *Choristoneura occidentalis*) produce an oral exudate when agitated that increases the number of larvae dispersing away from the region on which it was deposited (Poirier and Borden 1995). If mysids employ a similar dispersal pheromone, the juveniles and immatures would likely disperse, for they are able to exploit the shallower environments that the adults cannot due to their greater sensitivity to light. Anti-congregation pheromones are being considered as a novel control tactic for the southern pine beetle (Turchin and Thoeny 1993) and may be worth exploring as a possible control method for mysids.

Another possibility concerning adult avoidance exhibited by juveniles and immatures is predator avoidance. Mysids are known to be cannibalistic, especially towards smaller mysids. The larva of the California newt (*Taricha torosa*) use conspecific chemical cues to move away from the cannibalistic adult newts, seeking shelter as a form of predator avoidance (Elliott et al. 1993). Previous studies in the olfactometer have shown that even adult mysids avoid water from macerated conspecifics (Quirt 1997). Such secretions could signal avoidance behaviour to young mysids that a predator consuming conspecific is nearby. Many other benthic organisms avoid water conditioned either by their predators or by secretions from macerated conspecifics (Dodson et al. 1994).

Although it could not be determined that sex pheromones cause an attractive response in mature mysids of the opposite sex, numerous factors could have affected the laboratory trials. Many mature female crustaceans only release an attractive sex pheromone after they moult (Dunham 1978). In marine mysids, this chemical compound is short-lived and remains potent for only two minutes (Wittman 1982). If this applies to *Mysis relicta*, the moult would likely have to take place during the olfactometer trials. Although females that were deemed likely to moult (based on the mean inter-moult period of 26 days) were used in 4-hour trials, moults were never observed. In addition, when trials were lengthened to 24 hours no moults were observed and male mysids avoided the chamber with conspecifics, possibly taking refuge from an increase in wastes building up during the trial(s).

Mysis relicta undergo a number of moults (between 12-13) before they achieve sexual maturity (Berrill and Lasenby 1983) and it seems likely that a mysid would release a sex pheromone only after the moult at which it achieved sexual maturity. When selecting recently moulted female mysids (within 24 hours) it was impossible, for example, to know if moult had occurred and whether it was the moult that signified sexual maturity. In fact, the males were more likely to choose the blank water. It is possible that the conditioned water may have resembled water conditioned by a macerated conspecific, which was found to be repellant to mysids.

In the laboratory, males and females were reared in separate tanks to avoid fertilization. However, some fertilization may have taken place in the field before they were isolated. Since eggs are very difficult to see in a live, actively swimming female mysid, it is possible that some brooding females used in the trials were mistaken as sexually mature females, precluding the release of any sex pheromone. Trials conducted with Okanagan Lake mysids were almost certain to have been with fertilized female mysids, since weather conditions postponed mysid capture well beyond the time of expected fertilization.

Activity analyses

Pheromones have also been known to have a wide array of effects of organisms. Sex pheromones do not always elicit a chemotactic (towards the source of the chemical stimulus) reaction but have been observed to affect changes in the level of activity of organisms (Dunham 1978). Lab treatments with sexually mature male and female mysids did not result in any activity difference of travelling mysids when presented with any of the treatments. Other chemical substances used in predator avoidance may decrease or increase levels of activity (Dunham 1978, Dodson et al. 1993). Juvenile mysids were significantly more active when exposed to water conditioned by adults that when exposed to water conditioned by immatures or juveniles. Like the larval newt, juvenile mysids may be more active when exposed to secretions from adults because they must seek refuge from cannibalism (Elliott et al. 1993). Conversely, adult mysids were more active when exposed to water conditioned by juveniles, perhaps as a result of food-searching behaviour. Mysids use a variety of mechanisms including tactile stimuli to seek and prey upon their food (Ramcharan and Sprules 1986). Secretions from juveniles could evoke food-searching behaviour that involves higher activity as the adult mysids search for tactile clues. This is similar to the behaviour of *Chaoborus*, which change position more frequently when exposed to water conditioned by their prey, increasing the predator-prey encounter probability (Dodson et al. 1994).

Decreased activity of immatures when exposed to water conditioned by adults rather than increased activity as demonstrated by the juveniles, may be a predator avoidance behaviour. Decreased levels of activity have been previously categorized as predator avoidance in a variety of other invertebrates, including *Gammarus pseudolimnaeus* (Williams and Moore 1985).

Future work

Mysid behaviour in response to other age classes of mysids suggests that an avoidance is more commonly observed than an attraction. Our studies to date have found no evidence of a sex pheromone in *Mysis relicta*. However, timing of adult female moulting immediately prior to depositing eggs into the brood pouch and possible subsequent release of a short-lived pheromone as observed in marine mysids (Wittman 1982) needs further examination.

The ability to repel mysids from a source has been demonstrated. One of the most well documented behaviours of mysids is their diurnal vertical migration. It is the movement into surface waters that results in mysids consuming cladocerans preferred by kokanee. If the migration of mysids could be halted or suppressed, mysids might not have as much a predatory impact on the cladocerans. The vertical position and pattern of vertical migration of other zooplankters can be altered by exposing them to water containing the predator's kairomone (Dodson et al. 1994). Previous studies have revealed that mature mysids avoid water from damaged conspecifics and from conspecifics that were contained for at least 24 hours (Quirt 1997). Juveniles and immatures seem to avoid water that has been conditioned by adults held for only 4 hours. Future research could explore the effects of a repellant substance on mysid vertical migration patterns. If migration could be disrupted cladocerans and other zooplankters could be provided with a respite from the predatory impact of the mysids. Considerable research would have to be carried out to determine the impact of such a measure on the rest of the lake's communities.

SUMMARY AND CONCLUSIONS

- The number of mysids increases with water depth in Okanagan Lake at a rate that can be predicted using one of three seasonal relationships.

- The only mysids inhabiting very shallow sites are juveniles and immatures, while all age classes of mysids are represented in deeper sites.

- The use of sex pheromones by mature mysids could not be detected in laboratory studies possibly as a result of our inability to accurately predict the timing of moulting and release of a short-lived pheromone.

- Juvenile and immature mysids select blank water over water conditioned by mature mysids.

- Adult mysids avoid water conditioned by macerated mysids as well as water that has been conditioned by mysids for over 24 hours.

- Juvenile mysids are most active in the presence of water from adult mysids, suggesting an active form of predator avoidance. Adult mysids are the most active when exposed to conditioned water from juveniles, perhaps a result of food-searching behaviour.

ACKNOWLEDGMENTS

This research was supported by the Habitat Conservation Trust Fund. Laurie McEachern and Graham Young provided invaluable assistance through the collection of mysid samples.

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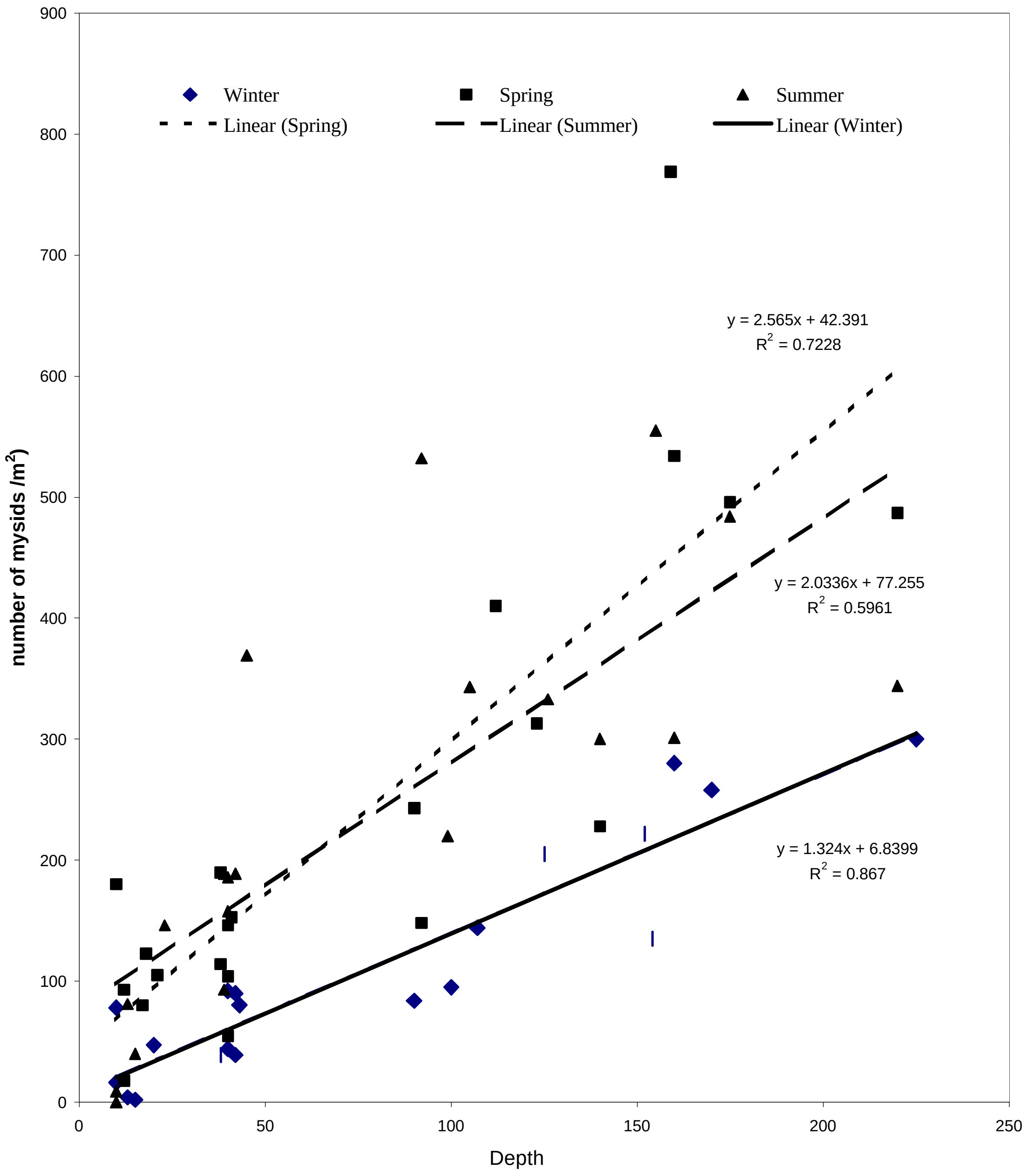

Figure 1. The # of mysids (m^2) vs depth for three pooled sites (OK 6, OK5, OK2) for three different seasons (1997 to 1998).

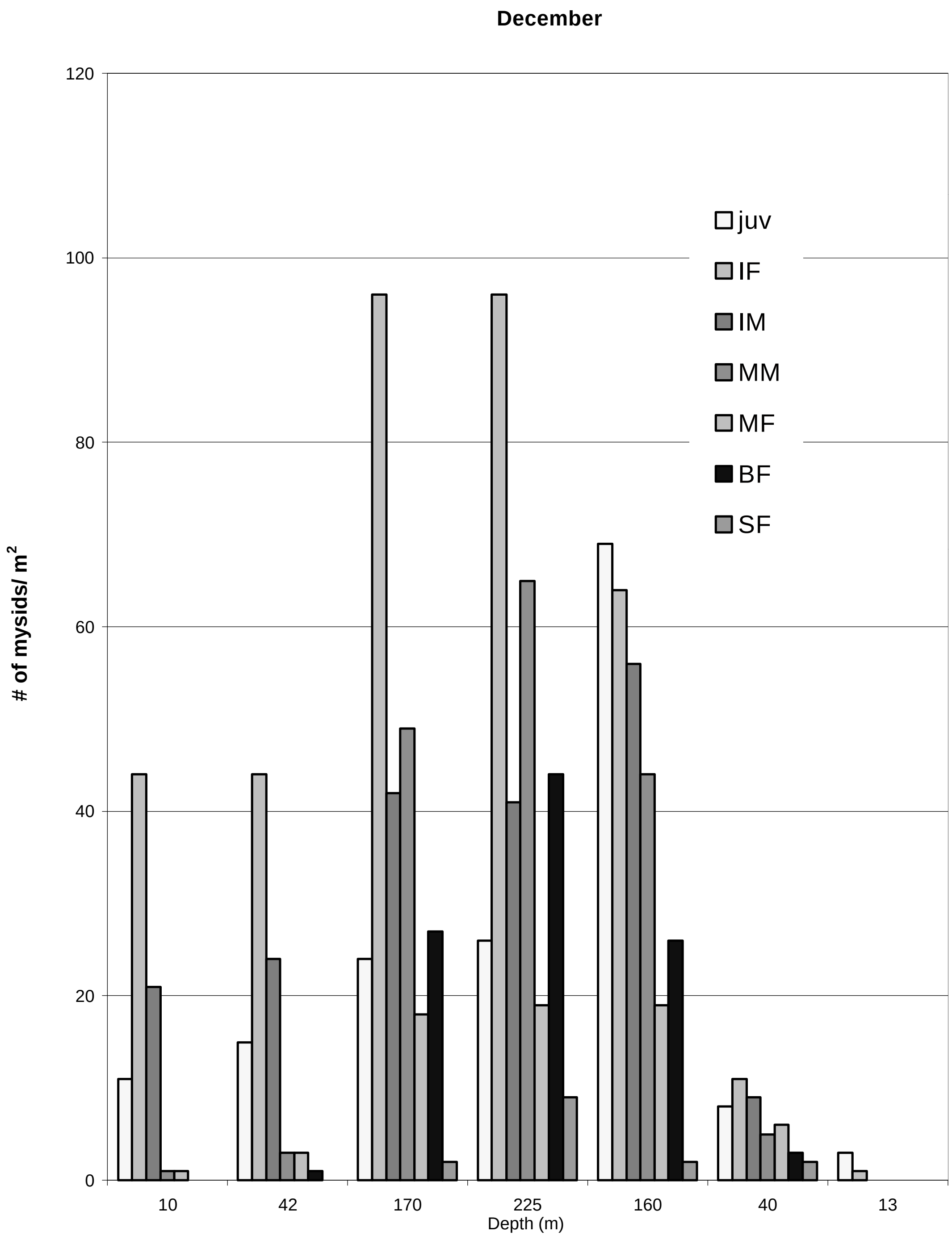

Figure 2. The density (· m^{-2}) and distribution of varying age classes of mysids at site OK 6 across a horizontal transect (west to east) sampled December 1, 1997.

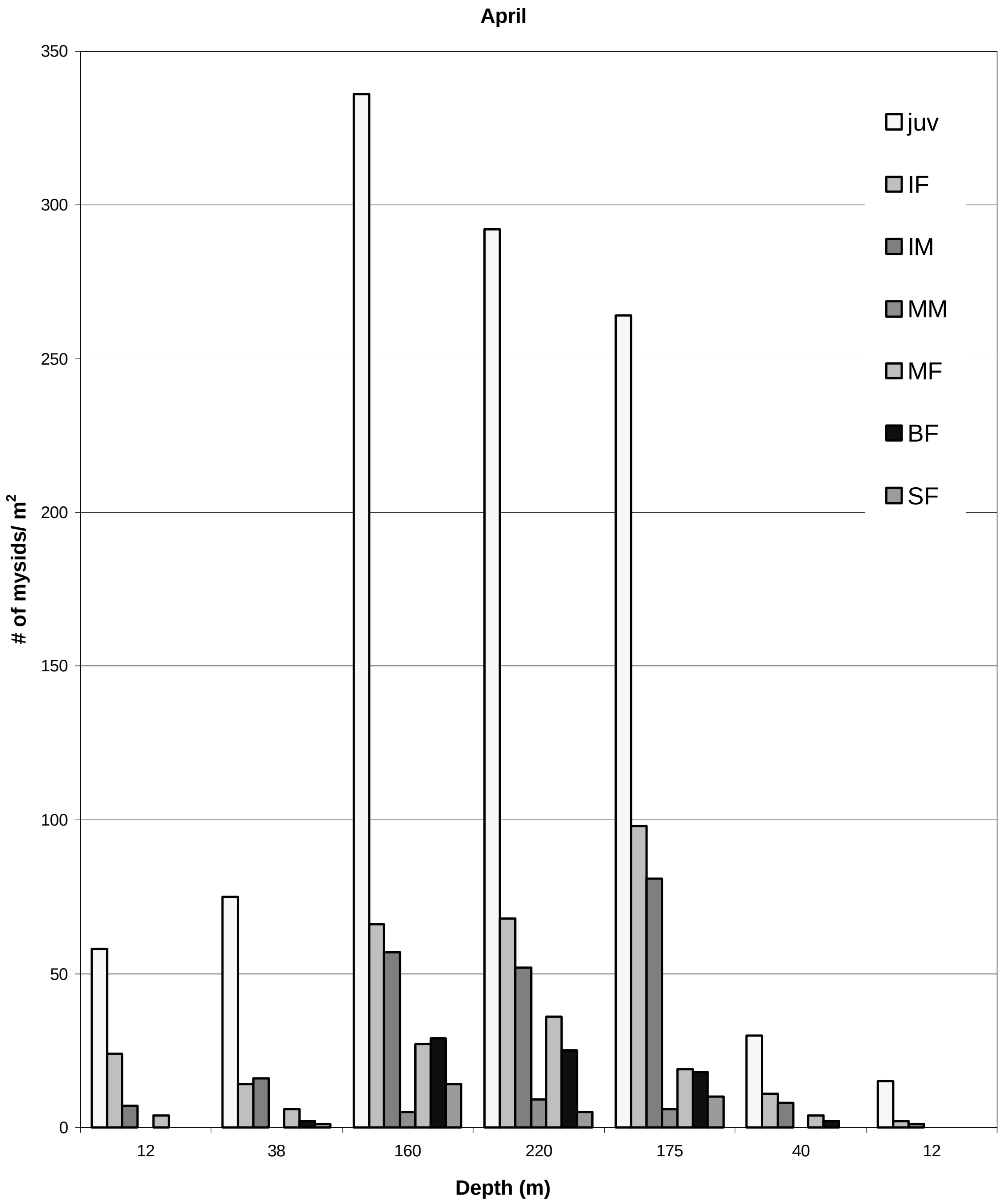

Figure 3. The density (· m²) and distribution of varying age classes of mysids at site OK 6 across a horizontal transect (west to east) sampled April 3, 1998.

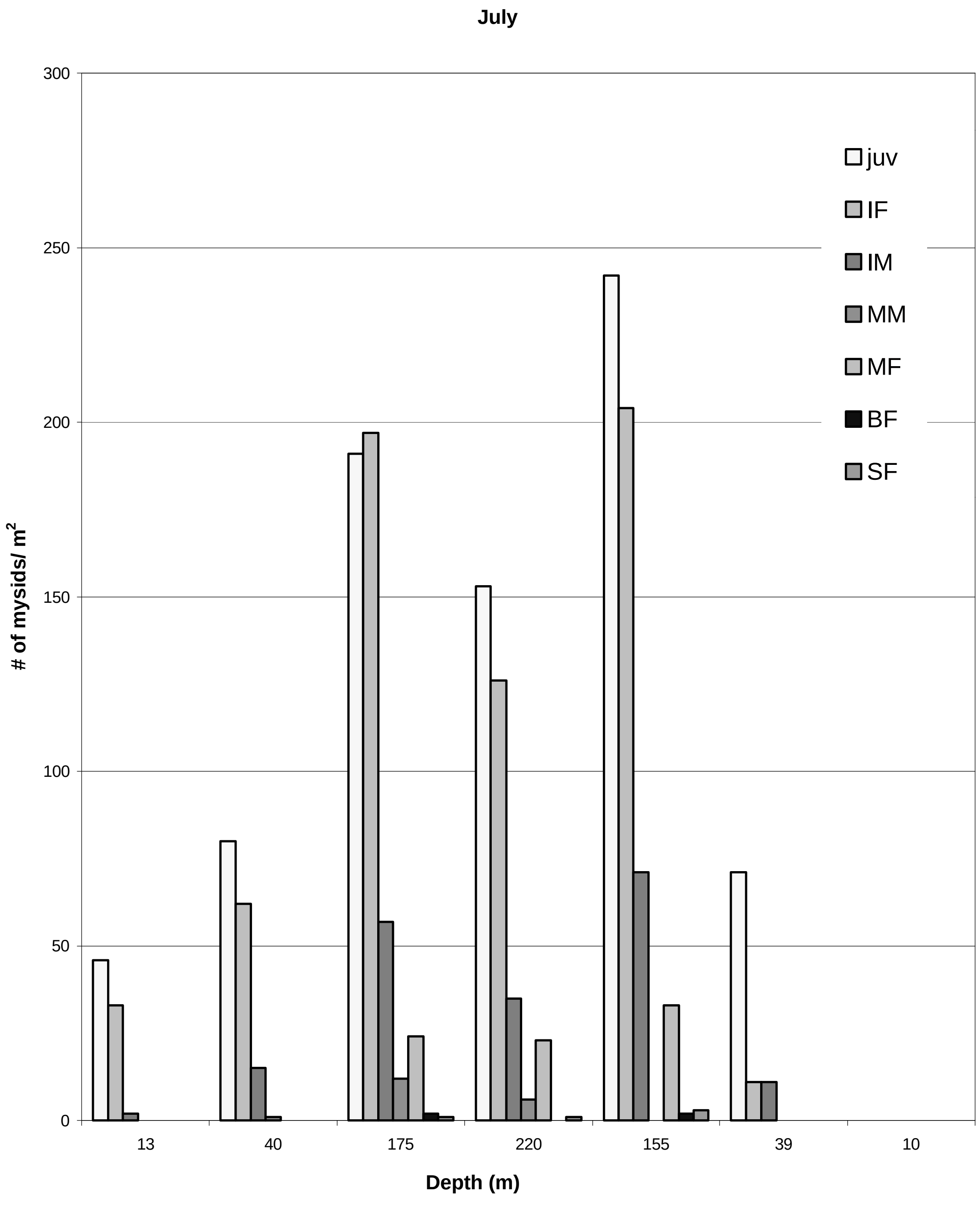

Figure 4. The density(m^2) and distribution of varying age classes of mysids at site OK 6 across a horizontal transect (west to east) sampled July 1, 1998.

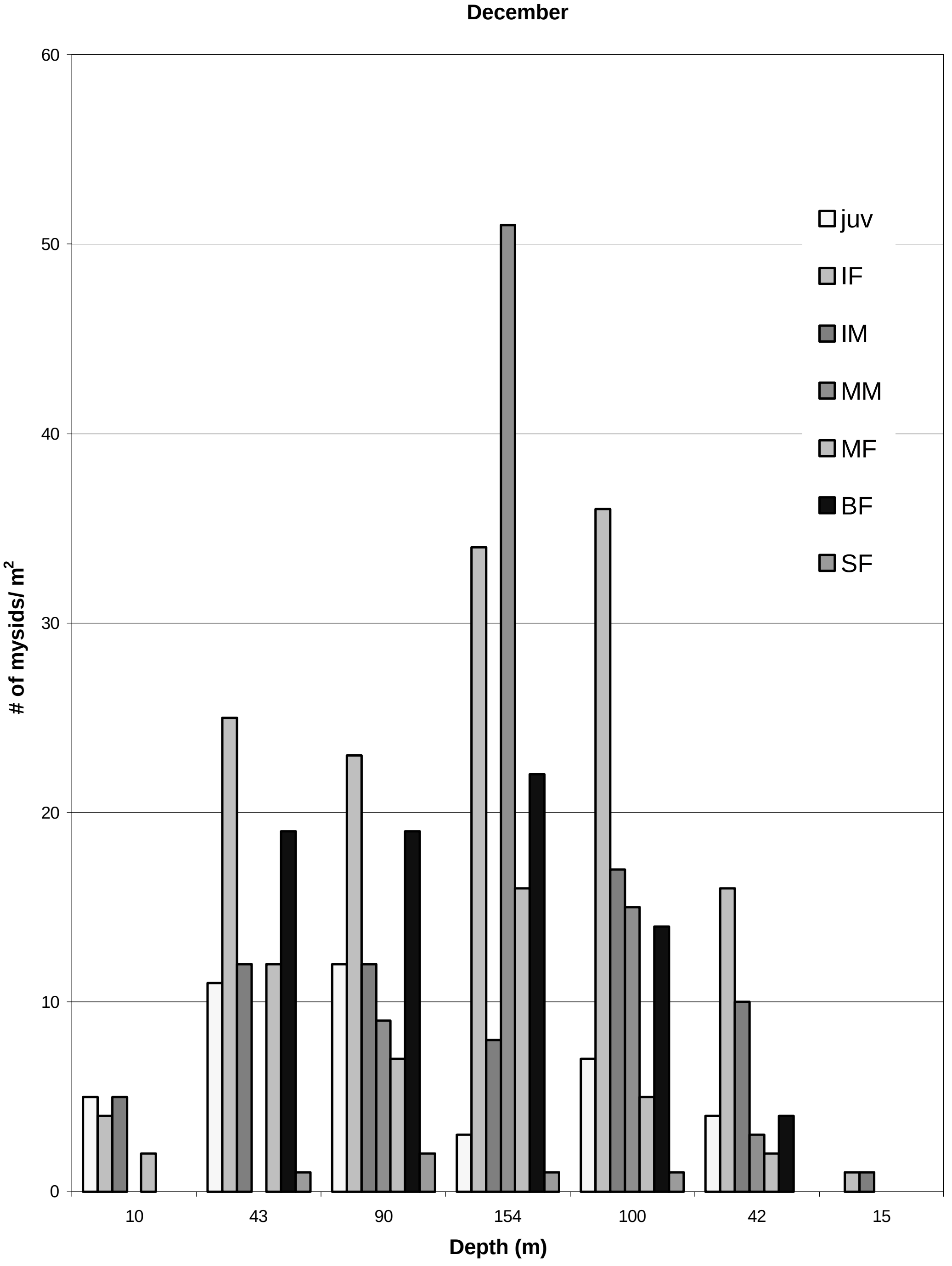

Figure 5. The density (· m^2) and distribution of varying age classes of mysids at site OK 4 across a horizontal transect (west to east) sampled December 1, 1997.

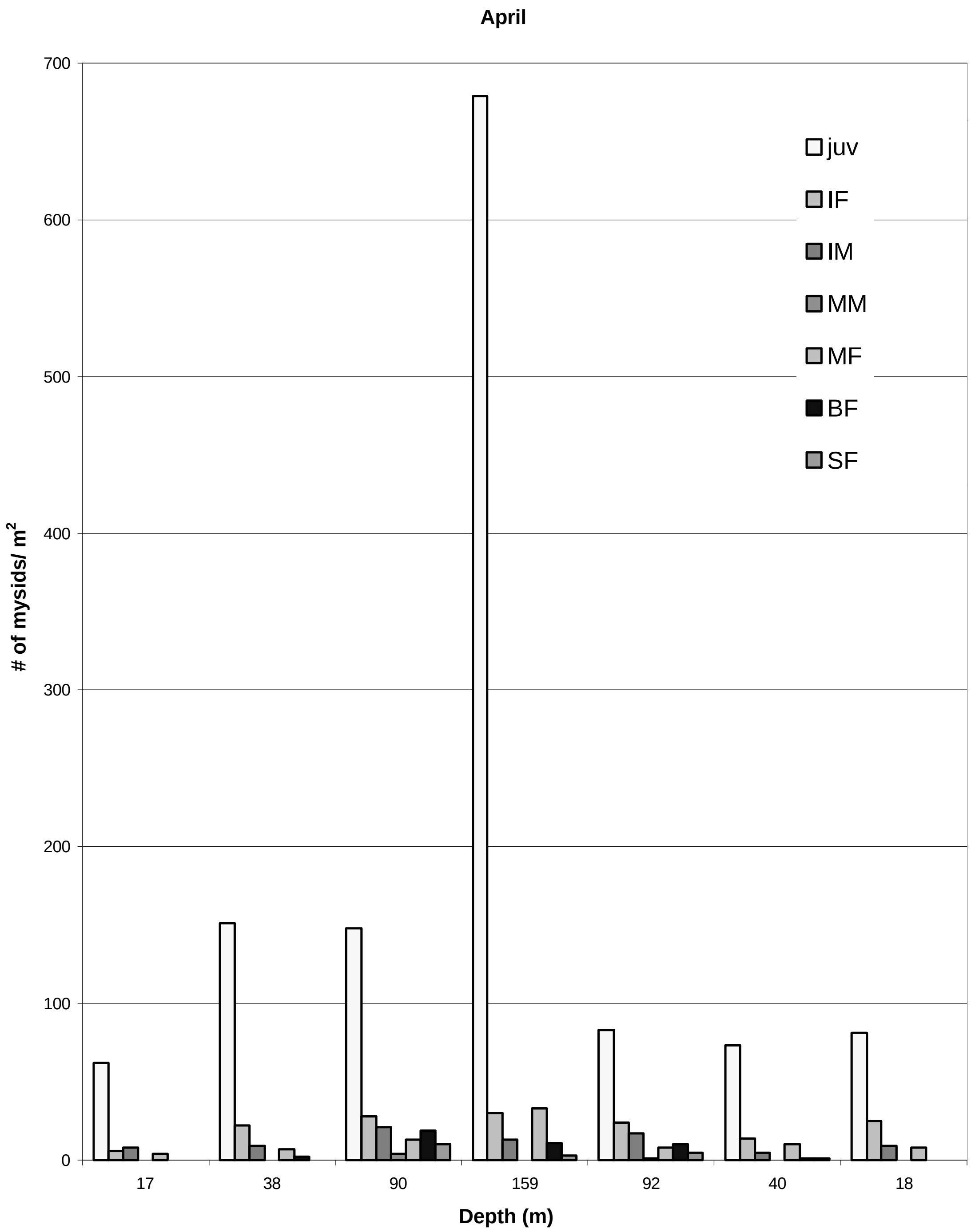

Figure 6. Density (· m^2) and distribution of varying age classes of mysids at site OK 5 across a horizontal transect (west to east) sampled April 3, 1998.

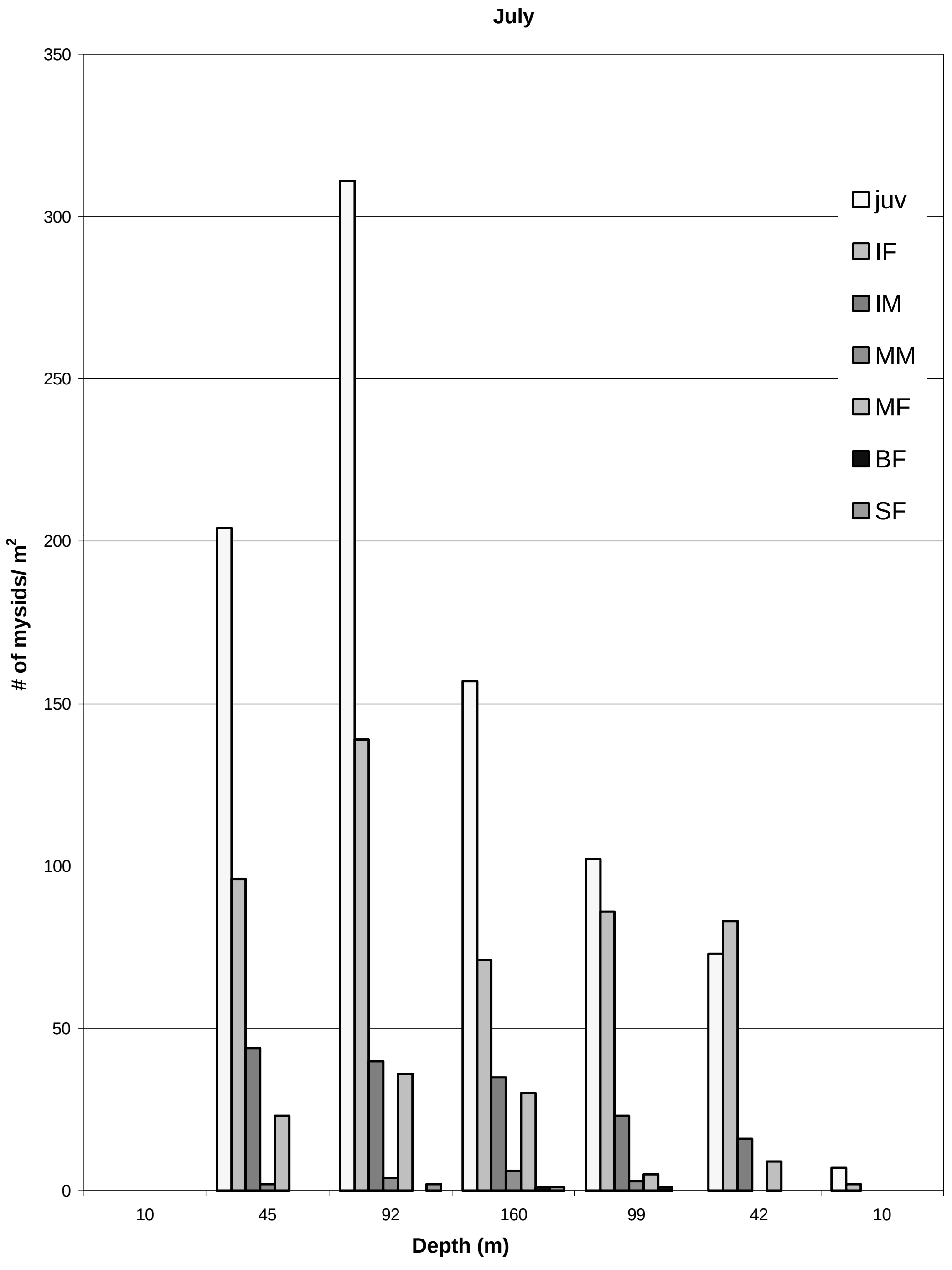

Figure 7. The density (· m^2) and distribution of varying age classes of mysids at site OK 5 across a horizontal transect (west to east) sampled on July 1, 1998.

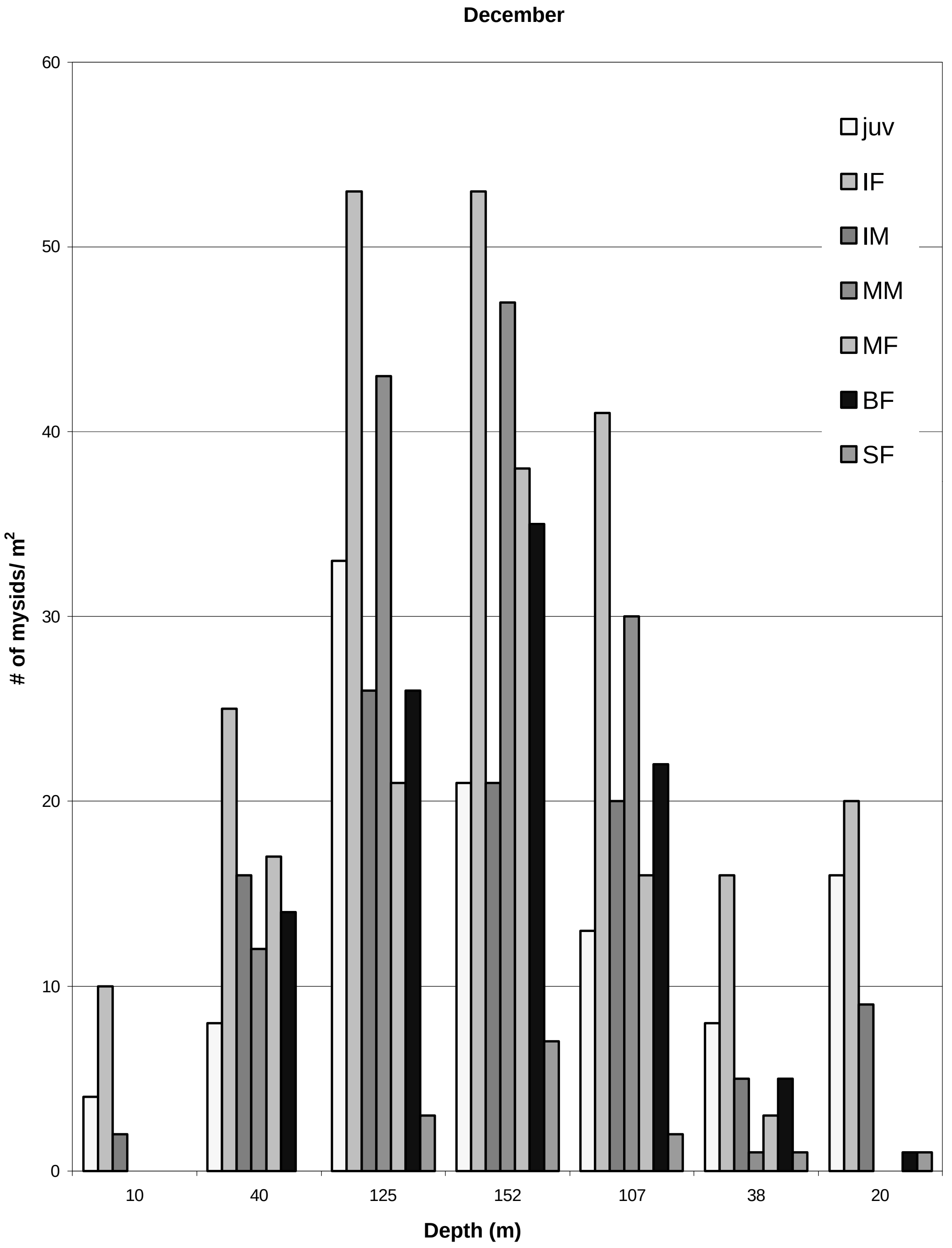

Figure 8. The density (· m^2) and distribution of varying age classes of mysids at site OK2 across a horizontal transect (west to east) sampled December 1, 1997.

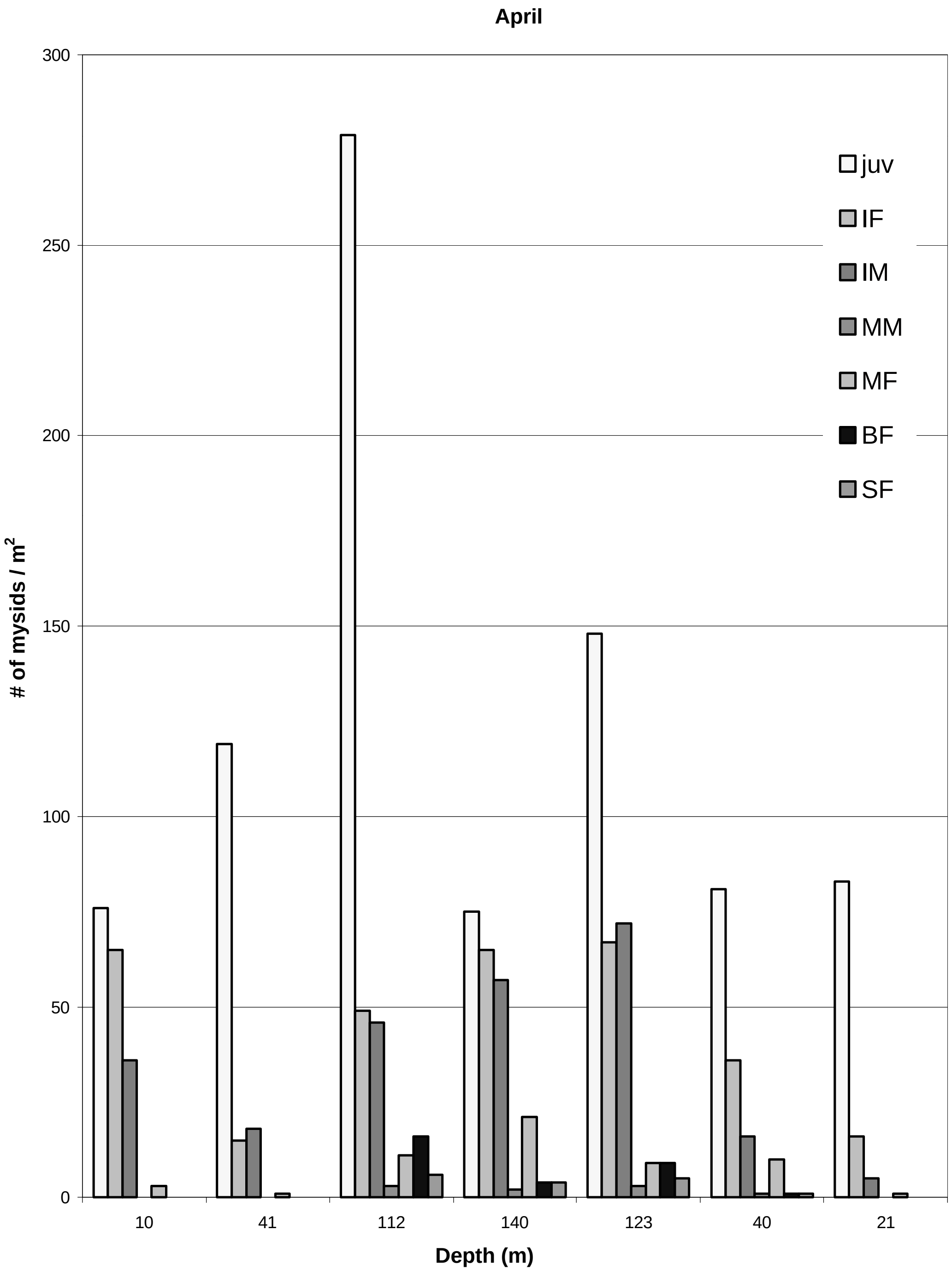

Figure 9. The density (· m^2) and distribution of varying age classes of mysids at site OK 2 across a horizontal transect (west to east) sampled April 3, 1998.

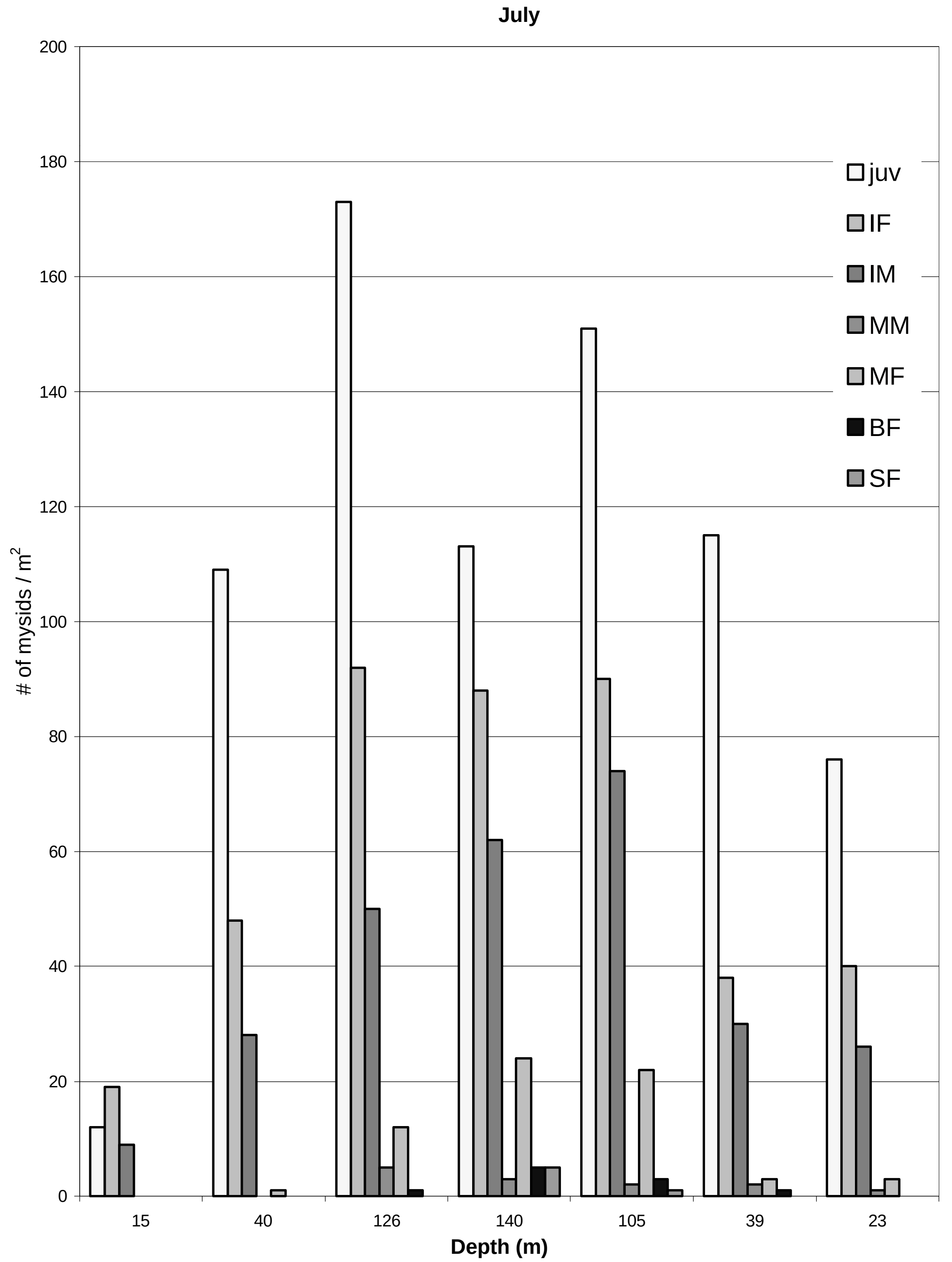

Figure 10. The density (· m^2) and distribution of varying age classes of mysids at site OK2 across a horizontal transect (west to east) sampled on July 1, 1998.

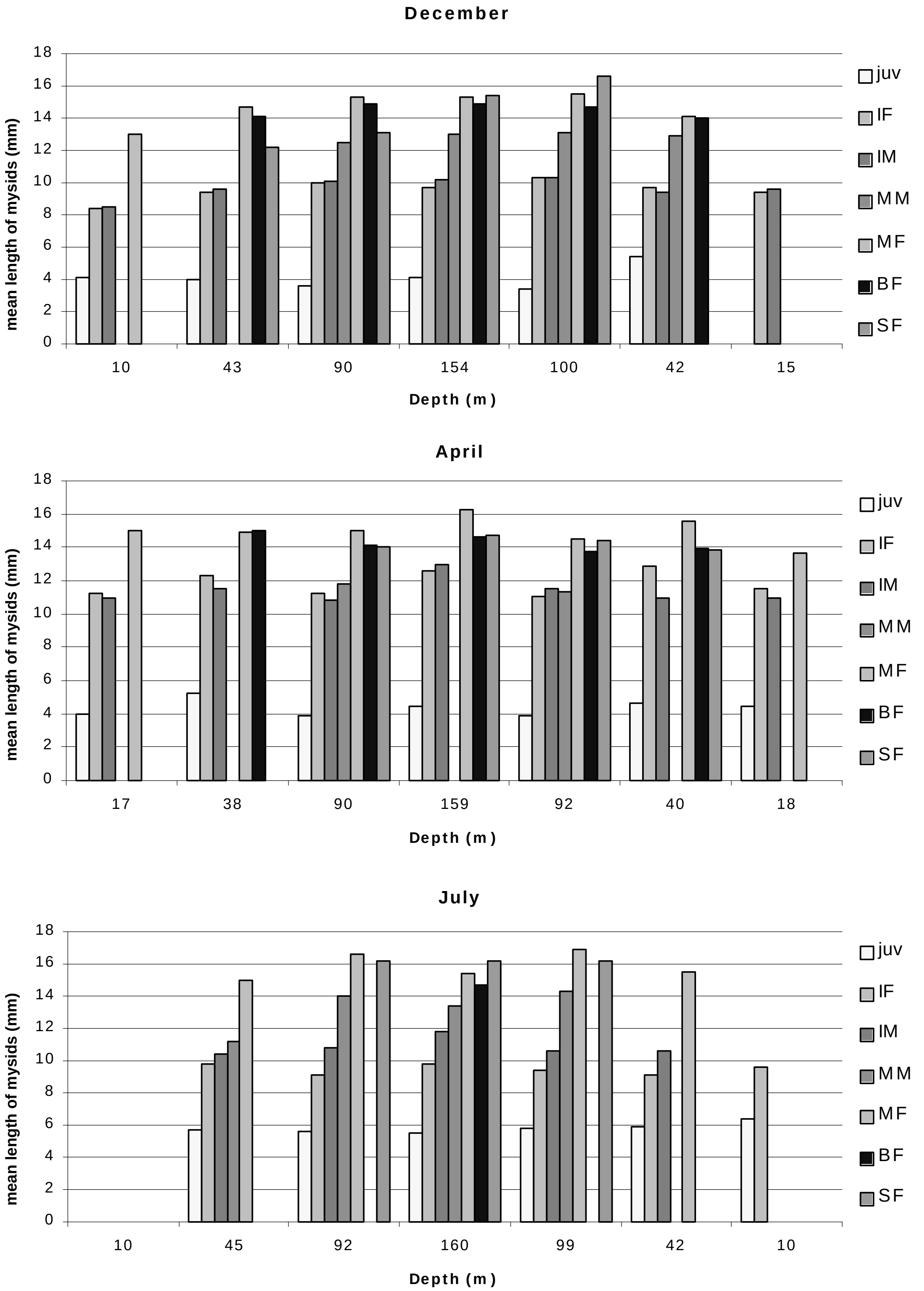

Figure 11. Average length (mm) of varying age classes of mysids across a horizontal transect (west to east) at site OK 5 collected at the beginning of December 1997, April 1998, July 1998.

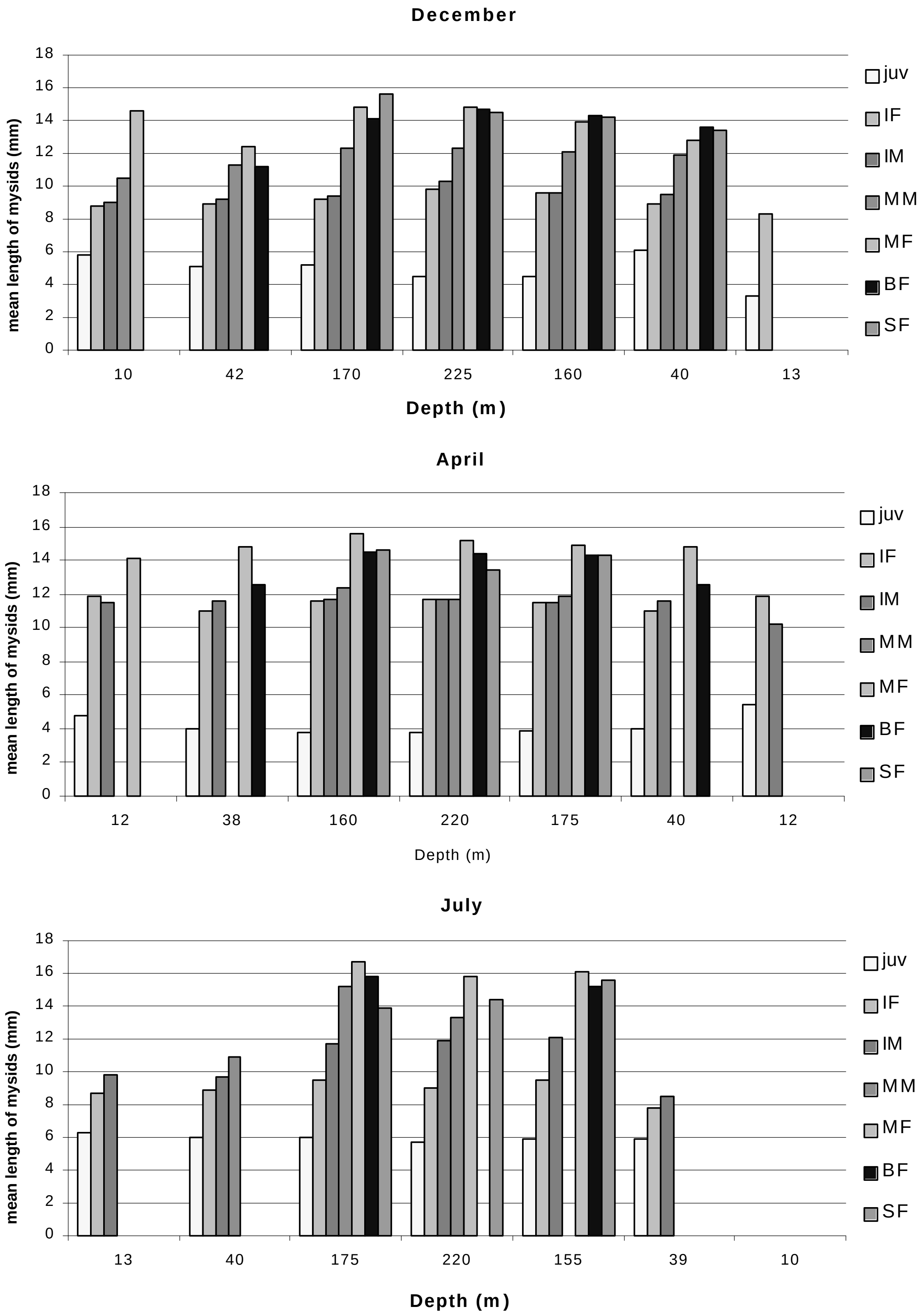

Figure 12. Mean length of varying age classes of mysids across a horizontal transect (west to east) at site OK 6 at the beginning of December 1997, April 1998, July 1998.

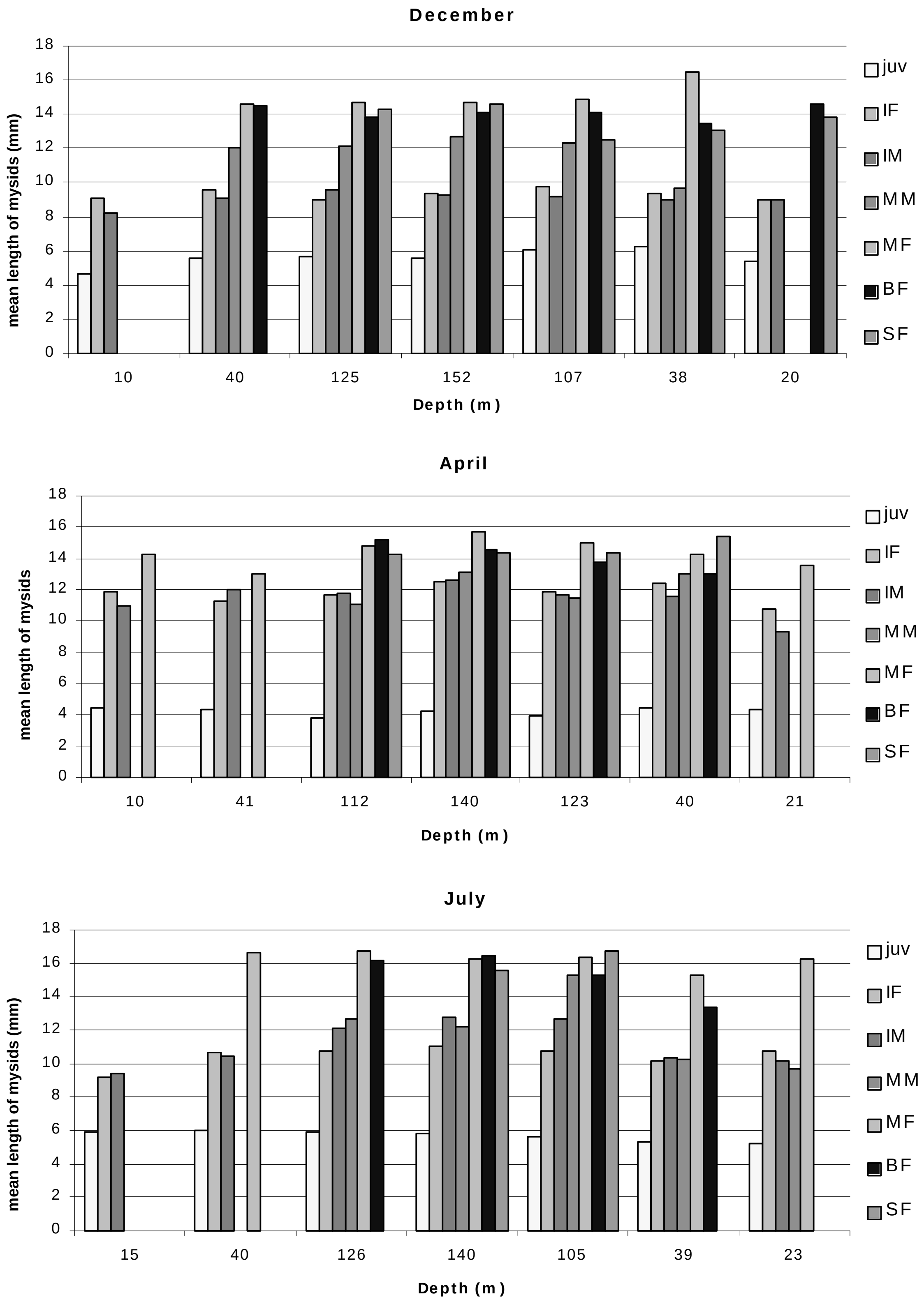

Figure 13. Mean length of varying age classes of mysids (mm) along a horizontal transect (west to east) at site OK2 collected at the beginning of December 1997, April 1998, July 1998.

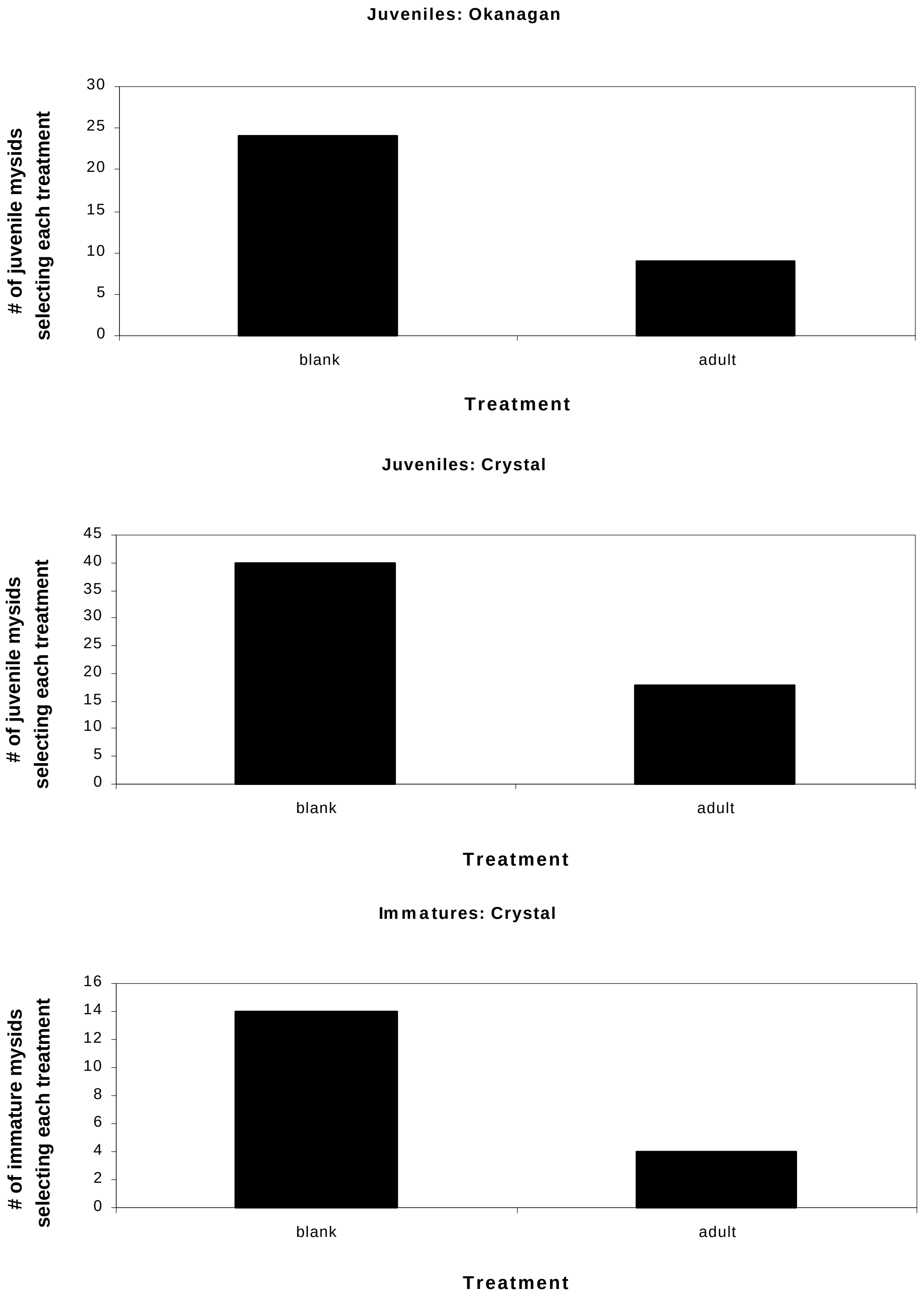

Figure 14. The # of travelling mysids (Okanagan juveniles, Crystal juveniles, and immature juveniles) in each of the treatment reservoirs showing a significant difference from a random distribution (0.05).

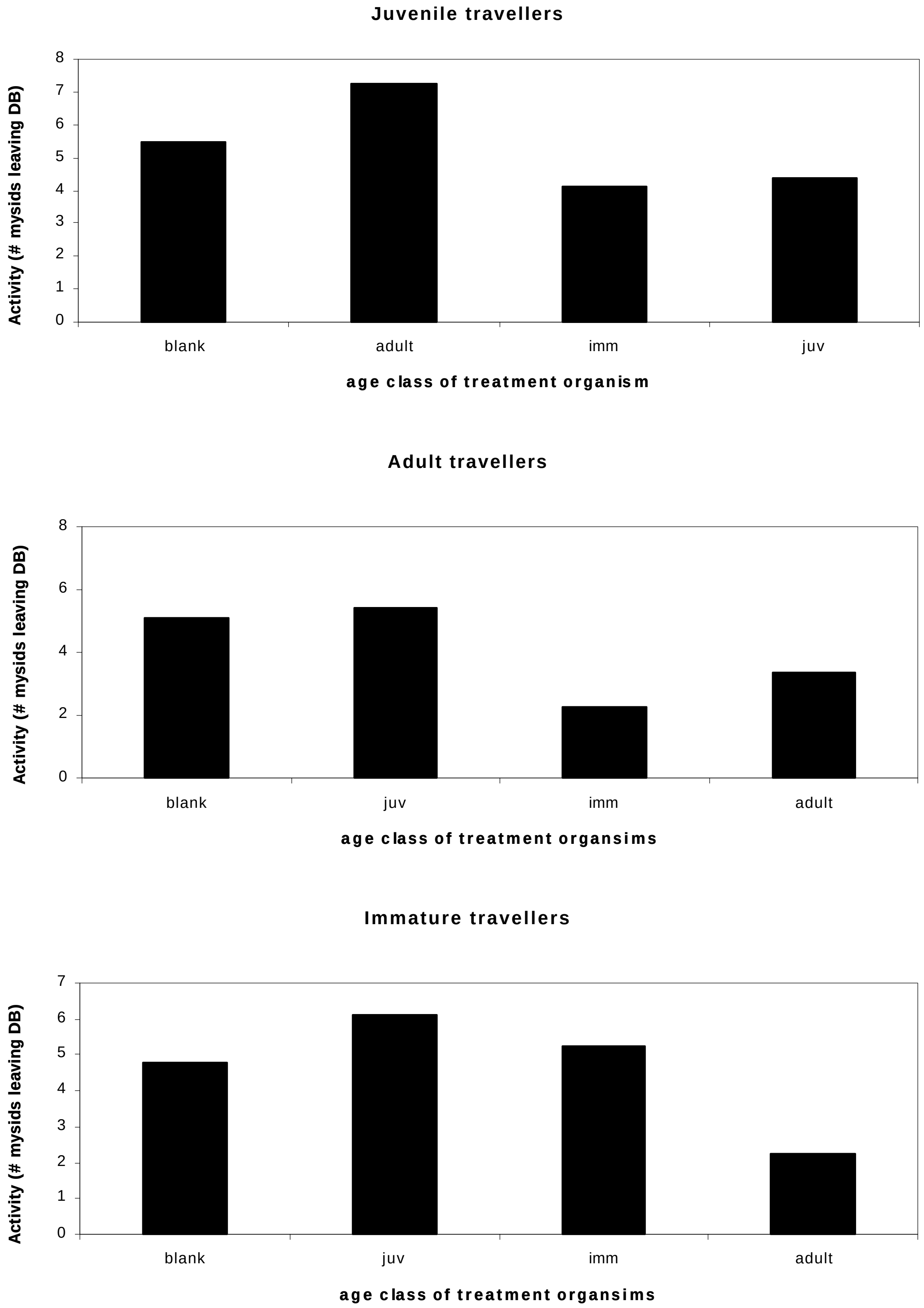

Figure 15. Significant (P < 0.10) differences in the activity of travelling mysids (# of travellers leaving departure bottle) in response to varying treatments.

EXPERIMENTAL MYSID TRAWLING IN OKANAGAN LAKE

by

Ken Ashley[1] and Dave Smith[2]

INTRODUCTION

Mysis relicta were introduced into Okanagan Lake in 1966 (see Shepherd *in:* Ashley et al. 1998). The mysids originated from Kootenay Lake, which had been stocked in 1949 and 1950 with approximately 25,000 mysids from Waterton Lake, Alberta (Sparrow et al. 1964). *Mysis relicta* do not occur naturally in British Columbia due to the distribution of the continental ice sheets during the last glacial period (i.e., Pleistocene). The rationale for the introduction of mysids into these large, deep oligotrophic lakes was to provide an additional food source for piscivorous rainbow trout (Northcote 1991). It was hoped that mysids would provide sufficient food items to bridge an apparent dietary gap in rainbow trout which occurred between ages 1 and 3 as they shifted from planktivory to a fish based (i.e., kokanee) diet (Lasenby et al. 1986). However, the mysids became competitors with kokanee for *Daphnia*, which is the preferred prey item for kokanee, and caused significant declines or collapses of the *Daphnia* and kokanee populations (Ashley et al. 1998). At present, there is a voluntary worldwide moratorium on mysid transplants (Nesler and Bergersen 1991). Unfortunately, the mysid problems remains and there are no known methods for eliminating a mysid population once it has become established in a lake (Northcote 1991).

A small-scale commercial harvest of mysids was attempted in Pend OReille Lake (Idaho) in the 1990s, however, this operation was recently terminated (see Shepherd *in:* Ashley et al. 1998). This report reviews the experimental mysid harvesting trials conducted in Okanagan Lake in 1998, which is the first commercial scale attempt at mysid harvesting in British Columbia.

MATERIAL AND METHODS

An experimental mysid net was designed in December 1997, and the net was constructed in late February 1998. The net is 26 m (~80 ft) long and 11 m (~33 ft) wide with stretched mesh tapering from 8 mm (3/8”) to 6 mm (1/4”). The net is held in position when fishing by a single cable which is affixed to a 9.5 m (~31 ft) aluminum beam and two 1.3 m (~4 ft) stakes which function to keep the mouth of the net open when trawling.

Field trials were conducted on Okanagan Lake in the first week of March 1998 during a period of calm weather. These conditions were favorable for deploying the test net from the MELP boat “Nerka”. After testing the net for fishing with various weights and lengths of cable a test harvest

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trial was attempted. The test was conducted on March 4, 1998, near Crescent Beach where a layer of mysids were known to exist during the day at 90 to 100 m. Approximately 3,600 grams of mysids were captured in this one test haul along with one 1+ kokanee. However, it was obvious the net was too large to handle without proper power gear, and the tests were suspended until a larger trawl boat could be obtained.

To more fully explore the feasibility of mysid harvest with the experimental net, a 13 m commercial shrimp boat owned and operated by Robert Bowker (Bamfield, BC) was transported to Okanagan Lake on November 13, 1998. The boat was rigged with the experimental net, and began fishing on November 15, 1998. The commercial vessel remained in Okanagan Lake until November 22, 1998, when it was removed and hauled back to Richmond, BC. The total cost of the operation was $25,000 including crane rental, boat hauling, gear modifications, boat and skipper charter, fuel, crew accommodation, crew transportation, crew wages and field expenses.

RESULTS

Harvest Rates

A total of 26 experimental trawls were conducted between November 15, 1998 and November 24, 1998 (see Appendix 1). A total of 231.5 kgs of mysids were harvested in 924 minutes of net trawl time, for an average harvest rate of 0.251 $kg\cdot min^{-1}$. There was a wide range in harvest rates as the skipper and crew were conducting mysid fishing for the first time, and some period of learning was required to determine how to fish the net and where to find the mysids. For example, the mysid harvest rate ranged from 0.0 $kg\cdot min^{-1}$ on November 16 and 17, 1998, when the skipper was just learning how to fish the net to 1.536 $kg\cdot min^{-1}$ on November 19, 1998, when the skipper had learned how and where to fish for mysids (Appendix 1). The largest single catch was obtained on November 21, 1998, when 49.75 kgs of mysids were captured in a 60-minute trawl, for a harvest rate of 0.829 $kg\cdot min^{-1}$.

Composition and Processing of Catch

Upon completion of each trawl the trawl cable and majority of the net were wound onto the net drum, the cod end of the net lifted onto the boat with the hydraulic winch and boom, and the catch emptied into a large plastic container. The mysids were scooped out with a kitchen sieve, shaken to remove excess water, weighed, then placed in plastic bags for later freezing. Fish that were captured in the net were identified and stomach content samples taken when possible. Overall, the incidental catch of fish was extremely small (Appendix 1). This was likely as a result of the decision to fish the net on the lake bottom during the daytime when mysids are congregated at or near the bottom and fish are in the water column. The trawl speed was variable (0.4 to 1.4 m/sec) but slow enough that any fish in the trawl pathway also had some opportunity for escape.

Potential Impact on the Mysid population

The potential impact of mysid harvesting on the mysid population in Okanagan Lake is difficult to estimate accurately. The efficiency of the mysid net, size-frequency distribution of the catch versus the population, and biomass estimates of mysids are quite crude. However, given the experience gained with the experimental trawling, some “back-of-the-envelope” calculations can be made to provide a rough estimate of the potential impact of full scale mysid harvesting.

As previously mentioned, the average harvest rate was 0.251 $kg{\cdot}min^{-1}$ using a 1/2 scale mysid net. Assuming catch efficiency would remain constant with a full size net, a catch rate of 0.502 $kg{\cdot}min^{-1}$ or 30.12 $kg{\cdot}hr^{-1}$ may be possible. This is a conservative estimate as the crew was regularly achieving catch rates several times higher than this figure during the latter phases of the test fishing. Assuming the boat fished for 8 hours per day, then a single boat could conservatively harvest 241 $kg{\cdot}d^{-1}$ of mysids.

An individual mysid ranges in wet weight from 2.8 mg for a small 5 mm mysid, to 6.5 mg for a 7 mm mysid, to 50 mg for a large 14 mm mysid (see Whall and Lasenby *in:* Ashley et al. 1998). The size-frequency distribution of the mysid catch has not been determined, however, field observations suggested the mysid catch consisted mainly of larger mysids, as the coarse mesh size likely allowed smaller mysids to pass through the net. Assuming an average weight of 20 milligrams per mysid for the size-blended catch, then approximately 12,050,000 mysids could be harvested per day. Using a higher catch rate of 1.0 $kg{\cdot}min^{-1}$, which was routinely achieved during the latter part of the November trials, then 120 $kg{\cdot}hr^{-1}$ could be possible, or 960 $kg{\cdot}d^{-1}$ of mysids. This suggests that a single vessel could harvest 48,000,000 mysids per day. One note of caution is that eight of the trawls used to calculate these averages were conducted in areas of high mysid density (natural depressions that would tend to concentrate mysids on vertical descent). These depressions are atypical when compared to the normal bathymetry of the lake.

The current mysid population in Okanagan Lake is estimated by a series of monthly vertical hauls from the bottom using a 1 m^2 mysid net (see McEachern 1999, in this report). Although not highly quantitative, the routine monitoring does indicate general trends in mysid abundance, even though the absolute number of mysids in Okanagan Lake is not known with a high degree of accuracy. The average annual mysid density estimates in Okanagan Lake for 1996 and 1997 were $256{\cdot}m^2$ (Ashley et al. 1998). Given that the surface area of Okanagan Lake is 351 km^2, and assuming 90% of the lake is suitable for mysids, then a rough estimate of the total number of mysids inhabiting this area (316 km^2) would be approximately 81,000,000,000 mysids. A harvest rate of 12,050,000 $mysids{\cdot}d^{-1}$ would capture 0.015 $\%{\cdot}d^{-1}$ of the mysid population, and a harvest rate of 48,000,000 $mysids{\cdot}d^{-1}$ would capture 0.06 $\%{\cdot}d^{-1}$. Therefore, it would take a single vessel 67 days to capture 1% of the mysid population at a harvest rate of 12,050,000 $mysids{\cdot}d^{-1}$ and 17 days to capture 1% of the mysid populations at a harvest rate of 48,000,000 $mysids{\cdot}d^{-1}$. A single vessel fishing 16 hours per day, or 2 vessels fishing 8 hours per day could double these rates. Consider that a fleet of 4 vessels fishing 8 hours per day could potentially capture 48,200,000 to 192,000,000 $mysids{\cdot}d^{-1}$, which is 0.06 to 0.24 $\%{\cdot}d^{-1}$ of the estimated mysid population with a landed wet weight of 964 to 3,840 kgs of mysids.

DISCUSSION

The back-of-the-envelope calculations presented indicate that it is theoretically possible to capture hundreds of kilograms of mysid per day using conventional shrimp trawling gear. Initially, this experimental harvest work confirms the feasibility of catching mysids using a large net near the lake bottom. Building upon additional experience with experimental trawling (i.e., location, depth, time of year), it may be possible to determine the potential effect of mysid harvesting on the recovery of Okanagan Lake kokanee stocks. For example, it may be feasible to only fish part of Okanagan Lake during a specific time of the year to exert a significant impact on mysid populations. If specific areas of Okanagan Lake can be identified which have unusually high concentrations of large, gravid female mysids, then a selected fishery conducted during the fall months may be highly effective.

It is also known that mysids move out of Armstrong Arm in late summer or fall so they must concentrate nearby in the main lake where the fishing power could be concentrated. In addition, mysids could be fished down where the greatest concentrations of kokanee fry and 1+ yearlings are located. Based on the Kootenay Lake North Arm fertilization experience and knowledge of kokanee fry distribution a highly effective mysid fishing strategy for Okanagan Lake could be developed in the near future.

The next steps in determining the biological impacts and economic viability of a targeted mysid fishery in Okanagan Lake are as follows:

1. conduct a series of accurate seasonal biomass and distribution estimates of mysids throughout the year;

2. examine the size-frequency distribution of the mysids captured in the trawl net;

3. use an underwater camera to determine the behaviour of mysids to the mysid net, and mysid vertical distribution off the lake bottom to determine if a more efficient net design or time and location of fishing is required;

4. deploy a full scale mysid net to determine if there are any problems scaling up to a full size net;

5. analyze the mysids to determine their protein and fatty acid contents, and conduct freeze-thaw cycles to examine product quality;

6. conduct an economic analysis and test marketing to determine if mysid harvesting could be potentially self-supporting;

7. determine the total annual yield under a variety of harvest scenarios; and

8. establish a limited entry licensing program for commercial harvest of mysids.

ACKNOWLEDGEMENTS

Special thanks to Bob Bowker for patiently responding to our questions and ideas about shrimp harvesting, and for agreeing to have his vessel transported across British Columbia during less than perfect weather. Thanks to the deck hands (Bruce Shepherd, Graham Young and Steve Matthews) for participating in the mysid harvest trials with an inquisitive and positive attitude.

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DIFFERENTIATION BETWEEN BEACH AND STREAM SPAWNING ECOTYPES OF KOKANEE *ONCORHYNCHUS NERKA* IN OKANAGAN LAKE: DEVELOPMENTAL BIOLOGY AND VARIATION AT MICROSATELLITE DNA LOCI

PROGRESS REPORT

by

Eric B. Taylor[1], A. Kuiper[1], and P.M. Troffe[1]

INTRODUCTION

This report summarizes work on the developmental biology and level of molecular genetic differentiation between spawning ecotypes (beach and stream spawning populations) of kokanee (*Oncorhynchus nerka*) in Okanagan Lake. This research is part of an ongoing collaboration between the Ministry of Fisheries (Conservation Section) and the laboratory of Dr. Eric Taylor of the UBC Department of Zoology. The overall research objective is to assess the level of genetic subdivision within the lake. Molecular markers are used to test the idea that Okanagan Lake kokanee constitute at least two fundamentally distinct biological units, primarily characterized by distinctive spawning habitats and ecology ("stream" and "beach spawners"). The existence of two or more genetically distinct groups of kokanee would suggest that they are, to some degree, demographically independent which should be considered when kokanee management goals and strategies are set. Our secondary goals are:

(i) to assess the level of differentiation in aspects of phenotype that may be more reflective of the different spawning ecology of stream and beach spawners, and
(ii) to assess the potential for molecular-based identification of juvenile samples in the lake's limnetic zone with respect to their origin from beach or stream spawning populations.

This report summaries activities from 1997 to 1998 that focussed on further characterization of populations using mitochondrial and microsatellite DNA analyses as well as investigations of the developmental biology of beach and stream spawners.

MATERIALS AND METHODS

Sample Collection

Individual male and female kokanee were collected using seine and dip nets from three areas in Okanagan Lake: two stream spawning sites (Peachland Creek, Mission Creek), and one beach spawning site "Paul's Tomb" 6 km north of Kelowna BC (Map 2). Samples of stream spawners

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were collected on September 25, 1997, and beach spawners were collected on October 23, 1997. Eggs were stripped from females and each batch of eggs was fertilized using sperm from a single male, thus all subsequent analyses were based on individual full-sib families. From each cross the male and female were measured for fork length, otoliths were removed for age determination, and a photograph was taken of each fish.

A sub-sample of 30 to 50 eggs was taken from each female and placed in 5% formalin for egg size determination. Fertilization took place on site using 8°C de-chlorinated Vancouver City water and after fertilization the zygotes were disinfected in Ovadine. Zygotes were then placed in 1 litre plastic tubes filled with water and chilled on ice to 4°C for transportation to UBC. Upon arrival at UBC, 100 zygotes from each cross were placed in individual containers within a "Heath-tray" type vertical stack incubator supplied with Vancouver City water chilled to 8°C and were left undisturbed until the "eyed" stage (about one month after fertilization). Individual family crosses were randomly assigned to compartments within the incubator. Water temperature was recorded at least twice daily throughout the incubation period. After the eyed stage had been reached, all dead or unfertilized eggs were removed from each container. Thereafter, each compartment was inspected for any eggs that had hatched, the number of which was recorded daily until all eggs had hatched.

Following hatching, alevins were retained in the individual family incubator compartments until 1,000 accumulated thermal units (days times average daily temperature) from fertilization. At this point, 15 fish from each full-sib family were preserved in 10% formalin for subsequent analysis.

Sub-gravel temperatures were obtained from temperature recorders placed near spawning sites in Peachland and Powers creeks as well at three locations (Okanagan NW, NE, and SE) near beach spawning sites in Okanagan Lake. Temperatures were recorded every hour from September 9, 1997, at stream spawning sites and from October 10, 1997, at the beach spawning areas.

Data Analysis

Egg size was estimated as the wet weight of individual eggs measured to the nearest 0.001 g. Time to hatching was expressed as the number of accumulated thermal units (ATUs) required for 50% of the individuals within a family to hatch. "Emergence" timing is another common milestone of salmonid development and various techniques have been employed to measure emergence (e.g., Hendry et al. 1998). Because emergence contains a behavioural component that may, or may not, necessarily coincide with an assessment of physical development (our primary concern) we decided to assay development rate as the extent of yolk absorption after a predetermined period of thermal unit accumulation. We selected 1,000 ATU as the appropriate point because it was close to the predicted "emergence" time of Okanagan Lake kokanee based on the models of Shepherd (1997, unpublished MS) and because in our laboratory setting 1,000 ATU produced a good range of yolk absorption amongst families.

Egg weights were analyzed by analysis of variance accompanied by Tukey's a posterior means test. Homogeneity of egg weight variance was confirmed using Bartlett's procedure. Accumulated thermal units to 50% hatching were negatively correlated with egg weight (r = -0.26, P$>0.05), so analysis of differences in ATUs to 50% hatch were analyzed by analysis of covariance (ANCOVA) with egg weight (log e) as the covariate. Similarly, percentage yolk remaining at 1,000 ATU was positively correlated with initial egg weight (r = 0.66, P<0.01) and, therefore, differences in yolk remaining at 1,000 ATU were analyzed by ANCOVA after egg weight and percentage yolk remaining (arcsine square root) were transformed.

Molecular Analysis

Molecular analysis consisted of assaying kokanee from a total of 5 sample sites at up to 8 microsatellite loci. Tissue samples (adipose fin clips) were collected from Mission Creek, Peachland Creek, Powers Creek, Okanagan Centre, and Squally Point during the autumn of 1994 as outlined by Taylor et al. (1997). During September and October 1997, tissue samples were obtained and stored in 95% ethanol from Mission and Peachland creeks, and from kokanee collected from Paul's Tomb site. Genomic DNA was extracted as outlined in Taylor et al. (1997).

Microsatellite variation was assayed in the 1994 samples at eight loci including three derived from an *Oncorhynchus nerka* genomic library (Table 2). Briefly, PCRs were carried out in a MJ Research PT-100 thermal cycler using 10 ul reaction volumes. Each reaction contained 1 X Gibco/BRL reaction buffer, 1.5 mM MgCl2, 0.8 mM dNTPs (0.2 mM each), 0.5 units of Taq polymerase (BRL), 0.05 uM of 32p-endlabelled primer 1, 0.25 uM unlabelled primer 1, 0.6uM unlabelled primer 2, and 100 ng genomic DNA. Amplifications consisted of a profile of 95°C for 3 min (minutes), locus specific annealing temperature + 2°C (Table 2) for 1 min, 72°C for one min for one cycle, 94ºC for 1 min, locus specific annealing temperature + 2ºC for 1 min, 72ºC for 1 min for 5 cycles, 92 for 45 s (seconds), locus specific annealing temperature for 45 s, 72ºC for 1 min for 30 to 35 cycles, followed by a final 5 min extension at 72ºC. Following amplification, 10 ul of formamide-based loading buffer was added to each sample, which were subsequently stored at -20ºC until electrophoresis. Allelic variation was visualized by denaturing acrylamide electrophoresis using 'Long Ranger' gels typically at 6% concentration. Samples were denatured at 95ºC for from 5 to 15 min, snap-cooled on ice, and 4 to 6 ul was loaded in each well. Gels were vacuum-dried and exposed to auto-radiographic film with an intensifying screen for 1 to 4 days at -80ºC. Each gel contained 1 to 4 control samples run on all gels and alleles were scored relative to an M13 sequencing ladder.

Finally, we also amplified four segments of the mitochondrial DNA genome (cytochrome *b*, dloop, NADH-5, NADH-6) totaling 4.6 kilobases in size (about one-third of the mtDNA genome size) using primers and procedures outlined in Redenbach and Taylor (1999). These mtDNA from 10 fish from each of the four populations were incubated with 11 restriction enzymes (*Alu* I, *Ava* II, *Bfa* I, *Hae* III, *Hin*f, I *Msp* I, *Mbo* I, and *Nla* III to try and resolve mtDNA restriction site differences with greater resolution than in the "whole-molecule" mtDNA assays of Taylor et al. (1997).

Data Analysis

Microsatellite allele frequencies at individual loci were examined for departures from Hardy-Weinberg equilibrium within populations and for departures from linkage-disequilibrium between loci using GENEPOP (Version 3.1, Raymond and Rousset 1995). Pairwise differences among populations in allele frequencies were tested using the permutation procedure in GENEPOP. All tests involving multiple pair-wise statistical tests incorporated the sequential Bonferroni correction (Rice 1989) to guard against inflated Type I Error rates. Microsatellite variation was partitioned in a hierarchical fashion using analysis of molecular variance as implemented in Arlequin (Schneider et al. 1997). These data were examined using both numbers of alleles (*Fst*) assuming an infinite alleles model of mutation as well as incorporating the size differences among alleles (*Rst*) assuming a stepwise mutation model.

We used theoretical relationships between Fst and number of migrants (Nm) and *Rst* and Nm to estimate demographic exchange amongst populations and ecotypes. Use of F-statistics to indirectly estimate gene flow among populations makes assumptions that are likely violated in most natural populations (Whitlock and McCauley 1999; Bossert and Prowell 1998) and we view our estimates of value only in terms of relative comparisons. We also utilized the microsatellite allele frequencies to test for evidence of recent bottlenecks in Okanagan Lake using the "mode-shift" test as implemented in BOTTLENECK (Cornuet and Luikart 1997). Populations that have undergone recent bottlenecks are expected to show a reduction in the proportion of low frequency alleles relative to alleles of moderate abundance. Recent bottlenecks are those that have occurred within 40-80 generations and the mode shift test assumes that the populations are in mutation drift equilibrium and are independent of the mutation model (IAM or SMM) for microsatellite loci (Luikart et al. 1998). The detection of recent bottlenecks in Okanagan Lake kokanee may be especially important. Population so affected may not have had time to adapt to potential problems imposed by small population sizes and may signal populations at risk of losing heteozygosity or variation at quantitative loci affecting fitness over the longer term (Luikart et al. 1998).

Beach spawning kokanee are difficult to enumerate on the spawning grounds because of water conditions during their relatively late spawning period and also due to poor understanding of their spawning behaviour. Consequently, alternative estimates of the relative abundance of the two spawning ecotypes are desirable for management purposes. Mid-water trawl samples are taken annually in the lake to estimate the abundance of juvenile kokanee (see Sebastian and Scholten 1999 *in:* Ashley et al. 1999). The apparent lack of morphological, allozyme, mtDNA, or minisatellite DNA differention between ecotypes (Taylor et al. 1997) makes the assignment of relative proportions of the two ecotypes in the mid-water trawl catch problematic. To assess the utility of microsatellite variation in discriminating between beach and stream spawning kokanee we used the assignment test of Paetkau et al. (1995) to assign individual kokanee to spawning ecotype based on their multilocus genotype. We used the online calculator (see http://gause.biology.ualberta.ca/jbrzusto/ Doh.html) to perform the assignment tests.

We also used the program "WHICHRUN" (available from M. Banks and W. Eichert, Bodega Bay Marine Laboratory, Bodega Bay, CA) to assign simulated "unknown" samples to beach or stream spawning ecotype. This analysis employs a maximum-likelihood algorithm similar to that of the assignment test, but explicitly calculates allele frequencies from a baseline of known fish identity. Using the multilocus genotypes of the baseline fish, individuals from a sample of unknown identity are identified by maximum-likelihood compared to one of the baseline set of populations.

In addition, jacknifing of the baseline samples was performed. Jacknifing entails classification of all individuals in the baseline file to one of the baseline populations after removing the individual that is being classified from the baseline "earning" sample. In this way, classification rates are not biased upwards by classifying individuals used to generate the learning genotype profiles. We also generated simulated mixture data sets by randomly sampling 15 individual kokanee from the learning data set and using the WHICHRUN analysis to assign these "unknowns" to beach or stream spawning ecotype. We conducted 15 such tests to determine the variability in the performance of WHICHRUN given the allele frequency distribution. The assignment and jacknife WHICHRUN tests attempt to correctly classify individual kokanee. The WHICHRUN mixture analysis is not concerned with correct identification of individual fish but rather attempts to characterize the sample as a whole as to the proportional representation of groups from the baseline sample.

RESULTS

Thermal Regimes at Natural Spawning Sites

Sub-gravel temperature profiles were obtained at five spawning sites: Mission, Peachland, and Powers creeks and three beach spawning sites (OKNE, OKNW, and OKSE Map 2). These data indicated that all sites went through a general decline in water temperature from the onset of spawning from about late September and mid-October for stream and beach spawners, respectively. Water temperatures decreased from about 12 to 16ºC down to 0 to 3ºC in December or January, followed by a gradual rise to 3 to 7ºC by mid-April, 1998. Beach spawning sites, however, did not begin the gradual autumnal decline in water temperature until about 1 month after the same decline commenced in stream spawning sites. Notably, water temperature during spawning and incubation (September 16 to April 16 for stream spawners; October 16 to April 16 for beach spawners) was, on average, higher at beach spawning sites (6 vs 3.5ºC). Despite spawning about one month *later* than stream spawning kokanee, beach spawning kokanee experience *more* accumulated thermal units over the six month period from October 16 to April 16 than stream spawning kokanee over a seven month period from September 16 to April 16 (Fig. 1).

Developmental Biology

Beach spawning kokanee were significantly smaller than kokanee sampled from the two stream spawning sites (Table 1). Beach spawning females had smaller eggs than stream spawners although only the difference between Peachland Creek and Paul's Tomb kokanee was significant (Tukey's test, P = 0.01). Stream spawning kokanee took approximately 690 ATUs (accumulated thermal units) to achieve 50% hatch (Fig. 2) with Mission Creek fish being slightly slower developers (mean of 706 ATU) than those from Peachland Creek (mean of 674 ATUs).

Kokanee from the beach spawning site were intermediate in hatching rate, requiring an average 680 ATUs for 50% hatching (Fig. 2). Families with larger eggs hatched faster than those with smaller eggs (r = -0.26) although the correlation was not statistically significant (P > 0.05). There was a significant effect of population on ATUs to 50% hatch after removing the effect of egg size variation (P = 0.024), but there were no consistent differences between stream spawners and beach spawners. Rather, Mission Creek kokanee had significantly slower hatching rates than both Paul's Tomb and Peachland Creek kokanee (Tukey's test, minimum P = 0.04). The slower hatching rate of Mission Creek kokanee appeared to be largely driven by the responses of five families of which three had amongst the smallest egg sizes (Fig. 2).

Table 1. Mean (N, SE) fork length (in cm) of male and female Okanagan Lake kokanee and mean (N, SE) egg weight (in mg) from females used in experimental crosses.

Population	**Fork length**	**Egg weight**
Paul's Tomb	22.8 (79, 0.12)	43.3 (11, 2.5)
Mission Cr.	26.5 (60, 1.0)	49.8 (10, 4.7)
Peachland Cr.	32.4 (43, 0.54)	61.3 (10, 4.7)

Kokanee from the beach spawning site appeared to have slightly, but significantly faster developmental rate from hatching to "emergence". This was assessed by measuring the extent of yolk reserves remaining after a set time of incubation (1,000 ATUs). At this time, beach spawning kokanee had an average of 7.8% (SE = 0.62, N = 10 families) of their yolk remaining while stream spawners had averages of 14.2% (SE = 1.3, N = 9) and 11.4% (SE =1.4, N = 8) yolk remaining for Peachland and Mission creeks, respectively ($P < 0.001$). Because egg size and yolk remaining at 1,000 ATU were positively correlated ($r = 0.68$, $P < 0.001$), the differences in yolk absorption rate between beach and stream spawners were probably, to a great extent, driven by form-based differences in egg size. When the differences in yolk remaining were adjusted for differences in initial egg size by ANCOVA, however, significant differences in developmental rate to 1,000 ATU remained; Peachland Creek kokanee had more yolk remaining than did kokanee from either Mission Creek or the beach-site at Paul's Tomb (Tukey's test, $P = 0.018$).

Molecular Analyses

A total of 8 microsatellite loci have been being investigated for their level of variation in Okanagan Lake kokanee: *Ssa* 85, *Omy* 77, *One* 2, *One* 8, *One* 14, *Ots*3, 100 and *Ots* 103. Of 40 tests of deviations from Hard-Weinberg equilibrium, two indicated significant departures (Table 3). All pair-wise comparisons between loci did not deviate significantly from expectations for loci in linkage equilibrium (min $P = 0.03$, non-significant after adjusting for multiple comparisons) indicating that all loci act as independent measures of genetic diversity within and between populations. Stream and beach spawning fish had significantly distinct allele frequencies at two loci (*SSa* 85 and *Ots* 3, both $P < 0.05$, e.g. Figs. 4, 5). Across all 8 loci combined the degree of genetic differentiation between ecotypes was highly significant ($P < 0.0001$). The value of Fst at the seven loci ranged from 0.001 (*One* 2) to 0.04 (*Ssa* 85 and {*Ots* 3) with a mean across all loci of 0.02 ($P < 0.005$). This indicates that 2% of the total variation can be attributed to differences between spawning ecotypes which is small, but over twice as great as that reported for allozymes and minisatellite DNA (Taylor et al. 1997). Using combined allele frequencies across the 8 loci, resulted in five significant differences of which four involved inter-ecotype comparisons (Table A.3).

Table 2. Locus name, source species, reference, total alleles observed (Na), sample size (N), molecular size range (in base pairs), and total expected heterozygosity for 8 microsatellite loci assayed in kokanee.

Locus	Source species	Reference	Annealing Temp.	Na	N	Size Range (bp)	He
Ssa 85	Atlantic salmon	O'Reilly et al. (1996)	58	16	96	88-128	0.87
Omy 77	Rainbow trout	Morris et al. (1996)	56	6	90	54-72	0.49
One 2	Sockeye salmon	Scribner et al. (1996)	60	5	100	204-260	0.60
One 8	Sockeye salmon	Scribner et al. (1996)	60	9	100	154-180	0.61
One 14	Sockeye salmon	Scribner et al. (1996)	52	8	100	92-112	0.49
Ots 3	Chinook salmon	D. Hedgecock, unpubl.	52	6	87	50-62	0.73
Ots 100	Chinook salmon	J. Nelson, unpublished	58	10	82	130-164	0.76
Ots 103	Chinook salmon	J. Nelson, unpublished	55	23	98	84-184	0.91

When the molecular variance is apportioned hierarchically using AMOVA, the vast majority of variation resides either within individual populations (92.5% for *Rst* to 96% for *Fst*) or among populations within spawning ecotype (10.5% for Rst, $P<0.02$; 3.1% for *Fst*, $P<0.001$). In fact, there is no significant variance attributable to spawning ecotype once variation within ecotypes is accounted for (-3.1% for *Rst*, $P = 0.64$ to 2% for *Fst*, $P = 0.09$). Gene flow estimates ranged from 6 to 12 and 24 to 75 individuals per generation between populations *within* stream and beach spawners, respectively to 7 to 10 individuals per generation *between* ecotypes.

A UPGMA clustering analysis of genetic distances (Fig. 6) suggested that Mission Creek kokanee may be somewhat intermediate, based microsatellite allele frequencies, between beach spawners and stream spawners from Peachland and Powers creeks, the latter of which appeared quite distinct from beach spawners.

Table 3. Sample sizes (N), numbers of observed alleles (Na), and expected (He) and observed (Ho) heterozygosities per locus and per kokanee population assayed. PC = Powers Creek, PEC = Peachland Creek, MC = Mission Creek, SP = Squally Point, OK = Okanagan Centre.

Locus	PC	PEC	MC	SP	OK	Mean
Ssa 85						
N	20	18	21	19	20	19.6
Na	11	8	12	10	6	9.4
He	0.82	0.84	0.85	0.81	0.75	0.81
Ho	0.83	0.77	0.86	0.58	0.7	0.74
Omy 77						
N	20	20	21	19	20	20.1
Na	6	5	5	5	5	5.2
He	0.6	0.54	0.68	0.37	0.45	0.53
Ho	0.6	0.75	0.53	0.36	0.5	0.55
One 2						
N	19	20	20	20	20	19.8
Na	3	4	3	3	4	3.4
He	0.56	0.64	0.68	0.52	0.48	0.67
Ho	0.47	0.6	0.52	0.6	0.6	0.56
One 8						
N	20	20	18	20	20	19.6
Na	6	7	4	5	5	5.4
He	0.62	0.59	0.54	0.6	0.58	0.59
Ho	0.48	0.3	0.35	0.35*	0.35	0.36
One 14						
N	20	18	18	18	18	18.4
Na	5	4	7	5	6	5.4
He	0.4	0.25	0.61	0.41	0.66	0.47
Ho	0.47	0.22	0.81	0.38	0.69	0.51
Ots 3						
N	20	18	18	18	18	18.5
Na	5	5	5	6	6	5.4
He	0.82	0.78	0.68	0.64	0.55	0.69
Ho	0.95	0.67	0.64	0.69	0.56	0.7
Ots 100						
N	19	18	20	18	20	19.8
Na	7	9	6	6	6	6.8
He	0.77	0.69	0.64	0.7	0.73	0.71
Ho	0.55	0.35*	0.75	0.89	0.75	0.66
Ots 103						
N	20	19	20	20	19	19.6
Na	12	16	15	15	14	14.4
He	0.89	0.91	0.9	0.88	0.9	0.9
Ho	0.8	0.99	0.95	0.8	0.89	0.89

* $P < 0.05$ (Bonferroni-corrected alpha for 8 within population simultaneous tests of HWE).

We subjected the allele frequency data within each population to the "mode-shift" test for recent bottlenecks. All populations showed "normal" shaped frequency distributions with no indication of recent bottlenecks.

Finally, we have also scored 10 fish from each of the 5 sample sites for restriction site variation in four regions of the mitochondrial DNA genome. This analysis used PCR amplified products from the d-loop, and cytochrome b, NADH 5, and NADH 6 genes that were cut with 11 enzymes. We resolved eight haplotypes (versus four haplotypes for whole molecular assays *in*: Taylor et al. 1997) with strong heterogeneity between spawning ecotypes (P = 0.017, Table 4).

Table 4. Mitochondrial DNA composite PCR/RFLP haplotypes in Okanagan Lake kokanee. composite haplotypes represent restriction site profiles for *Alu* I, *Ava* II, *Bfa* I, *Hha* I, *Hae* III, *Hin*f I, *Msp* I, *Mbo* I, *Nla* III, and *Rsa* I, respectively.

	Peachland Creek	**Powers Creek**	**Mission Creek**	**Okanagan Centre**	**Squally Point**
Haplotype					
AAAAAAAAAA	7	6	7	6	1
AAAAAAAABB				2	
AAAABABAAA					1
AAAAAAAABA	4	3	2	2	2
AAAABAAAAA					1
AAAAAABAAA					3
AAAAAABABA					2
AAAAAAAAAB				1	

Mixture Analyses

The "assignment test" procedure of Paetkau et al. (1995) was employed to see how well microsatellite loci might be able to identify individual fish from either beach or stream spawning populations. This procedure calculates the probability of an individual being from each of several populations based on its multi-locus genotype and the allele frequencies of the reference populations. The individual being examined is assigned to the population for which this probability is highest. Using this procedure, stream spawners were correctly identified 62% of the time while beach spawners were correctly identified 73% of the time. The greater success of beach spawner identification appeared to be due to the generally greater distinctiveness of Okanagan Centre kokanee (90% classification success versus only 5% success for Squally Point beach spawners). Using WHICHRUN, success was slightly lower with between 67% and 65% of individuals correctly classified for stream and beach spawners, respectively.

The WHICHRUN analyses, however, were able to selectively test loci for their discriminatory ability and comparable classification success was achieved using only 4 of the 8 loci (*Ssa* 85, *Omy* 77, *Ots* 3 and *Ots* 103). Further, in terms of proportional analysis (i.e., determining the proportion of each spawning type in a mixture without regard to the identity of individual fish per se), WHICHRUN analyses suggested there is good potential for microsatellite loci in mixed population assessment. In 15 different simulations of 15 fish each, WHICHRUN was able to predict the proportional representation of stream and beach spawning fish quite accurately. Using these same four loci both averaged across the 15 tests as well as within most of the individual simulations the predicted and actual proportions of spawning ecotypes in the mixed samples averaged within 1% of each other and the actual mixture (Fig. 7).

DISCUSSION

Developmental Biology

The results of the developmental rate experiment demonstrated no consistent differences between spawning ecotypes in time to hatching; Paul's Tomb kokanee were intermediate in ATUs required for 50% hatch with Mission Creek kokanee eggs slowest to 50% hatch and, Powers Creek kokanee the fastest. In our experiment variability in time to hatching appeared to be strongly influenced by egg size. Possibly the faster hatching of larger eggs is related to the presumably greater physical strength of larger embryos contained within larger eggs as well as the smaller surface area to volume ratio of larger eggs. This difference should make larger egg embryos easier to breach than in smaller eggs. Because beach spawning kokanee are smaller than stream spawners (this study, Taylor et al. 1997) hence smaller egg size, it is possible that larger sample sizes may yield a consistent trend towards slower hatching in beach spawning kokanee i.e., due to their smaller egg sizes.

Our data showed a more consistent difference between ecotypes in developmental rate from hatching to "emergence" (defined as 1,000 ATUs). Beach spawning kokanee have less yolk reserve at this point than did fish from the stream spawning areas. There was, however, considerable variation among females within ecotypes, which appeared to be largely driven by female-based differences in egg size. Again, these differences appear related to ecotype-based differences in egg size. Time to emergence was negatively correlated with egg size within ecotypes and stream spawning female kokanee tend to have larger eggs. There was also some evidence of differences in developmental rate that were independent of egg size differences because Peachland Creek kokanee still had the greatest amount of yolk remaining even after statistically adjusting for initial differences in egg size.

In general, our data suggest that there are broad, ecotype-level differences in developmental biology in Okanagan Lake kokanee. These differences may, however, stem largely from ecotype-based differences in egg size which themselves likely result from the smaller size of female kokanee that spawn on the beaches. Whether such differences in developmental rate are pleiotropic responses to adaptive variation in egg size or simply plastic responses to phenotypically-based differences in the body size-egg size relationship cannot be determined without more extensive experimentation.

Although beach spawning kokanee begin spawning about one month later than peak spawning in streams, their temperature profiles (later decline, higher average temperature) indicate they experience more ATUs after six months of incubation (mid-October to mid-April) than do stream spawning kokanee over seven months (mid-September to mid-April). Consequently, divergent selection on developmental rate between beach and stream spawning kokanee may be weak or non-existent because rate compensation in later-spawning kokanee on beaches is not necessary given the generally higher water temperatures at beach spawning sites. In fact, spawning time may be the real focus of divergent selection. For example, if there is an optimal time for emergence and fry out-migration based on timing of spring plankton production Okanagan Lake kokanee may have diverged in spawning time with later spawning being favoured in warmer beach habitats and earlier spawning favoured in colder, stream habitats. It would be very interesting to conduct controlled studies of development in terms of maturation schedules to test this hypothesis.

Molecular Analyses

The microsatellite analysis revealed substantial levels of genetic variation in Okanagan Lake kokanee. Average heterozygosity values across the 8 loci were comparable to values reported for microsatellites (including two of the same loci) assayed in sockeye salmon in Alaska and British Columbia (Allendorf et al. 1998, unpublished MS, Beacham et al. 1998). In four Bristol Bay sockeye salmon populations, Fst values ranged from 0.100 - 0.190 (Allendorf et al. 1998), values substantial higher than observed for Okanagan Lake kokanee. The greater level of subdivision in Alaskan sockeye likely stems, in large part, to the greater geographic range of populations sampled in Alaska (three distinct lake drainage systems in Cook Inlet, 50 to 300 km apart). Nevertheless, substantial variation was found in microsatellite allele frequencies among populations of Okanagan Lake kokanee, but only about 2% could be attributable to difference between stream and beach spawning ecotypes. This low degree of divergence probably reflects the post-glacial origin of ecotypes within Okanagan Lake (Taylor et al. 1997). Future work will emphasize increased sample size to refine our estimates of divergence between ecotypes.

To date, our microsatellite assays (and further mtDNA work) corroborate our earlier mitochondrial data (Taylor et al. 1997) that indicated significant restrictions in gene flow between beach and stream spawning components of the Okanagan Lake kokanee system. This implies that the ecotypes are demographically and genetically independent and must be treated as distinct management units for conservation. In particular, the microsatellite variability, while subtle, appears to offer great potential for classifying juvenile kokanee in the limnetic zone as to the relative contributions of beach and stream spawning kokanee to juvenile populations. Although the number of simulations was low, WHICHRUN was able to accurately (about 1% error rate) predict the composition of simulated mixtures based on multilocus genotypes across four loci.

Although the overall differentiation between ecotypes was low (i.e., about 2%), the dendrogram (Fig. 6) indicated relatively higher levels of divergence between the two beach spawning populations and Powers and Peachland creek kokanee. Mission Creek kokanee appeared somewhat intermediate which likely limited the resolution of ecotype-based divergence in our AMOVA analyses, but could still result in higher levels of resolution in the mixture analysis as they were to some extent also resolvable from the beach spawning kokanee (Fig. 6).

FUTURE WORK

Our research is continuing with the analysis of samples collected during the fall of 1997 from two stream and one beach spawning sites. Microsatellite analyses for these samples will be completed by the spring of 1999 and will be used to: (i) increase the baseline samples for mixed population analyses to a total of approximately 140 stream spawners and 80 beach spawners, and (ii) assess temporal stability in microsatellite allele frequency distributions. In addition, we will examine a sample of 50 juvenile kokanee collected by mid-water trawl to classify a truly unknown mixed sample as to the proportion of stream- and beach spawner in a juvenile sample.

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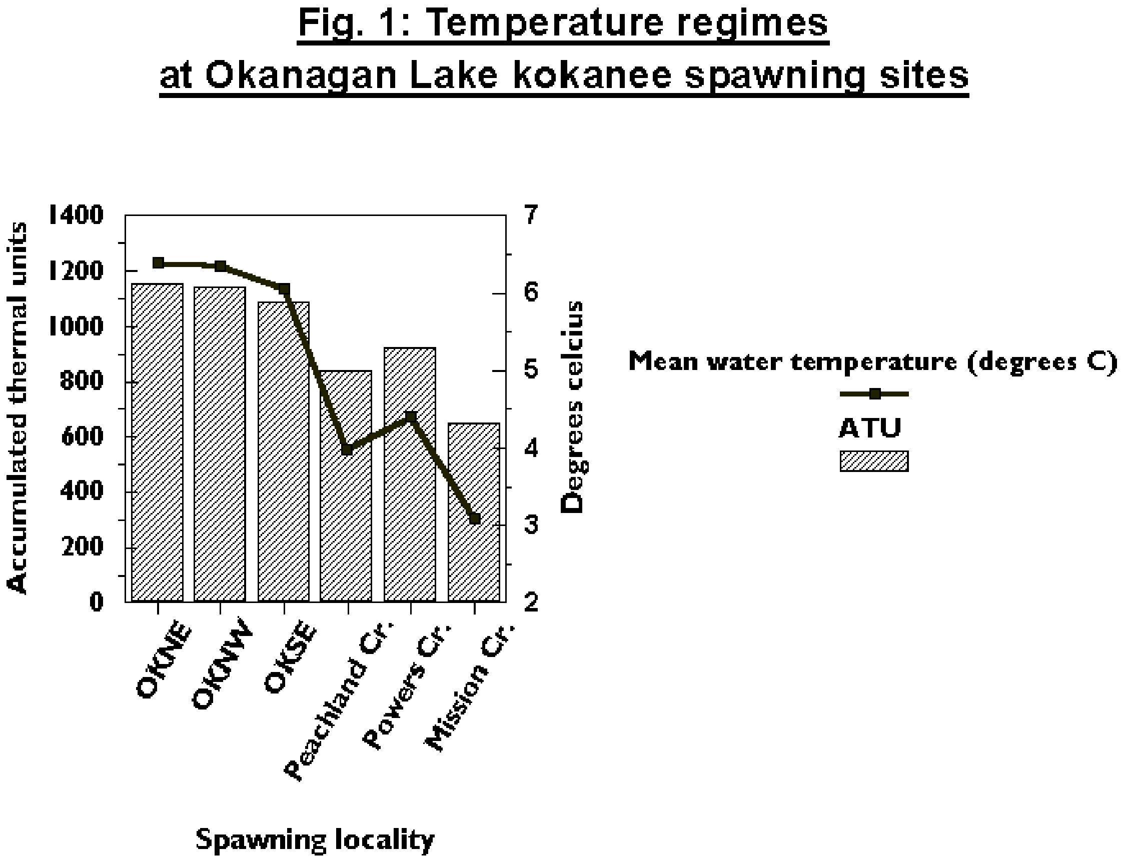


Figure 1. Average sub-gravel water temperatures and accumulated thermal units for stream and beach spawning sites in Okanagan Lake. Water temperatures were recorded hourly and represent the period September 16 to April 16 for Peachland and Powers creeks and from October 16 to April 16 for the Okanagan NE, NW, and SE beach spawning sites. Accumulated thermal units are the product of average water temperature X 180 days for beach sites and 210 days for stream sites. Data for Mission Creek provided by P. Dill (Okanagan University College, Kelowna, BC).

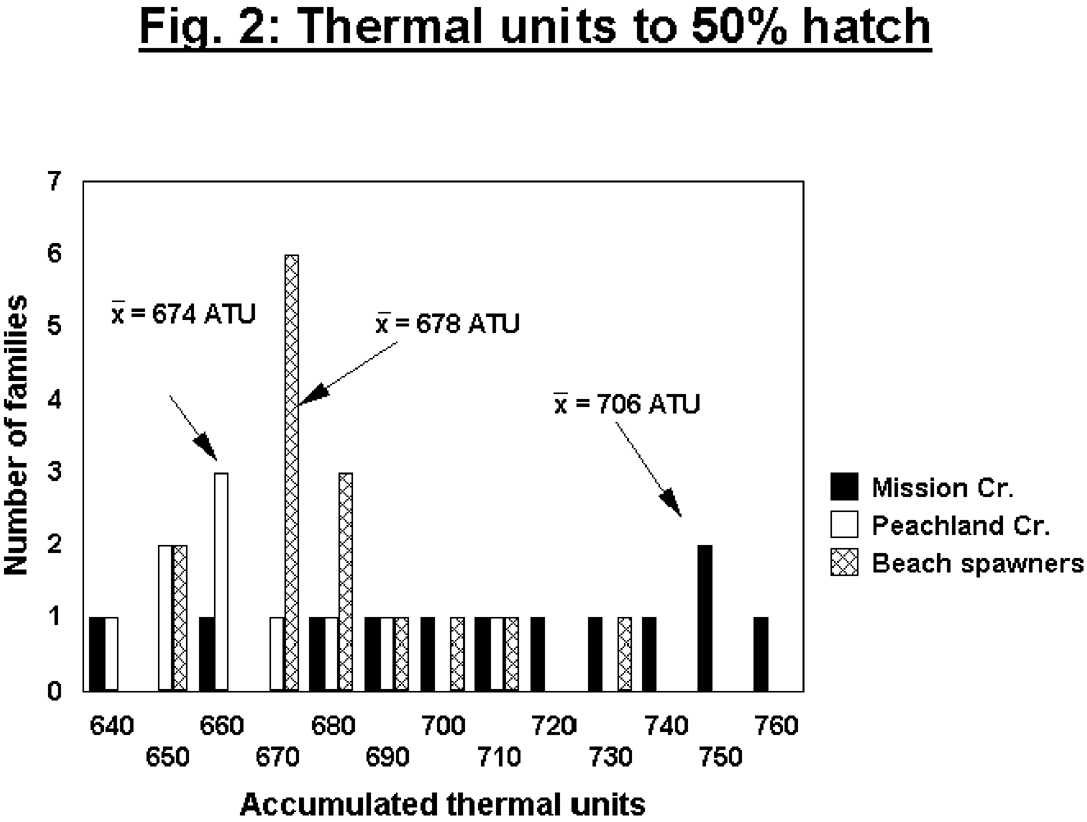


Figure 2. Accumulated thermal units (degree days) to 50% hatch for individual families of kokanee from Mission Creek, Peachland Creek, and Paul's Tomb (beach spawning site) incubated at 8ºC.

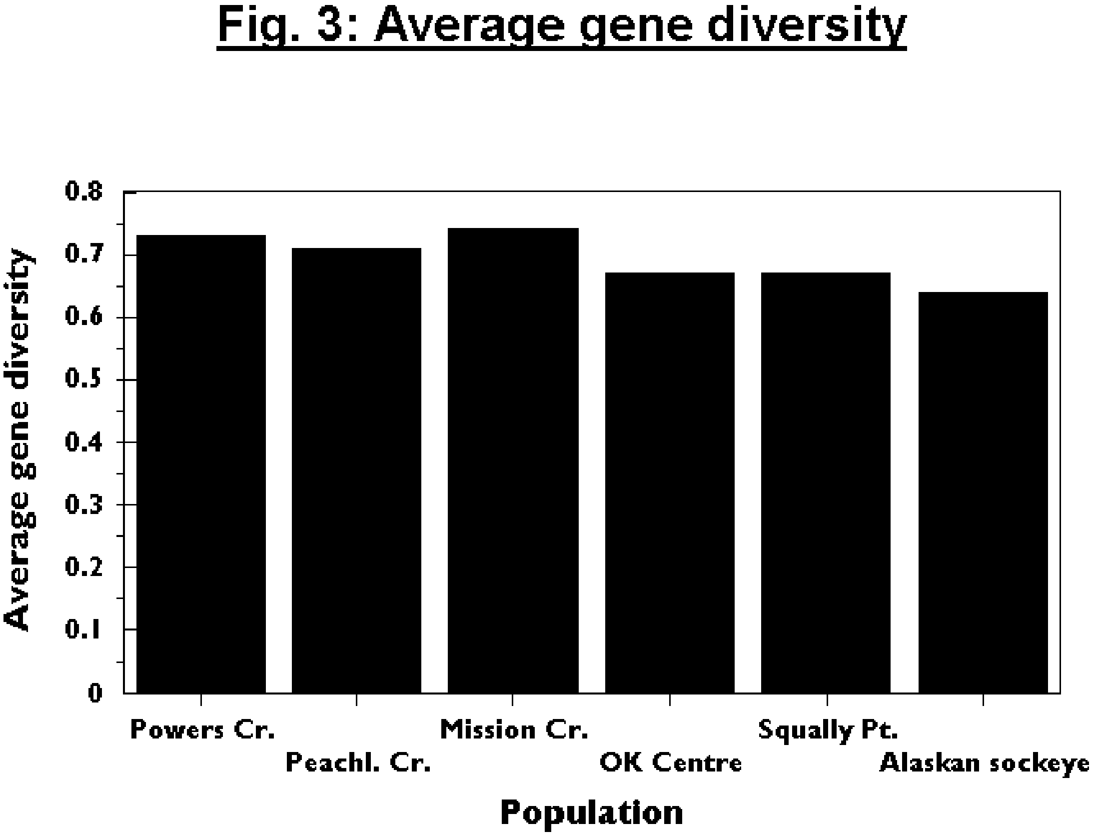


Figure 3. Average gene diversity (expected heterozygosity) pooled across loci for eight bull trout populations. Also shown is the gene diversity across four loci for four Alaskan sockeye salmon populations.

Fig. 4: *Ots* 3 Allele Frequency Stream and Beach Spawners

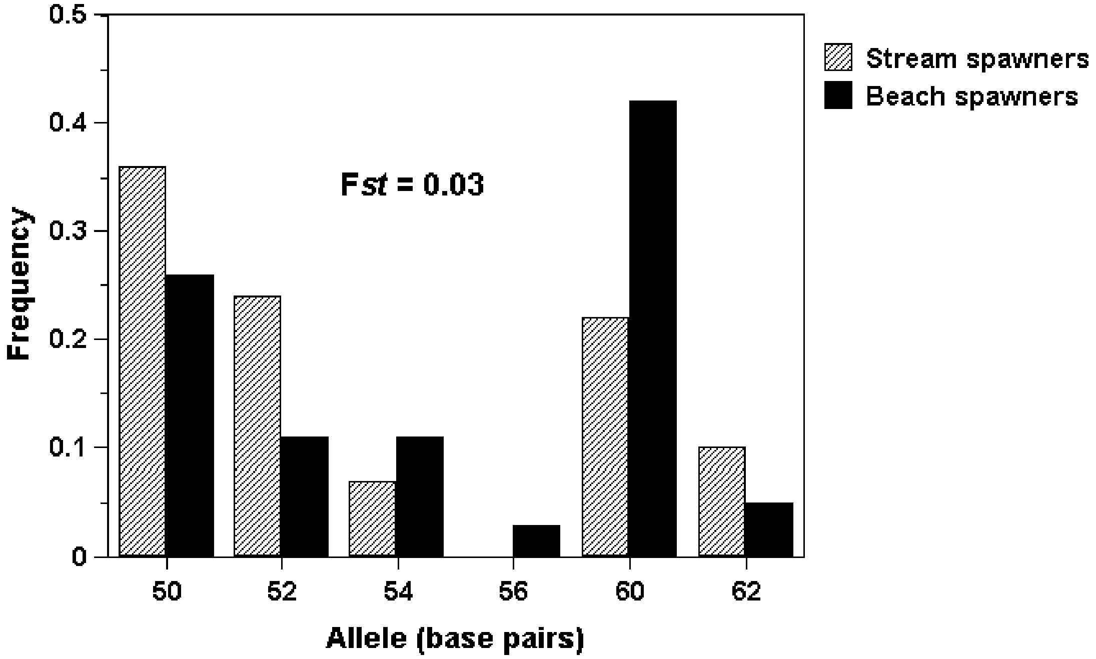


Figure 4. Allele frequencies at *Ots* 3 between beach and stream spawning kokanee in Okanagan Lake.

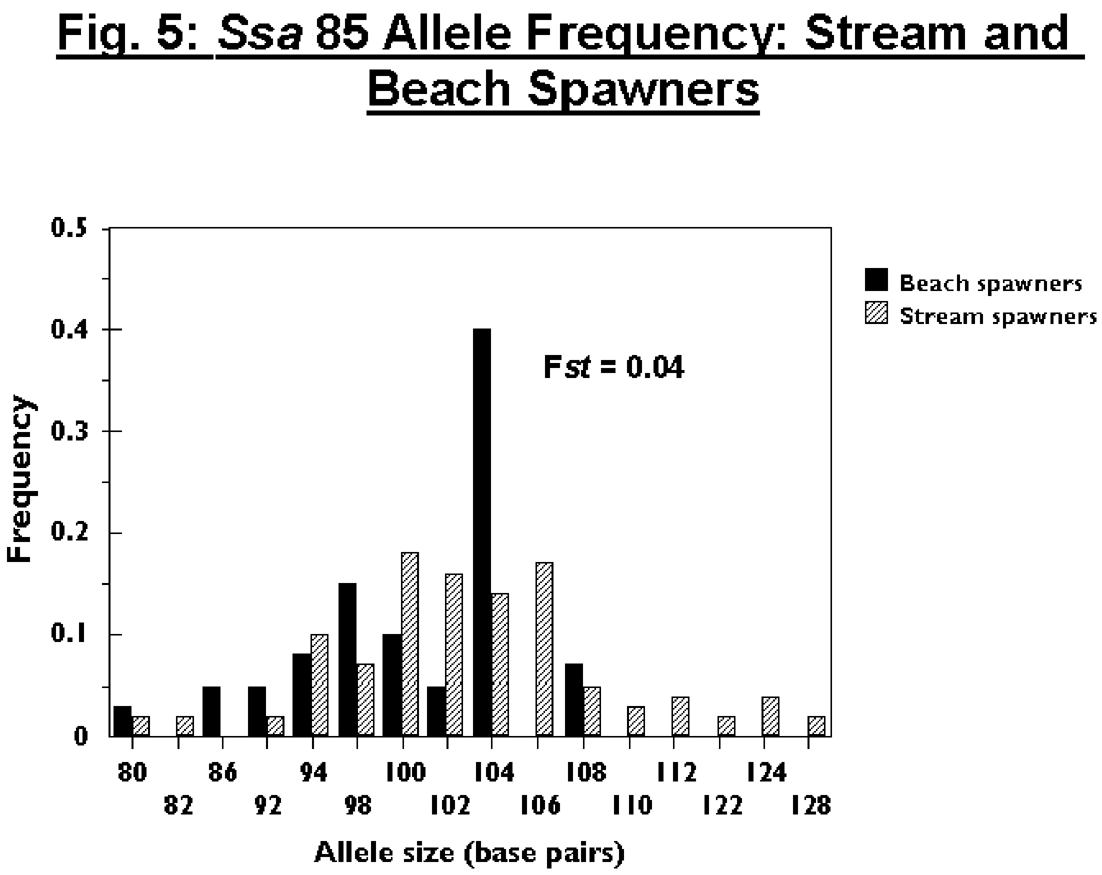


Figure 5. Allele frequencies at *Ssa* 85 between beach and stream spawning kokanee in Okanagan Lake.

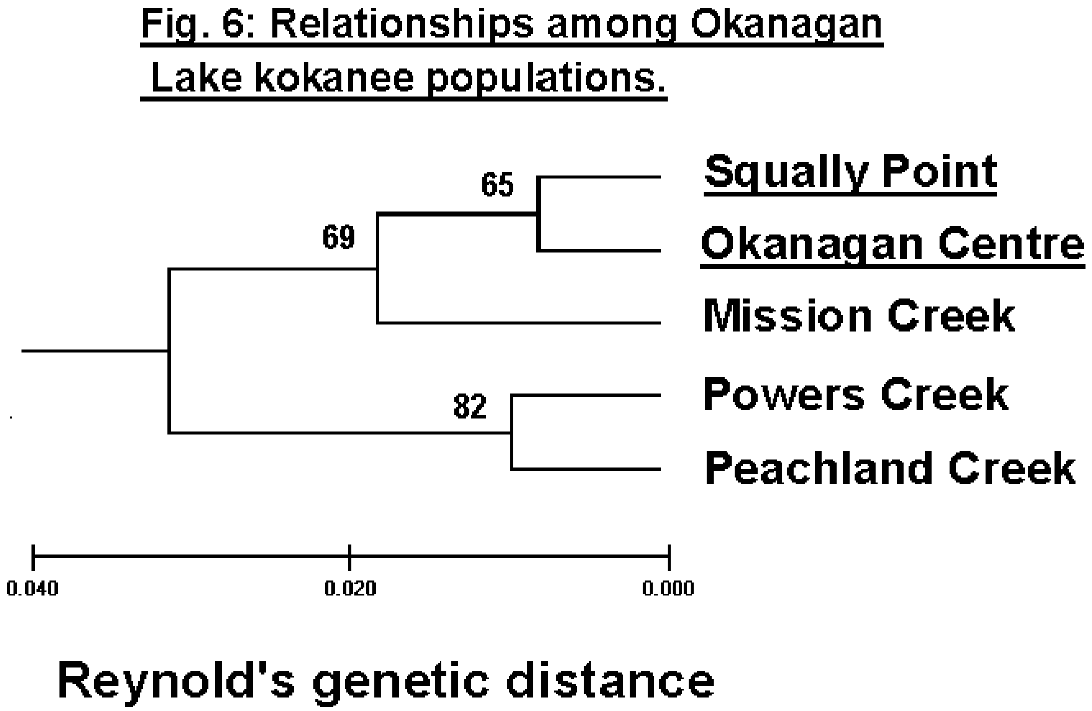


Figure 6. UPGMA dendrogram of relationships among five kokanee populations sampled. Dendrogram was derived by clustering estimates of Reynold's genetic distance derived from assays at 8 microsatellite loci. Bootstrap support scores (out of 1,000 trees) are given at branch points. Beach spawning kokanee populations are underscored.

Fig. 7: Mixture analysis of kokanee ecotypes

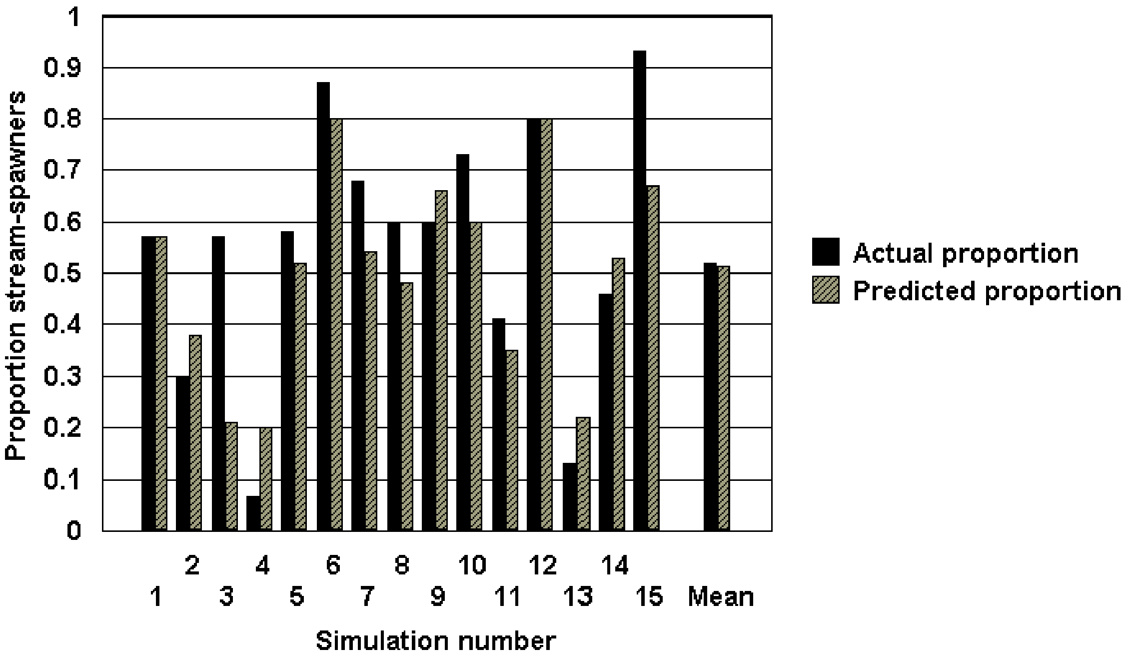


Figure 7. Results of mixture analysis for kokanee from Okanagan Lake. Shown are the actual and predicted proportions of stream spawning kokanee in fifteen simulated mixtures each consisting of 15 randomly selected kokanee. The mean and standard deviation of all fifteen simulations is indicated. The mixture sample was derived from a baseline sample of approximately 60 stream spawners and 40 beach spawners. The mixture analysis is based on allelic variation at four microsatellite loci *Omy* 77, *Ssa* 85, *Ots* 3, and *Ots* 103.

A.1. Allele frequencies at 8 microsatellite loci in 5 kokanee populations from Okanagan Lake.

Locus: SSA85

Pop	Alleles	N																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		
POWERS	20	0	0	0	0.028	0.111	0.139	0.028	0.333	0.111	0.111	0.056	0.028	0.028	0	0	0.028	18
PEACHL	22	0	0	0	0	0.111	0.111	0.194	0.111	0.194	0.194	0.056	0	0	0.028	0	0	18
MISSUP	7	0.024	0.024	0	0	0.119	0.048	0.286	0.095	0.071	0.167	0.024	0.024	0.048	0	0.071	0	21
SQUALL	22	0.026	0	0	0.026	0.132	0.026	0.184	0.132	0.316	0	0.053	0	0	0.026	0.079	0	20
OKCENT	73	0	0	0.1	0	0	0.3	0.15	0.05	0.35	0	0.05	0	0	0	0	0	20

Locus: OMY77

Pop	Alleles	N						
	1	2	3	4	5	6		
POWERS	20	0.025	0.55	0.025	0.3	0.075	0.025	20
PEACHL	22	0.025	0.575	0	0.35	0.025	0.025	20
MISSUP	7	0	0.818	0	0.182	0	0	22
SQUALL	22	0	0.763	0.026	0.211	0	0	19
OKCENT	73	0.075	0.7	0	0.225	0	0	20

Locus: ONE08

Pop	Alleles	N									
	1	2	3	4	5	6	7	8	9		
POWERS	20	0.053	0.079	0.632	0.079	0	0.026	0	0.132	0	19
PEACHL	22	0	0.2	0.55	0.1	0.025	0	0.025	0.075	0.025	20
MISSUP	7	0	0.19	0.476	0.167	0	0	0.167	0	0	21
SQUALL	22	0	0.2	0.65	0.025	0	0	0.075	0.05	0	20
OKCENT	73	0	0.125	0.7	0.1	0.025	0	0	0.05	0	20

Locus: ONE2

Pop	Alleles	N					
	1	2	3	4	5		
POWERS	20	0	0.475	0.35	0.175	0	20
PEACHL	22	0.05	0.3	0.55	0.1	0	20
MISSUP	7	0	0.475	0.475	0.05	0	20
SQUALL	22	0	0.275	0.525	0.2	0	20
OKCENT	73	0	0.325	0.55	0.1	0.025	20

Locus: ONE14

Pop	Alleles	N								
	1	2	3	4	5	6	7	8		
POWERS	20	0.079	0	0.026	0.079	0.763	0	0	0.053	19
PEACHL	22	0.056	0	0	0.028	0.861	0.056	0	0	18
MISSUP	7	0.125	0.031	0	0.063	0.594	0.125	0.031	0.031	21
SQUALL	22	0.056	0.028	0	0.083	0.75	0.083	0	0	18
OKCENT	73	0.063	0.031	0	0.156	0.531	0.063	0	0.156	20

Locus: OTS100

Pop	Alleles	N										
	1	2	3	4	5	6	7	8	9	10		
Powers	20	0.1	0	0.3	0	0	0.1	0.1	0.15	0.175	0.075	20
PEACHL	22	0.056	0	0.417	0.111	0.028	0.111	0.056	0.056	0.111	0.056	18
MISSUP	7	0	0.036	0.464	0	0	0.071	0.036	0.286	0	0.107	23
SQUALL	22	0.125	0	0.563	0	0	0	0.031	0.094	0.063	0.125	18
OKCENT	73	0.056	0	0.639	0	0	0.056	0.028	0.194	0	0.028	19

Locus: OTS3

Pop	Alleles	N						
	1	2	3	4	5	6		
POWERS	20	0.25	0.361	0.028	0	0.222	0.139	20
PEACHL	22	0.464	0.25	0.143	0	0.071	0.071	20
MISSUP	7	0.417	0.042	0.042	0	0.417	0.083	19
SQUALL	22	0.194	0.139	0.111	0.028	0.472	0.056	19
OKCENT	73	0.325	0.1	0.125	0.025	0.375	0.05	20

Locus Ots 103

Pop	Alleles	N																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23		
POWERS	20	0	0.05	0	0	0	0	0	0	0.025	0.05	0	0.025	0.1	0.125	0.075	0.1	0.2	0.1	0.075	0	0.075	0	0	20
PEACHL	22	0	0.053	0.053	0.026	0	0.026	0	0	0.026	0.053	0	0.079	0.053	0.053	0.026	0.105	0.132	0.105	0.132	0	0.053	0.026	0	19
MISSUP	7	0	0.025	0	0.05	0.025	0.025	0.025	0	0	0.025	0.025	0	0.05	0.1	0.125	0.125	0.075	0.175	0.125	0.025	0	0	0	20
SQUALL	22	0.025	0	0	0.025	0	0.025	0.05	0.025	0	0.025	0	0.025	0.025	0.125	0.175	0.125	0.2	0.1	0.025	0	0.025	0	0	20
OKCENT	73	0	0	0	0.026	0	0	0.026	0.026	0	0.026	0	0.132	0.079	0.026	0.158	0.158	0.105	0.079	0.079	0	0	0.053	0.026	19

A.2 Note: Loci in tables above have been renamed.
(For each locus: first line = new names; second line = old names in base pairs)

Locus: SSA85

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
80	82	86	92	94	98	100	102	104	106	108	110	112	122	124	128

Locus: OMY77

1	2	3	4	5	6
54	60	62	66	68	72

Locus ONE08

1	2	3	4	5	6	7	8	9
154	156	162	164	166	170	172	174	180

Locus ONE2

1	2	3	4	5
204	228	236	238	260

Locus ONE14

1	2	3	4	5	6	7	8
92	96	98	100	106	108	110	112

Locus OTS100

1	2	3	4	5	6	7	8	9	10
130	132	134	140	144	150	154	156	160	164

Locus OTS3

1	2	3	4	5	6
50	52	54	56	60	62

Locus Ots103

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
84	116	118	120	122	124	128	132	136	140	142	144	148	152	156
16	17	18	19	20	21	22	23							
160	164	168	172	174	176	180	184							

A.3 Matrix of combined probabilities of no difference between populations involved in each pairwise comparison. Tests are for allele frequency distributions combined over all 8 loci.

	Powers	**Peachland**	**Mission**	**Squally**	**Okanagan C.**
Powers	-				
Peachland	0.1711	-			
Mission	0.0001	0.0130	-		
Squally	0.0018	0.0183	0.0370	-	
Okanagan C	0.0000	0.0004	0.0005	0.0108	-

CHAPTER 5

PUBLIC COMMUNICATIONS

This component involves communication with the public on all aspects of implementation of the Action Plan. Aside from organized public meetings a great deal of coverage is afforded by means of the local media. Refer to Appendix II for examples of media coverage in 1996 and 1997.

1998 MEDIA COVERAGE OF OKANAGAN LAKE FISHERIES ISSUES

by

Steven Matthews

There was considerable media coverage on a variety of fisheries issues relating to Okanagan Lake in 1998. The more prominent issues reported on by the media are summarized below. A cross section of newspaper articles covering these issues is also included. Detailed information relating to all of these topics, with the exception of low flow impacts, is available elsewhere in this report.

Kokanee Die-offs

Two significant kokanee die-offs in Okanagan Lake in 1998 and the ensuing investigations received extensive coverage by the media. These types of events have a huge impact on the public due to their highly visual nature. Further interest was generated when a similar kokanee die-off was investigated at Skaha Lake. A total of 40 media interviews were conducted, including extensive television coverage.

Okanagan Lake Action Plan Public Meetings

Public Meetings were held throughout the Okanagan in June 1998 in order to update progress on the Okanagan Lake Action Plan and provide the public with an opportunity for input regarding future direction of the plan. Media and public attendance at these meetings was limited due to poor advertising and conflicts with other community events. A total of six media interviews were conducted.

Low Flow Impacts

Fish mortalities in some tributaries during the hot, dry summer of 1998 also generated some media interest. In one case, an irrigation district is under investigation for charges under the *Fisheries Act* for diverting all of the flow from an Okanagan Lake tributary stream that supports rainbow trout. Media coverage of this infraction has played an important role in educating water users on the need to conserve water and the importance of some small Okanagan streams for fish production. A total of 10 media interviews were conducted.

Mysis Relicta Commercial Harvest

Media coverage of a project investigating the feasibility of developing a commercial fishery for *Mysis relicta* in Okanagan Lake was extensive. The commercial shrimp trawl boat utilized for this project was highly visible and drew considerable attention. This was one of the few good news stories of 1998 due to the positive results and the opportunity it provided to show that a serious attempt to improve conditions for kokanee in Okanagan Lake was underway. A total of 18 media interviews were conducted including television coverage by CHBC-TV (Kelowna), BCTV, and Discovery Channel.

Kokanee Escapement

The drastic decline in kokanee escapement in 1998 attracted considerable media attention and provided strong justification for the ongoing investigations into the feasibility of developing a commercial fishery for *Mysis relicta*. The obvious link between the record low number of spawners and the kokanee mortality events described above was also well documented. A total of 16 media interviews were conducted.

Vernon Morning Star - Jan 19/

Okanagan fish stocks threatened

by RICHARD ROLKE
Morning Star Writer

The number of kokanee in Okanagan Lake has dropped to dangerously low levels and that means catching the fish in future could be as rare as netting the elusive Ogopogo.

The Ministry of Environment reports 1998 was a record-low year for spawning kokanee, with about 13,000 fish recorded. There were 63,000 in 1997 and 182,000 in 1992.

"We are very concerned. This took us by surprise. Things really took a decline this year," said Steve Matthews, a fisheries biologist.

"If things continue on this road and we can't do anything soon, that (extinction) is a distinct possibility."

However, Matthews believes there are still enough juvenile kokanee in the lake to turn the situation around if action is taken quickly.

"It's discouraging but we're not ready to throw up our hands and give up on it."

Among the culprits for the drastic decline are loss of habitat and mysis shrimp, a tiny creature introduced to the lake in the 1960s as a food source for the kokanee. However, the experiment back-fired and the large mysis shrimp population now compete with kokanee for other food.

"We must reduce the population of mysis in the lake and that would increase the food for kokanee," said Matthews.

A trawler plied the lake in the fall to catch mysis to see if a commercial harvest would be feasible. The matter is still being investigated and Matthews believes "the shrimp harvest may be our only option."

While some have suggested increasing kokanee stock by rearing fish in a hatchery, Matthews insists the food problem in the lake must be addressed first.

"If there is a bottleneck in the food supply, it doesn't make sense into a low survival situation."

The rising and lowering of water to control levels on Okanagan Lake and on the Okanagan River may also be impacting kokanee.

"We are trying to develop better ways of predicting inflows into the lake so we can provide a better (water) release regime that's better for the kokanee," said Matthews.

One action that remains in place is the current ban on kokanee fishing on Okanagan Lake.

In 1998, Okanagan Lake returns were about 12,000 stream spawners which is 39 per cent lower than the all-time low of 31,000 fish in 1997.

The worst declines in stream spawners were in Mission Creek in Kelowna and Powers Creek in Westbank, which used to support 70 per cent of all stream production. Vernon Creek was only one of two monitored streams where there was an increase in spawners.

Kokanee shore spawner numbers experienced a more substantial drop, with less than 1,000 fish found along shoreline spawning sites. This represents a 96 per cent drop from the 1997 estimate.

Data collected from echo-sounding and trawling surveys, which provides information on juvenile kokanee populations in Okanagan Lake, indicates no recovery can be expected in the next three to four years.

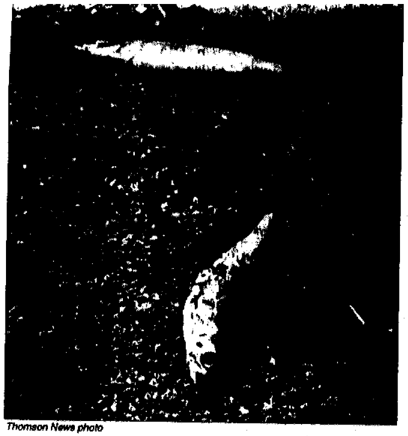
However, the situation is more positive on Kalamalka and Wood lakes, where the kokanee population is stable.

There were 33,500 spawners in Kal Lake in 1998 and 1,400 in Wood Lake.

Matthews isn't sure why fish in those two lakes remain stable when they are declining in Okanagan. There is mysis shrimp in Kal Lake.

"There are some differences in Kal in terms of the food chain."

He added there also some physical differences between Kal and Okanagan lakes that makes it hard



Thomson News photo

Dead kokanee salmon have been washing up on the shores of Skaha Lake. Their mysterious die-off is being monitored by biologists but no cause has been determined. The latest deaths come after an estimated 25,000 fish were found dead in the North Okanagan last month.

MYSTERIOUS DEATHS

Experts say worst has past for fish

■ Recent die-offs have occurred between Okanagan Mission and Rattlesnake Island near Kelowna

By Thomson News Service

B.C. Environment officials continue to monitor a mysterious fish kill that has taken a toll on both Okanagan and Skaha lakes, but they feel the worst is over.

Fish biologist Steve Matthews said they were on the water Sunday, and have nothing new to report. He says it appears this die-off of young kokanee has passed.

"What we saw were dead at least a day, probably two," he said. "There was no sign of stressed fish. But there were a lot of fish washing up."

The events of the past few days come after an estimated 25,000 kokanee died in the northerly portion of the Okanagan Lake, near Vernon, in mid-May. The more recent die-offs have been concentrated between Okanagan Mission and Rattlesnake Island near Kelowna, and on Skaha Lake, south of Penticton.

Matthews says while the carnage appears to have subsided, people will continue to see the results of the recent die-offs.

"It's going to continue for some time," Matthews said. "Fish are going to continue to wash up. We'll continue to monitor but the worst has passed."

While a virus or bacteria have been ruled out by scientists as the cause of last month's kokanee kill, dead fish from recent incidents have been sent to the Environment ministry's fish-health lab in Nanaimo for analysis.

According to Matthews, such episodes are sometimes simply a matter of nature taking its course.

"These die-offs are a natural occurrence to varying levels," he said. "We're always getting one fish or another coming up."

In particular, he pointed to bottom-feeding suckers that are known to wash up on shore.

Matthews doesn't feel there's an immediate danger to dealing with the washed-up fish.

"We don't encourage people to handle them but it's no different from any other dead animal. We suggest they collect and bury them or dispose of them in some fashion."

ENVIRONMENT

June 29/98
Pent. Herald

Valley fish kill spreads south

By Thomson News Service

The mysterious fish kill that claimed thousands of kokanee in the north end of Okanagan Lake last month has spread to Skaha Lake and the Kelowna area.

Hundreds of dead fish were washing up on the eastern shore between Okanagan Mission and Rattlesnake Island Friday and Saturday. The kokanee were all one or two years old, and most had been dead for a day or two.

Fish biologists Steve Matthews and Bruce Shepherd, of B.C. Environment, spent several hours Friday driving a boat between Penticton and Kelowna to collect samples of dead fish and monitor the carnage.

■ Dead fish washing up on shore in Kelowna and near Penticton

"In general, it doesn't look like the numbers we saw at the north end (of Okanagan Lake) in May," Matthews said Saturday. "The densities are much lower... (but) we're seeing varying concentrations of dead fish."

About 25,000 kokanee aged two to three years died between Okanagan Centre and Vernon in mid-May. Tests of four moribund fish found at the north end of the lake failed to find a cause of the die-off.

A similar die-off of kokanee is now happening in Skaha Lake just south of Penticton. Matthews planned to further investigate just how bad it is.

"Similar-sized fish are dying at the same time (in Skaha)," he said. "We don't know what the cause is of either one."

Winds from the south and west have helped concentrate dead or dying fish on the east side of Okanagan Lake. Only a handful of dead fish were found on the west side of the lake.

On Friday, Matthews and Shepherd found at least three stressed kokanee near the surface, but failed to catch them for lab analysis.

Instead, the scientists collected 40 samples of dead kokanee, of which they'll send 20 to the Environment ministry's fish-health lab in Nanaimo for post mortem. Each was 10 to 18 centimetres long.

Scientists ruled out a virus or bacteria as the cause of last month's fish kill. The four samples of moribund fish showed evidence of lice on their gills, which can interrupt the flow of water through a kokanee's breathing system.

But 95 per cent of kokanee aged three and younger in Okanagan Lake have some degree of lice infestation, so no one can say the parasite caused the die-off.

This recent kill was first reported near Penticton on Wednesday. Few dead or dying fish were found south of the halfway point between Kelowna and Penticton, but concentrations increased from Rattlesnake Island to the area across from Green Bay.

The dying is still happening but this episode doesn't appear to be as deadly as the northern die-off in May, which lasted about two weeks, said Matthews.

Similar fish kills have been documented in virtually all kokanee-bearing lakes in the Pacific Northwest, and don't appear to be caused by people, pollution or lightning. The deaths always happen in pockets and never affect an entire lake at the same time.

The Globe and Mail, Thursday, May 21, 1998

Bizarre fish kill hits B.C. salmon

VERNON, B.C. — Up to 50,000 kokanee salmon have perished in a mysterious fish kill in Okanagan Lake.

Most of the dead fish were found in the Vernon arm of the lake, but remains have also been discovered up to 20 kilometres to the south.

Biologist Steve Matthews said yesterday that a natural cause is suspected, such as a disease, virus or parasite.

He said he does not believe the deaths were caused by humans.

"There's no reason for people to be alarmed," he said.

"Fish die-offs, they're natural occurrences, and I don't think people should automatically assume because there's some dead fish appearing that there's some toxin in the water."

Mr. Matthews also ruled out the city of Vernon's discharge of treated sewage into the lake as a cause. — *CP*

Capital News May 20/98

Thousands of kokanee found dead

Government scientists say the discovery of tens of thousands of dead fish in Okanagan Lake does not mean humans are in any danger.

BY JUDIE STEEVES
STAFF REPORTER

The carcasses of thousands, perhaps hundreds of thousands of silver-bellied kokanee float on Okanagan Lake, but the cause of their death may remain a mystery.

Kelowna resident Kevin Orr first noticed the dead fish on Friday afternoon when he reached his cabin on the west side of the lake.

"I could see nothing but their white bellies floating all over the lake, glistening in the sun," recalled Orr, adding that as the wind came up it blew them onto shore.

After 30 years living in the valley, he says he used to fish for the kokanee, until a rapid decline in their numbers led to a ban several years ago.

"It's a beautiful lake. It's my playground and I do all I can do to conserve it," he added.

He feels the provincial government should be doing more to protect the lake, and to restore kokanee stocks.

Environment ministry fishery biologist Steve Mathews was on the lake Tuesday afternoon trying to find a live fish to preserve for testing. Because there's a rapid breakdown in their cells on death, it's important to examine live ones in order to find out what happened.

Ironically, he was fighting off the gulls for any fish still wriggling, and the gulls were winning. The birds didn't seem very interested in fish that were already dead, he said.

With him was Vic Jensen, an environment biologist with the ministry who tested the water for oxygen and temperature. Both seemed about normal for the time of year, he said.

Mathews said there was no indication of any toxin in the water, and there have been no lightning strikes for the past week and a half, ruling out several more possibilities.

"It seems to be due to a natural occurrence," he said. "It's happened in the past with kokanee. We had an estimated 100,000 killed three or four years ago."

Old-timers have reported such kills of kokanee decades ago as well, he added.

It's difficult to estimate without seeing the lake from the air, but Mathews guessed there are at least 50, 000 to 100,000 now dead.

He said it would be silly to think there's something in the lake that could harm humans because there are dead kokanee. No trout or other species of fish seem to have been affected.

Anyone finding a kokanee slipping around at the surface of the lake, but not yet dead is asked to freeze it immediately and notify the ministry at 1-800-461-1127.

Heat taking a toll on fish

■ Rising temperatures in creeks killing some species

By **DON PLANT**
The Daily Courier

The record-breaking heat is killing whitefish and threatening kokanee and trout stocks in Okanagan rivers.

Hundreds of cool-water fish have already died in the Kettle, Shuswap and Okanagan rivers this summer. Many more are expected to succumb to the warm water, lower creek levels and sinking oxygen levels in the weeks ahead.

"Fish are starting to keel," said fisheries biologist Bruce Shepherd of B.C. Environment. "If (the heat wave) continues, we'll see a fairly significant die-off. Let's hope it will break."

Whitefish are more vulnerable to the punishing heat than trout or kokanee. Sores are appearing on their scales, and all of them are under stress.

Fish in Okanagan Lake can find refuge by swimming to cooler depths. Species living in creeks and streams are far more sensitive to a five-degree rise in water temperature.

"They don't like 20 to 21C. When they get 25-26C, you're talking lethal," said Shepherd.

"They're definitely under stress. They're waiting and hoping."

Compounding the problem is extra demand for irrigation water from Okanagan farmers. When the water flow in creeks starts dropping, the temperature rises even further and less water covers the creek bed.

"We're not getting any oxygen in because it's too warm," said Jim McMillan, president of the Lonely Loon flyfishers in Kelowna.

"We'll probably hear about a lot more deaths by the time this heat wave is finished."

In some Okanagan lakes, the water level has dropped as much as five feet, said McMillan. Even the high mountain creeks haven't escaped the heat. McMillan recently returned from a fishing trip to the upper creeks near the Alberta border, where the water was far from cold.

"It will be discouraging for everyone, for sure," he said.

Kelowna Courier Aug/98

OKANAGAN A4
THE OKANAGAN SATURDAY, JANUARY 16, 1999

Kokanee stocks at all-time low

■ Low numbers shock ministry biologist, environmentalists

By Okanagan Saturday Staff

It may not be a complete collapse of Okanagan Lake kokanee stocks, but the most recent spawning numbers are raising concerns of extinction if present trends continue.

In figures released this week, the Ministry of Environment has recorded a decline in shore spawners of 96 per cent since 1997, to just 1,000 fish. Stream spawners were just 12,300, 39 per cent lower than the all time low of 31,000 fish in 1997. Just six years ago, shore and stream spawners in Okanagan Lake were near 200,000. As recently as 1995, numbers had not dropped below 100,000.

Penticton and Vernon creeks were the only monitored streams to record increases in spawner numbers. Declines was most evident in Mission and Powers creeks, which typically support about 70 per cent of stream production. Numbers plunged 87 and 74 per cent respectively in the two creeks, said fisheries biologist Steve Matthews.

"We expected the trend to continue, but not to this extent. It took us by surprise," Matthews said.

A less-steep decline in younger fish offers some hope, he said. "We are seeing very little survival to the adult phase. If juvenile numbers were showing the same decline, we would say yes, maybe it is too late."

Other Okanagan area lakes faired better. Skaha Lake kokanee spawning in Okanagan River had the second highest number of spawners recorded over the past 10 years, despite a major kokanee die-off in July, said Matthews. And primary spawning creeks for Kalamalka and Wood Lake kokanee saw good returns.

Still, the shocking numbers in Okanagan Lake have environmentalists worried. "Our first reaction was 'Are we to the point of extinction?,'" said Rene Barone, Okanagan Region fisheries chairman for the B.C. Wildlife Federation. "Our thinking was, maybe we should save some genetic material."

While urbanization has been blamed for decimating the kokanee population from historic numbers in the millions earlier this century, declines in the past decade are blamed primarily on the mysis shrimp.

The non-native invertebrate was introduced in the 1960s as a food source for mature kokanee. Scientists have since determined the shrimp out compete juvenile kokanee for plankton, causing high juvenile mortality.

Barone and Matthews agree the stocks can be saved, but only if action is taken in the next two years. "We think there is still hope," said Matthews. "We think the key is reducing the shrimp numbers."

The ministry is expanding efforts begun last year to develop a commercial shrimp fishery on the lake. They hope to have a boat in the water in early spring to test different net designs and trawling methods.

"We are hoping to get a camera on the net to get a better idea how they are reacting and design the best possible net for catching them. We feel there is a market out there for them."

It is estimated there are 6,500 metric tonnes of the 0.5- to one-centimetre long shrimp in the lake. Their protein levels make them a good supplement for livestock or fishfarm feed.

The weak link to that plan is funding, Barone says. He said the federation has been lobbying the province for years to provide adequate backing to efforts to renew a fishery worth more than $25 million to the Okanagan economy as recently as 1990.

He said the government is providing less than half the recommended $500,000 a year suggested by the Okanagan Lake Action Plan.

"This isn't new. We've been writing letters to the government since the early '80s saying the kokanee are in trouble.

"I think if we gave the ministry the resources, they would be able to pull it out of the hat. If not, I don't think they can be saved."

Vernon Morning Star Nov 16/98

Local News

Shrimp harvest begins

by RICHARD ROLKE
Morning Star Writer

Shrimp trawlers could soon become a common sight on Okanagan Lake in an attempt to save the kokanee from extinction.

The Ministry of Environment launched an innovative trial program Saturday that will see a trawler ply the waters of Okanagan Lake to catch mysis shrimp. Mysis compete with kokanee for food sources and have been one of the main culprits in the fish's rapid decline.

"If this works out, we would be looking at a commercial shrimp harvest to help the kokanee," said Steve Matthews, a Ministry of Environment fisheries biologist.

The trial period will run for about 10 days and will focus on Okanagan Centre and Cameron Point, near Ellison Provincial Park. The trawler is coming from Vancouver Island.

"We want to see what kind of numbers he'll pick up. We want to see how catchable the shrimp are," said Matthews.

Mysis shrimp were introduced into Okanagan Lake in 1965 to act as an additional food source for adult kokanee. However, the experiment failed miserably and the mysis population climbed, becoming a major competitor for food.

A food shortage has developed and the kokanee stock in the lake has plummeted.

"We're never going to get rid of the shrimp, but we don't rule out having a big enough impact that we can't help the kokanee," said Matthews.

Figures for the 1998 kokanee spawning run are still being tallied, but it will be a record-low year.

"Things are looking very low. We're in bad shape again this year," said Matthews.

He believes that while adult kokanee numbers are extremely low, action such as shrimp-harvesting can turn the situation around for juvenile kokanee.

If a commercial industry developed, the mysis shrimp which are about one-centimetre in size - would be used for stocking aquariums and as a protein supplement for livestock and fish farms.

There are no immediate plans for the shrimp to find its way on to barbecues and stir fries.

"I wouldn't rule it out. There may be ways to use it for human consumption and that is still being investigated," said Matthews.

The trawler will use a net developed especially for the Okanagan Lake project. Matthews admits the net could scoop up other fish, but the chances are reduced because the mysis shrimp live along the lake bottom.

"During the day, on the bottom, there aren't many other critters around."

According to Matthews, encouraging a commercial mysis shrimp harvest is likely the best option for enhancing kokanee.

"It's a way to knock back the mysis shrimp but also to create jobs and revenue."

Penticton Herald Nov 13/98

Trawler to scoop up kokanee's tiny rival

■ Province hires boat to test feasibility of commercial shrimp fishery on Okanagan Lake

By JOHN MOORHOUSE
Penticton Herald

The battle to save Okanagan Lake's few remaining kokanee will now include a direct attack on the tiny mysis shrimp.

As part of its Okanagan Lake Action Plan to preserve plummeting kokanee stocks, the Ministry of Environment has hired a specially equipped shrimp trawl boat from Vancouver Island.

Steve Matthews, a B.C. Environment fisheries biologist in Penticton, said Thursday the trawler is expected to be launched into the lake Saturday morning near Kelowna and will collect shrimp in a specially designed net for 10 days, mainly in the north end of the lake near Okanagan Centre and Cameron Point.

The boat owner will test the feasibility of establishing a commercial shrimp fishery on the lake. Cost of the project, funded by the Habitat Conservation Trust Fund, will amount to about $25,000.

Mysis shrimp were introduced into Okanagan Lake in 1965 to serve as an extra food source for adult kokanee. However, it was later discovered they compete for the same food as juvenile koka-

The numbers, no matter how we look at it, are going to be very low this year — the lowest we've ever seen," Matthews said. "We need to do something in terms of improving survival for those fish.

We want to concentrate on the areas with the highest densities of mysis," he said. "It's a net specifically designed to trawl along the bottom of the lake."

Although mysis shrimp travel up towards the surface at night, they tend to congregate in large numbers near the bottom during daylight hours. By targeting them during the day, the ministry hopes to minimize the chances of accidentally netting kokanee or other bycatches.

But Matthews refutes any suggestion this might be a case of too little, too late. He noted there are still a reasonable number of juvenile kokanee in the lake, which will benefit from a shrimp fishery.

"There's still enough out there that we feel can respond if we do improve conditions foodwise. They can still turn it around," he said.

"The key is that we're aiming this at improving survival of those younger age class kokanee. If we can do that, then we'll start to see more adults."

Mysis shrimp are about one centimetre long, roughly the size of a person's baby fingernail. They could be used commercially as feed for aquarium fish or as a protein supplement for livestock food and fish farms.

However, this will not be the first time the

Penticton Herald **Tuesday, December 8, 1998** Front Page 60 cents + 4 cents GST = 64 cents

Mysis misses as snack

■ Biologist's own taste test suggests any future market for Okanagan shrimp won't lie in its appeal as an appetizer

By RON SEYMOUR
Special to the Herald

Here's a menu item you're not likely to ever see in your favourite restaurant: fresh Okanagan shrimp.

There are millions of mysis shrimp scuttling around in Okanagan Lake, but they aren't exactly a taste treat. The frail, pale-looking creatures, only distantly related to coastal shrimp, are just a centimetre long, roughly the size of your baby fingernail.

But their most unappetizing feature, according to one biologist who popped one in his mouth, are the little legs dangling off them.

"He said it was kind of like eating a little ball of cat hair," said Steve Matthews, a fisheries official with the Ministry of Environment in Penticton.

About 1,000 pounds of shrimp were caught in a 10-day trial last month, designed to test the viability of a commercial shrimp fishery on Okanagan Lake.

While these shrimp may never end up on a dinner plate, they could eventually be used for protein supplements at fish farms. But ministry staff don't yet know if there's enough commercial demand to support even that kind of shrimp fishery.

Photo courtesy of Ministry of Environment

The mysis shrimp isn't nearly as appetizing as its coastal counterpart, but it may yet have its place as a commodity of some value. A recent experiment was designed to help authorities assess the potential for a commercial mysis shrimp fishery on Okanagan Lake.

"Whether we could rely on market conditions to entice shrimp fishermen up here from the Coast, or whether we'd have to provide some kind of incentive, that's the question we'll have to look at down the line," Matthews said.

Joe Bauer, who represents the 250 West Coast fishermen with licences to catch coastal shrimp, said he thinks at least a few of them might be interested in also trawling Okanagan Lake, provided it made financial sense.

"The guys are always looking for ways to help fill the void caused by the collapse of the coastal fishery," Bauer said. "If the government wants to help pay them to try shrimp fishing up there, they'd be willing to give it a try."

The ministry paid West Coast shrimper Bob Bowker about $25,000 to trawl for mysis in Okanagan Lake in last month's project. It was the first time for such an experiment and there were a few glitches as they attempted to catch the shrimp which tend to gather near the bottom during the daytime.

"We caught a lot of big bags of mud and the net was torn a few times," said Dave Smith, another fisheries biologist who worked on board Bowker's boat. "But the learning curve and our success rates went up as we went along."

The proliferation of mysis shrimp is seen as a key reason why the Okanagan's kokanee population has plummeted to record low levels, since they eat the same plankton that young kokanee depend on. It's estimated there are now 6,500 metric tonnes of mysis shrimp in the lake.

Meanwhile, Matthews said Tuesday that although results from last month's trial are still being reviewed, some form of shrimp-catching program will return next year.

"If this doesn't work, there's not a lot of other options we can take," he said. "If we can't improve catches (of mysis) in the lake, then we're in trouble."

The ministry has already looked at improving fish habitat and spawning areas, Matthews said. And "enriching" the lake by adding fertilizers, as has been done in Kootenay Lake, is not a viable alternative in the Okanagan where high phosphorous levels are already a concern.

CHAPTER 6

SUMMARY OF ACTION PLAN REPORT

DISCUSSION

The information collected in Year 3 (1998) of the Okanagan Lake Action Plan (OLAP) has provided greater insight into the complexity and dynamics of Okanagan Lake. To some extent results from one years work is analogous to building a house. After clearing the land and surveying the site the foundation can be laid. The foundation of the OLAP has been laid with a great deal of emphasis on baseline data collection and heightened protection of key fish habitat. The process of integrating all the relevant information and moving in a coordinated manner towards resolution (i.e., building the house) of key issues is undoubtedly too slow for many but necessary if long term solutions are to be identified and acted upon. There were some positive developments that arose in 1998 that will contribute to the long-term solutions on Okanagan Lake.

Habitat Protection and Restoration

To date habitat protection measures related to the OLAP have focussed on public education and stream habitat protection and these must continue. The review of the operating rule curve for lake levels has promise. Data from this years work outlines an improved method for predicting spring runoff thereby providing the regulatory agency with another tool for managing the lake level more conducive to shore spawning kokanee requirements. Further analysis and refinement of this method is required in 1999.

Watershed assessment work in years 1 and 2 have led to some on the ground action in 1998. The watershed restoration work conducted in 1998 on Trout Creek is a small but significant step towards restoration of this watershed. Public involvement will be an essential requirement for further, incremental improvements to this watershed. The initial evaluation and proposal for a rainbow trout rearing channel and some kokanee spawning habitat on upper Mission Creek has considerable potential. Perhaps of equal importance is that this project reinforces to the public and politicians alike that the Action Plan is serious about protecting and restoring valuable fish habitat.

Limnology

Routine monthly sampling of physical and chemical parameters was again conducted in 1998. However, as the baseline data accumulates and a better understanding of the lakes' limnology develops there will be a reduction in some basic data collection. This has already taken place with some scaling back of stations sampled in 1998.

The unusual characteristics of Armstrong Arm compared to the rest of Okanagan Lake were again evident in 1998. Of particular interest is the absence of *Mysis relicta* during the fall months when the deeper water layers are nearly void of oxygen while surface waters are still relatively warm. The higher numbers of preferred kokanee food -*Daphnia*- in Armstrong Arm when the mysids move out is especially important information. Seasonal horizontal movement by mysids out of Armstrong Arm may provide some important clues for development of a mysid harvest strategy.

Mysis relicta are believed to be one of the primary reasons why Okanagan Lake kokanee have declined since they are competitors with kokanee for the same zooplanktors. There has been a gradual decline in mysid numbers over the last ten years but this decline can quickly be reversed, as often is the case with mysids elsewhere. Mysids and *Daphnia* tend to co-exist in waters with higher productivity and this makes Armstrong Arm an interesting exception to the rest of Okanagan Lake which is oligotrophic. Future limnological work should focus on the dynamics of Armstrong Arm.

Initial results of the mysid pheromone research showed promise but the work in 1998 could not confirm the presence of a sex pheromone. Research evidence does indicate juvenile avoidance of mature mysids and this knowledge may well assist in the mysid harvest strategy.

Regarding mysid harvest, some considerable progress was made in 1998. Deployment of a commercial size boat with an experimental net on the lake in November certainly caught mysids as well as the imagination and hopes of the public. This experimental work moved the mysid harvest strategy one step closer to reality. Results were encouraging enough to seriously consider full scale commercial mysid harvest in 1999. Information obtained on mysids distribution, abundance, and behaviour from the other 1998 OLAP studies will be used in developing a 1999 mysids fishing strategy.

Kokanee Populations

Hydroacoustic and trawl net surveys were again conducted in 1998. This work has been ongoing since 1988 and provides valuable estimates of in-lake abundance of all ages of kokanee and provides comparative time series information. Total abundance was estimated at 5.0 in 1998. This compares with a range of 5-14 million from 1988-1998 and confirms what the spawning counts have indicated, i.e., a decline in numbers over time. Fry abundance has declined from 9.0 to 2.9 million in just over two cycles i.e., 1989 to 1998.

The trawl work also provides very good biological data on length at age, growth and shore spawner distribution. This information has been used to confirm age of stream spawners as predominately 3+.

The 1998 genetics work has made a significant breakthrough. It appears that DNA analysis can possibly be used as a tool for differentiating between shore and stream spawning stocks. More work is required in 1999 but the implications of developing this analytic tool are significant for kokanee managers. If this technique is confirmed then trawl samples can be analyzed to determine the ratio of stream and shore fish. An estimate of the number stream vs shore origin fish would then be possible and this would greatly assist fisheries management.

The 1998 shore count indice was less than 1,000 fish, the lowest count ever recorded. This count compares with 200,000 to 730,000 in the 1970s. Stream spawner estimates were equally dismal with the estimate only about 13,000. It is difficult to imagine the dramatic decline these fish have undergone over the last thirty years and makes the task of the OLAP all that more critically important. The near future of kokanee in Okanagan lake is, to say the least, perilous.

PRELIMINARY CONCLUSIONS

The following are some tentative conclusions drawn from the work conducted in 1998:

- Informing the public of the value of protecting fish habitat must be a continuous effort. It is only through public recognition and acceptance of resource ownership (i.e., resource stewardship) that the resource base will be ensured appropriate protection.

- Development of the rule curve for lake level regulation using the SOI technique described in this report may be of assistance to lake regulators and could benefit shore-spawning kokanee without impacting on other uses.

- The watershed restoration project on Trout Creek is a good start to stream restoration on Okanagan Lake.

- In-lake trawl and acoustic surveys provide valuable time series data sets.

- Limnology of Okanagan Lake is similar to other large lakes in southern BC including Kalamalka Lake. Differences between Kalamalka and Okanagan lakes are capacity related.

- Phosphorus is limiting in Okanagan Lake but there are also times when nitrogen may be limiting.

- Experimental mysid harvesting advanced to pre-commercial level with successful use of a commercial sized boat and net. Commercial harvest appears feasible but more work is required in 1999.

- Genetic analysis using DNA appears to be feasible in distinguishing origin of kokanee ie. shore vs stream spawners.

- Stream spawning counts are valuable for understanding long term trends.

- The kokanee population is at an all time low and will not likely improve significantly for years to come.

RECOMMENDATIONS

1. Action Plan results should be reported annually.
2. Public meetings should be conducted in May-June to review progress and results in annual report.
3. Refine the SOI technique to assist in predicting spring runoff conditions.
4. Watershed restoration work should continue and be a high priority within the region.
5. Continue routine limnological sampling and focus on the dynamics of Armstrong Arm relative to the main body of Okanagan Lake.
6. Produce a report on comparative analysis of Okanagan Lake limnology with other similar lakes in North America.
7. Complete paleolimnology analysis in 1999.
8. Develop a mysid harvest strategy based on information gained in 1998 both from the experimental harvest and limnological data. Pursue cost recovery to fund further priority work on Okanagan Lake.
9. Confirm age of spawning for both populations of kokanee using otoliths and trawl length frequency data.
10. Correlation between trawl data and shore counts should be investigated further.
11. Pursue technique of DNA analysis for differentiating between shore and stream spawning stocks.
12. Plan for a comprehensive workshop on Okanagan Lake where world and provincial experts analyze the results and direction of the OLAP.

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APPENDIX 1

1996-2001: *Conserve native stocks, protect habitat and collect priority information*

Priority Remedial Measures	*Sustained Monitoring Program*	*Comparative Analyses Studies*	*Functional Studies*	*Large Scale Experiments*	*Long Term Applied Research*
Develop protection & restoration plans for stream and shore spawning habitats	Maintain annual basic fisheries and limnological monitoring program	Historical review and inventory of changes in kokanee stream/shore spawning habitat	Investigate kokanee shore spawning cues	Conduct bench and pilot scale epilimnetic bubble pump entrainment experiments on mysids	Conduct mysid pheromone and behavioural cues research
Implement stream and shoreline preservation activities	Develop improved shore spawner enumeration methods	Review of kokanee shore spawning habitat requirements	Examine early kokanee lake dispersal and mortality	Examine implications of liberal rainbow trout harvest regulations	Conduct pilot scale harvest tests of mysids
Defer hatchery stocking of kokanee	Expand annual mysid sampling program	Establish limnological monitoring program on Wood and Kalamalka lakes	Examine P budget for specific sources and seasonal dispersion patterns	Defer mass liberations of kokanee fry	Investigate potential new stock ID methods
Examine implications of removal of kokanee angling closure	Determine stock composition of sport catch (when feasible)	Collect and analyse core samples from Okanagan Lake	Resolve age 1 kokanee avoidance of trawl gear		
Implement public consultation, education and working group plans	Mark all enhanced kokanee (if feasible)		Examine lake drawdown timing and kokanee fry emergence		

Phase 1 rationale: Conservation of native stocks and habitat protection to preserve remaining stocks and collection of priority information to improve present management and develop innovative future resource management techniques.

2001-2006: *Rebuild native stocks, restore habitat and collect priority information*

Priority Remedial Measures	*Sustained Monitoring Program*	*Comparative Analyses Studies*	*Functional Studies*	*Large Scale Experiments*	*Long Term Applied Research*
Implement restoration plans for stream and shore spawning habitat	Determine stock composition of sport catch (if feasible)	Incorporate results of historical review in restoration plans	Complete investigation of kokanee shore spawning cues	Conduct full scale bubble pump experiments on mysids if pilot scale is successful	Complete mysid pheromone and behavioural cues research
Minimize hatchery stocking of kokanee	Mark all enhanced kokanee	Incorporate review of shore spawning habitat in restoration plans	Complete examination of early kokanee lake dispersal and mortality	Implement liberal rainbow trout harvest regulations if yields are sustainable	Conduct large scale harvest tests of mysids if pilot scale is successful
Maintain stream and shoreline preservation activities	Implement improved shore spawner enumeration methods	Evaluate findings of lake coring studies on kokanee carrying capacity	Complete P budget for specific sources and seasonal dispersion patterns	Consider potential impacts of mass liberations of kokanee fry	Implement new stock ID methods if successful
Consider removal of kokanee angling closure	Maintain annual basic fisheries and limnological monitoring program	Evaluate findings from Wood/Kal comparative monitoring	Modify trawling methods to capture age 1 kokanee		
	Continue expanded annual mysid sampling program		Implement results of timing lake drawdown timing and kokanee fry emergence study		

Phase 2 rationale: Rebuilding of native stocks and restoration of habitat, continuation of priority information collection to improve present management, initial application of new information and development of innovative resource management techniques.

2006-2011: *Rebuild native stocks, restore habitat and innovative management*

Priority Remedial Measures	*Sustained Monitoring Program*	*Comparative Analyses Studies*	*Functional Studies*	*Large Scale Experiments*	*Long Term Applied Research*
Complete restoration of stream and shore spawning habitat	Monitor stock composition of sport catch	Review needs	Integrate results of kokanee shore spawning cues	Implement full scale bubble pump for mysid control if experiments are successful	Review needs
Maintain stream and shoreline preservation activities	Mark all enhanced kokanee		Update kokanee model with information on early kokanee lake dispersal and mortality	Maintain liberal rainbow trout harvest regulations if yields are sustainable	
Implement mysid pheromone/ behavioural traps if feasible	Maintain improved shore spawner enumeration methods			Consider impacts of mass liberations of kokanee fry	
Implement large scale harvesting of mysids if harvest tests are successful	Maintain annual basic fisheries and limnological monitoring program				
Modify kokanee angling regulations as required	Continue expanded annual mysid sampling program				

Phase 3 rationale: Rebuilding of native stocks and restoration of habitat, completion of priority information collection to improve present management, further application of new information and implementation of innovative resource management techniques.

2011-2016: *Conserve native stocks, protect habitat and innovative management*

Priority Remedial Measures	*Sustained Monitoring Program*	*Comparative Analyses Studies*	*Functional Studies*	*Large Scale Experiments*	*Long Term Applied Research*
Maintain stream and shoreline preservation activities	Monitor stock composition of sport catch	Review needs	Review needs	Consider effects of mass liberations of kokanee fry	Review needs
Maintain liberal rainbow trout harvest regulations if yields are sustainable	Mark all enhanced kokanee			Review other possibilities	
Maintain full scale bubble pump if cost-effective	Maintain improved shore spawner enumeration methods				
Continue harvesting of mysids if cost-effective	Maintain annual basic fisheries and limnological monitoring program				
Continue mysid pheromone/ behavioural traps if successful	Continue expanded annual mysid sampling program				

Phase 4 rationale: Conservation of native stocks and habitat protection to maintain the biodiversity of kokanee stocks with full implementation of innovative resource management techniques.

			No. counted						% sample	No. per litre							
Date	Site No.	Location	cala.	cyclo.	*Daphnia*	*Diaph.*	*Bos.*		counted	cala.	cyclo.	*Daphnia*	*Diaph.*	*Bos.*	*Lepto.*	*Lepto. (p/a)*	
96/08/18	O500246	Kala.S.E.	518	1909	24	46	46	0	3.125	1.876	6.9137	0.08692	0.1666	0.1666	0	absent	
		sample spilled - only one rep															
Total/Average			518	1909	24	46	46			1.876	6.9137	0.0869	0.1666	0.1666	0		
96/08/19	O500847	Kala.D.B.	254	1007	22	40	9	0	1.5625	1.84	7.294	0.159353	0.28973	0.0652	0	absent	
96/08/19	O500847	Kala.D.B.	142	579	5	78	14	0	0.78125	2.057	8.3878	0.072433	1.12996	0.2028	0	absent	
96/08/19	O500847	Kala.D.B.	150	556	10	55	7	0	0.78125	2.173	8.0546	0.144866	0.79676	0.1014	0	"	
Total/Average			546	2142	37	173	30			2.023	7.9121	0.125551	0.73882	0.1231	0		
96/08/20	O500239	Arm.Arm	305	1837	16	9	1	0	0.78125	4.418	26.612	0.231786	0.13038	0.0145	0	absent	
96/08/20	O500239	Arm.Arm	247	702	2	3	1	0	0.390625	7.156	20.339	0.057947	0.08692	0.029	0	absent	
96/08/20	O500239	Arm.Arm	256	979	5	2	1	0	0.390625	7.417	28.365	0.144866	0.05795	0.029	0	"	
Total/Average			808	3518	23	14	3			6.331	25.105	0.144866	0.09175	0.0241	0		
96/08/20	E206611	Vern.Out.	417	575	6	7	0	0	0.78125	6.041	8.3298	0.08692	0.10141	0	0	absent	
96/08/20	E206611	Vern.Out.	506	538	17	9	3	0	0.78125	7.33	7.7938	0.246273	0.13038	0.0435	0	"	
96/08/20	E206611	Vern.Out.	327	510	27	10	1	0	0.78125	4.737	7.3882	0.391139	0.14487	0.0145	0	absent	
96/08/20	E206611	Vern.Out.	327	488	18	10	0	0	0.78125	4.737	7.0695	0.260759	0.14487	0	0	"	
Total/Average			1577	2111	68	36	4			5.711	7.6453	0.246273	0.13038	0.0145	0		
96/08/20	O500730	N.OK Centre	732	811	36	39	1	0	1.5625	5.302	5.8743	0.260759	0.28249	0.0072	0	absent	
96/08/20	O500730	N.OK Centre	455	515	26	10	0	0	0.78125	6.591	7.4606	0.376653	0.14487	0	0	absent	
96/08/20	O500730	N.OK Centre	537	521	31	17	2	0	0.78125	7.779	7.5475	0.449086	0.24627	0.029	0	"	
Total/Average			1724	1847	93	66	3			6.558	6.9608	0.362166	0.22454	0.0121	0		
96/08/21	O500456	UPS Kel.STP	1128	1032	60	18	0	0	1.5625	8.17	7.4751	0.434599	0.13038	0	0	absent	
96/08/21	O500456	UPS Kel.STP	536	496	32	5	0	0	0.78125	7.765	7.1854	0.463572	0.07243	0	0	absent	
96/08/21	O500456	UPS Kel.STP	647	448	50	10	0	0	0.78125	9.373	6.49	0.724332	0.14487	0	0	"	
Total/Average			2311	1976	142	33	0			8.436	7.0502	0.540834	0.11589	0	0		
96/08/21	O500236	DNS Kel.STP	574	1053	71	37	0	0	1.5625	4.158	7.6272	0.514276	0.268	0	0	absent	
96/08/21	O500236	DNS Kel.STP	308	536	44	9	0	0	0.78125	4.462	7.7648	0.637412	0.13038	0	0	absent	
96/08/21	O500236	DNS Kel.STP	253	475	20	6	0	0	0.78125	3.665	6.8812	0.289733	0.08692	0	0	"	
Total/Average			1135	2064	135	52	0			4.095	7.4244	0.480473	0.16177	0	0		
96/08/21	E223295	Rattlesnake	894	2258	222	77	0	0	1.5625	6.476	16.355	1.608017	0.55774	0	0	absent	
96/08/21	E223295	Rattlesnake	598	1075	118	36	1	0	0.78125	8.663	15.573	1.709423	0.52152	0.0145	0	absent	
96/08/21	E223295	Rattlesnake	604	1015	65	39	0	0	0.78125	8.75	14.704	0.941631	0.56498	0	0	"	
Total/Average			2096	4348	405	152	1			7.963	15.544	1.41969	0.54808	0.0048	0		
96/08/23	O500729	S.Squally Pt.	614	1276	56	31	2	0	1.5625	4.447	9.2425	0.405626	0.22454	0.0145	0	absent	
96/08/23	O500729	S.Squally Pt.	365	756	26	13	0	0	0.78125	5.288	10.952	0.376653	0.18833	0	0	absent	
96/08/23	O500729	S.Squally Pt.	288	728	37	12	1	0	0.78125	4.172	10.546	0.536006	0.17384	0.0145	0	"	
Total/Average			1267	2760	119	56	3			4.636	10.247	0.439428	0.19557	0.0097	0		
96/08/23	O500454	S.Prairie Cr.	552	868	16	21	0	0	1.5625	3.998	6.2872	0.115893	0.15211	0	0	absent	
96/08/23	O500454	S.Prairie Cr.	381	467	19	21	0	0	0.78125	5.519	6.7653	0.275246	0.30422	0	0	absent	
96/08/23	O500454	S.Prairie Cr.	417	454	26	26	1	0	0.78125	6.041	6.5769	0.376653	0.37665	0.0145	0	"	
Total/Average			1350	1789	61	68	1			5.186	6.5431	0.255931	0.27766	0.0048	0		
96/09/19	O500246	Kala.S.E.	133	388	2	32	2	0	0.78125	1.927	5.6208	0.028973	0.46357	0.029	0	absent	
96/09/19	O500246	Kala.S.E.	163	437	0	21	1	0	0.78125	2.361	6.3307	0	0.30422	0.0145	0	"	
96/09/19	O500246	Kala.S.E.	151	422	1	26	0	0	0.78125	2.187	6.1134	0.014487	0.37665	0	0	absent	
96/09/19	O500246	Kala.S.E.	161	461	1	31	1	0	0.78125	2.332	6.6783	0.014487	0.44909	0.0145	0	"	
Total/Average			608	1708	4	110	4			2.202	6.1858	0.014487	0.39838	0.0145	0		
96/09/19	O500847	Kala.D.B.	171	482	0	13	0	0	0.78125	2.477	6.9826	0	0.18833	0	0	absent	
96/09/19	O500847	Kala.D.B.	165	490	1	19	0	0	0.78125	2.39	7.0985	0.014487	0.27525	0	0	"	
96/09/19	O500847	Kala.D.B.	215	554	3	10	0	0	0.78125	3.115	8.0256	0.04346	0.14487	0	0	absent	
96/09/19	O500847	Kala.D.B.	215	519	2	22	1	0	0.78125	3.115	7.5186	0.028973	0.31871	0.0145	0	"	
Total/Average			766	2045	6	64	1			2.774	7.4063	0.02173	0.23179	0.0036	0		
96/09/16	O500239	Arm.Arm	383	569	5	1	9	0	0.390625	11.1	16.486	0.144866	0.02897	0.2608	0	present	
96/09/16	O500239	Arm.Arm	297	506	5	4	13	0	0.390625	8.605	14.66	0.144866	0.11589	0.3767	0	"	
96/09/16	O500239	Arm.Arm	269	488	2	1	11	0	0.390625	7.794	14.139	0.057947	0.02897	0.3187	0	present	
96/09/16	O500239	Arm.Arm	282	521	6	3	5	0	0.390625	8.17	15.095	0.17384	0.08692	0.1449	0	"	
Total/Average			1231	2084	18	9	38			8.917	15.095	0.13038	0.06519	0.2752	0		
96/09/16	E206611	Vern.Out.	434	508	6	5	11	0	0.78125	6.287	7.3592	0.08692	0.07243	0.1594	0	absent	
96/09/16	E206611	Vern.Out.	391	459	6	12	12	0	0.78125	5.664	6.6494	0.08692	0.17384	0.1738	0	"	
96/09/16	E206611	Vern.Out.	418	478	11	4	2	0	0.78125	6.055	6.9246	0.159353	0.05795	0.029	0	absent	
96/09/16	E206611	Vern.Out.	416	431	14	4	5	0	0.78125	6.026	6.2437	0.202813	0.05795	0.0724	0	"	
Total/Average			1659	1876	37	25	30			6.008	6.7942	0.134001	0.09054	0.1086	0		
96/09/17	O500730	N.OK Centre	410	489	7	10	10	0	0.78125	5.94	7.084	0.101406	0.14487	0.1449	0	absent	
96/09/17	O500730	N.OK Centre	377	503	3	12	3	0	0.78125	5.461	7.2868	0.04346	0.17384	0.0435	0	"	
96/09/17	O500730	N.OK Centre	347	487	7	5	17	0	0.78125	5.027	7.055	0.101406	0.07243	0.2463	0	absent	
96/09/17	O500730	N.OK Centre	285	473	11	5	11	0	0.78125	4.129	6.8522	0.159353	0.07243	0.1594	0	"	
Total/Average			1419	1952	28	32	41			5.139	7.0695	0.101406	0.11589	0.1485	0		
96/09/17	O500456	UPS Kel.STP	586	476	33	6	3	0	0.78125	8.489	6.8956	0.478059	0.08692	0.0435	0	absent	
96/09/17	O500456	UPS Kel.STP	623	411	28	12	3	0	0.78125	9.025	5.954	0.405626	0.17384	0.0435	0	"	
96/09/17	O500456	UPS Kel.STP	632	540	46	5	7	0	0.78125	9.156	7.8228	0.666385	0.07243	0.1014	0	absent	
96/09/17	O500456	UPS Kel.STP	768	556	40	8	10	0	0.78125	11.13	8.0546	0.579465	0.11589	0.1449	0	"	
Total/Average			2609	1983	147	31	23			9.449	7.1817	0.532384	0.11227	0.0833	0		
96/09/18	O500236	DNS Kel.STP	360	421	12	7	10	0	0.78125	5.215	6.0989	0.17384	0.10141	0.1449	0	absent	
96/09/18	O500236	DNS Kel.STP	305	415	26	16	11	0	0.78125	4.418	6.012	0.376653	0.23179	0.1594	0	"	
96/09/18	O500236	DNS Kel.STP	475	522	33	4	6	0	0.78125	6.881	7.562	0.478059	0.05795	0.0869	0	absent	
96/09/18	O500236	DNS Kel.STP	406	519	51	18	4	0	0.78125	5.882	7.5186	0.738818	0.26076	0.0579	0	"	
Total/Average			1546	1877	122	45	31			5.599	6.7979	0.441842	0.16297	0.1123	0		
96/09/18	E223295	Rattlesnake	328	516	17	13	1	0	0.78125	4.752	7.4751	0.246273	0.18833	0.0145	0	absent	
96/09/18	E223295	Rattlesnake	382	471	15	10	1	0	0.78125	5.534	6.8232	0.2173	0.14487	0.0145	0	"	
96/09/18	E223295	Rattlesnake	413	625	18	14	1	0	0.78125	5.983	9.0541	0.260759	0.20281	0.0145	0	absent	
96/09/18	E223295	Rattlesnake	404	591	24	10	1	0	0.78125	5.853	8.5616	0.347679	0.14487	0.0145	0	"	

Total/Average			1527	2203	74	47	4			5.53	7.9785	0.268003	0.17022	0.0145	0		
96/09/18	O500729	S.Squally Pt.	343	586	14	7	1	0	0.78125	4.969	8.4892	0.202813	0.10141	0.0145	0	absent	
96/09/18	O500729	S.Squally Pt.	320	561	5	5	2	0	0.78125	4.636	8.127	0.072433	0.07243	0.029	0	"	
96/09/18	O500729	S.Squally Pt.	227	469	16	4	4	0	0.78125	3.288	6.7942	0.231786	0.05795	0.0579	0	absent	
96/09/18	O500729	S.Squally Pt.	318	505	32	6	11	0	0.78125	4.607	7.3158	0.463572	0.08692	0.1594	0	"	
Total/Average			1208	2121	67	22	18		3.125	4.375	7.6815	0.242651	0.07968	0.0652	0		
96/09/18	O500454	S.Prairie Cr.	408	471	37	8	1	0	0.78125	5.911	6.8232	0.536006	0.11589	0.0145	0	absent	
96/09/18	O500454	S.Prairie Cr.	435	554	44	11	2	0	0.78125	6.302	8.0256	0.637412	0.15935	0.029	0	"	
96/09/18	O500454	S.Prairie Cr.	379	434	28	15	1	0	0.78125	5.49	6.2872	0.405626	0.2173	0.0145	0	absent	
96/09/18	O500454	S.Prairie Cr.	408	422	30	10	1	0	0.78125	5.911	6.1134	0.434599	0.14487	0.0145	0	"	
Total/Average			1630	1881	139	44	5			5.903	6.8123	0.503411	0.15935	0.0181	0		
96/10/15	O500847	Kala.D.B.	336	496	0	42	7	0	0.78125	4.868	7.1854	0	0.60844	0.1014	0	absent	
96/10/15	O500847	Kala.D.B.	393	436	0	39	4	0	0.78125	5.693	6.3162	0	0.56498	0.0579	0	"	
96/10/15	O500847	Kala.D.B.	334	346	0	24	11	0	0.78125	4.839	5.0124	0	0.34768	0.1594	0	absent	
96/10/15	O500847	Kala.D.B.	344	363	0	45	6	0	0.78125	4.983	5.2586	0	0.6519	0.0869	0	"	
Total/Average			351.75	410.25	0	37.5	7	0		5.096	5.9431	0	0.54325	0.1014	0		
96/10/23	O500239	Arm.Arm	682	356	72	10	9	1	0.78125	9.88	5.1572	1.043038	0.14487	0.1304	0.01	present	
96/10/23	O500239	Arm.Arm	530	355	49	6	16	0	0.78125	7.678	5.1428	0.709845	0.08692	0.2318	0	"	
96/10/23	O500239	Arm.Arm	560	395	29	4	7	0	0.78125	8.113	5.7222	0.420112	0.05795	0.1014	0	present	
96/10/23	O500239	Arm.Arm	541	399	33	8	7	0	0.78125	7.837	5.7802	0.478059	0.11589	0.1014	0	"	
Total/Average			578.25	376.25	45.75	7	9.75	0.25		8.377	5.4506	0.662764	0.10141	0.1412	0		
96/10/17	E206611	Vern.Out.	774	924	13	2	15	0	1.5625	5.606	6.6928	0.094163	0.01449	0.1086	0	absent	
96/10/17	E206611	Vern.Out.	740	1006	18	7	19	0	1.5625	5.36	7.2868	0.13038	0.0507	0.1376	0	"	
96/10/17	E206611	Vern.Out.	356	474	1	5	9	0	0.78125	5.157	6.8667	0.014487	0.07243	0.1304	0	absent	
96/10/17	E206611	Vern.Out.	374	500	2	4	5	0	0.78125	5.418	7.2433	0.028973	0.05795	0.0724	0	"	
Total/Average			561	726	8.5	4.5	12	0		5.385	7.0224	0.067001	0.04889	0.1123	0		
96/10/17	O500730	N.OK Centre	452	548	6	3	22	0	0.78125	6.548	7.9387	0.08692	0.04346	0.3187	0	absent	
96/10/17	O500730	N.OK Centre	493	607	6	7	11	0	0.78125	7.142	8.7934	0.08692	0.10141	0.1594	0	"	
96/10/17	O500730	N.OK Centre	504	583	7	3	17	0	0.78125	7.301	8.4457	0.101406	0.04346	0.2463	0	absent	
96/10/17	O500730	N.OK Centre	525	636	6	4	12	0	0.78125	7.605	9.2135	0.08692	0.05795	0.1738	0	"	
Total/Average			493.5	593.5	6.25	4.25	15.5	0		7.149	8.5978	0.090541	0.06157	0.2245	0		
96/10/17	O500456	UPS Kel.STP	375	455	8	0	21	0	0.78125	5.432	6.5914	0.115893	0	0.3042	0	absent	
96/10/17	O500456	UPS Kel.STP	391	504	5	1	31	0	0.78125	5.664	7.3013	0.072433	0.01449	0.4491	0	"	
96/10/17	O500456	UPS Kel.STP	365	449	11	3	22	0	0.78125	5.288	6.5045	0.159353	0.04346	0.3187	0	absent	
96/10/17	O500456	UPS Kel.STP	371	494	5	1	29	0	0.78125	5.375	7.1564	0.072433	0.01449	0.4201	0	"	
Total/Average			375.5	475.5	7.25	1.25	25.75	0		5.44	6.8884	0.105028	0.01811	0.373	0		
96/10/17	O500236	DNS Kel.STP	389	374	15	1	3	0	0.78125	5.635	5.418	0.2173	0.01449	0.0435	0	absent	
96/10/17	O500236	DNS Kel.STP	328	321	12	2	10	0	0.78125	4.752	4.6502	0.17384	0.02897	0.1449	0	"	
96/10/17	O500236	DNS Kel.STP	308	333	7	4	8	0	0.78125	4.462	4.824	0.101406	0.05795	0.1159	0	absent	
96/10/17	O500236	DNS Kel.STP	347	375	8	0	14	0	0.78125	5.027	5.4325	0.115893	0	0.2028	0	"	
Total/Average			343	350.75	10.5	1.75	8.75	0		4.969	5.0812	0.15211	0.02535	0.1268	0		
96/10/17	E223295	Rattlesnake	367	392	12	1	8	0	0.78125	5.317	5.6788	0.17384	0.01449	0.1159	0	absent	
96/10/17	E223295	Rattlesnake	379	379	7	0	7	0	0.78125	5.49	5.4904	0.101406	0	0.1014	0	"	
96/10/17	E223295	Rattlesnake	427	517	9	4	6	0	0.78125	6.186	7.4896	0.13038	0.05795	0.0869	0	absent	
96/10/17	E223295	Rattlesnake	413	520	8	1	12	0	0.78125	5.983	7.5331	0.115893	0.01449	0.1738	0	"	
Total/Average			396.5	452	9	1.5	8.25	0		5.744	6.548	0.13038	0.02173	0.1195	0		
96/10/16	O500729	S.Squally Pt.	721	743	25	3	27	0	0.78125	10.44	10.764	0.362166	0.04346	0.3911	0	absent	
96/10/16	O500729	S.Squally Pt.	787	723	28	3	17	0	0.78125	11.4	10.474	0.405626	0.04346	0.2463	0	"	
96/10/16	O500729	S.Squally Pt.	570	580	20	1	11	0	0.78125	8.257	8.4022	0.289733	0.01449	0.1594	0	absent	
96/10/16	O500729	S.Squally Pt.	653	648	20	3	15	0	0.78125	9.46	9.3873	0.289733	0.04346	0.2173	0	"	
Total/Average			682.75	673.5	23.25	2.5	17.5	0		9.891	9.7567	0.336814	0.03622	0.2535	0		
96/10/16	O500454	S.Prairie Cr.	233	228	4	1	5	0	0.78125	3.375	3.303	0.057947	0.01449	0.0724	0	absent	
96/10/16	O500454	S.Prairie Cr.	235	198	2	2	4	0	0.78125	3.404	2.8684	0.028973	0.02897	0.0579	0	"	
96/10/16	O500454	S.Prairie Cr.	277	196	6	3	10	0	0.78125	4.013	2.8394	0.08692	0.04346	0.1449	0	absent	
96/10/16	O500454	S.Prairie Cr.	296	232	5	4	11	0	0.78125	4.288	3.3609	0.072433	0.05795	0.1594	0	"	
Total/Average			260.25	213.5	4.25	2.5	7.5	0		3.77	3.0929	0.061568	0.03622	0.1086	0		
96/11/25	E206611	Vern.Out.	518	394	0	1	0	0	1.5625	3.752	2.8539	0	0.00724	0	0	absent	
96/11/25	E206611	Vern.Out.	514	395	0	0	0	0	1.5625	3.723	2.8611	0	0	0	0	"	
96/11/25	E206611	Vern.Out.	549	405	0	0	0	0	0.78125	7.953	5.8671	0	0	0	0	absent	
96/11/25	E206611	Vern.Out.	600	405	0	0	1	0	0.78125	8.692	5.8671	0	0	0.0145	0	"	
Total/Average			545.25	399.75	0	0.25	0.25	0		6.03	4.3623	0	0.00181	0.0036	0		
96/11/25	O500730	N.OK Centre	393	351	0	0	0	0	0.78125	5.693	5.0848	0	0	0	0	absent	
96/11/25	O500730	N.OK Centre	494	408	0	0	2	0	0.78125	7.156	5.9105	0	0	0.029	0	"	
96/11/25	O500730	N.OK Centre	482	352	0	0	0	0	0.78125	6.983	5.0993	0	0	0	0	absent	
96/11/25	O500730	N.OK Centre	531	378	0	0	0	0	0.78125	7.692	5.4759	0	0	0	0	"	
Total/Average			475	372.25	0	0	0.5	0		6.881	5.3927	0	0	0.0072	0		
96/11/25	O500456	UPS Kel.STP	580	566	2	0	1	0	0.78125	8.402	8.1994	0.028973	0	0.0145	0	absent	
96/11/25	O500456	UPS Kel.STP	693	638	1	0	2	0	0.78125	10.04	9.2425	0.014487	0	0.029	0	"	
96/11/25	O500456	UPS Kel.STP	493	420	0	0	5	0	0.78125	7.142	6.0844	0	0	0.0724	0	absent	
96/11/25	O500456	UPS Kel.STP	567	524	0	0	3	0	0.78125	8.214	7.591	0	0	0.0435	0	"	
Total/Average			583.25	537	0.75	0	2.75	0		8.449	7.7793	0.010865	0	0.0398	0		
			Calanoida	Cyclopoida	*Daphnia*	*Diaphanosoma*	*Bosmina*	%counted	Calanoida	Cyclopoida	*Daphnia*	*Diaphanosoma*	*Bosmina*	*Leptodora*	*Mysis*		
97/02/410	E206611	Vern.Out.	122	108	0	0	0	0.78	1.76737	1.565	0	0	0				
97/02/410	E206611	Vern.Out.	114	124	0	0	1	0.78	1.651476	1.796	0	0	0.0145				
97/02/410	E206611	Vern.Out.	178	159	0	0	0	0.78	2.578621	2.303	0	0	0				
97/02/410	E206611	Vern.Out.	180	137	0	0	0	0.78	2.607594	1.985	0	0	0				
Total/Average			594	528	0	0	1		2.151265	1.912	0	0	0.0036				
97/02/10	O500730	N.OK Centre	544	237	0	0	0	0.78	7.88073	3.433	0	0	0				
97/02/10	O500730	N.OK Centre	546	250	0	0	0	0.78	7.909703	3.622	0	0	0				
97/02/10	O500730	N.OK Centre	502	216	0	0	0	0.78	7.272291	3.129	0	0	0				
97/02/10	O500730	N.OK Centre	484	204	0	0	0	0.78	7.011532	2.955	0	0	0				
Total/Average			2076	907	0	0	0		7.518564	3.285	0	0	0				
97/02/17	O500456	UPS Kel.STP	191	171	0	0	0	0.78	2.766947	2.477	0	0	0				
97/02/17	O500456	UPS Kel.STP	206	177	0	0	0	0.78	2.984247	2.564	0	0	0				
97/02/17	O500456	UPS Kel.STP	154	89	0	0	0	0.78	2.230942	1.289	0	0	0				
97/02/17	O500456	UPS Kel.STP	185	104	0	0	0	0.78	2.680028	1.507	0	0	0				
Total/Average			736	541	0	0	0		2.665541	1.959	0	0	0				
97/02/17	O500236	DNS Kel.STP	337	289	0	0	0	0.78	4.881996	4.187	0	0	0				
97/02/17	O500236	DNS Kel.STP	366	329	0	0	0	0.78	5.302109	4.766	0	0	0				
97/02/17	O500236	DNS Kel.STP	272	258	0	0	0	0.78	3.940365	3.738	0	0	0				

	O500236	DNS Kel.STP	275	248	0	0	0	0.78	3.983825	3.593	0	0	0				
Total/Average			1250	1124	0	0	0		4.527074	4.071	0	0	0				
97/02/11	E223295	Rattlesnake	456	260	0	0	1	0.78	6.605906	3.767	0	0	0.0145				
97/02/11	E223295	Rattlesnake	440	213	0	0	0	0.78	6.37412	3.086	0	0	0				
97/02/11	E223295	Rattlesnake	407	184	0	0	0	0.78	5.896061	2.666	0	0	0				
97/02/11	E223295	Rattlesnake	464	202	0	0	0	0.78	6.721799	2.926	0	0	0				
Total/Average			1767	859	0	0	1		6.399471	3.111	0	0	0.0036				
97/02/11	O500729	S.Squally Pt.	199	178	0	0	0	0.78	2.88284	2.579	0	0	0				
97/02/11	O500729	S.Squally Pt.	179	190	0	0	0	0.78	2.593108	2.752	0	0	0				
97/02/11	O500729	S.Squally Pt.	175	196	0	0	0	0.78	2.535161	2.839	0	0	0				
97/02/11	O500729	S.Squally Pt.	176	222	0	0	0	0.78	2.549648	3.216	0	0	0				
Total/Average			729	786	0	0	0		2.640189	2.847	0	0	0				
97/02/11	O500454	S.Prairie Cr.	234	139	0	0	0	0.78	3.389873	2.014	0	0	0				
97/02/11	O500454	S.Prairie Cr.	265	168	0	0	0	0.78	3.838958	2.434	0	0	0				
97/02/11	O500454	S.Prairie Cr.	251	162	0	0	0	0.78	3.636146	2.347	0	0	0				
97/02/11	O500454	S.Prairie Cr.	236	160	0	0	0	0.78	3.418846	2.318	0	0	0				
Total/Average			986	629	0	0	0		3.570956	2.278	0	0	0				
97/03/13	O500847	Kala.D.B.	698	289	0	0	0	1.56	5.055836	2.093	0	0	0				
97/03/13	O500847	Kala.D.B.	576	269	0	0	0	1.56	4.172151	1.948	0	0	0				
97/03/13	O500847	Kala.D.B.	434	344	0	0	0	0.78	6.2872	4.983	0	0	0				
97/03/13	O500847	Kala.D.B.	503	299	0	0	0	0.78	7.286778	4.332	0	0	0				
Total/Average			2211	1201	0	0	0		5.700491	3.339	0	0	0				
97/03/16	E206611	Vern.Out.	234	127	0	0	0	0.78	3.389873	1.84	0	0	0				
97/03/16	E206611	Vern.Out.	243	109	0	0	0	0.78	3.520252	1.579	0	0	0				
97/03/16	E206611	Vern.Out.	305	145	0	0	0	0.78	4.418424	2.101	0	0	0				
97/03/16	E206611	Vern.Out.	329	160	0	0	0	0.78	4.766103	2.318	0	0	0				
Total/Average			1111	541	0	0	0		4.023663	1.959	0	0	0				
97/03/16	O500730	N.OK Centre	141	155	0	0	0	0.78	2.042616	2.245	0	0	0				
97/03/16	O500730	N.OK Centre	154	132	0	0	0	0.78	2.230942	1.912	0	0	0				
97/03/16	O500730	N.OK Centre	197	230	0	0	0	1.56	1.426934	1.666	0	0	0				
97/03/16	O500730	N.OK Centre	214	233	0	0	0	1.56	1.55007	1.688	0	0	0				
Total/Average			706	750	0	0	0		1.81264	1.878	0	0	0				
97/03/17	O500456	UPS Kel.STP	271	275	0	0	1	1.56	1.962939	1.992	0	0	0.0072				
97/03/17	O500456	UPS Kel.STP	319	295	0	0	0	1.56	2.310618	2.137	0	0	0				
97/03/17	O500456	UPS Kel.STP	232	216	0	0	0	1.56	1.68045	1.565	0	0	0				
97/03/17	O500456	UPS Kel.STP	257	229	0	0	0	1.56	1.861533	1.659	0	0	0				
Total/Average			1079	1015	0	0	1		1.953885	1.838	0	0	0.0018				
97/03/17	O500236	DNS Kel.STP	240	211	0	0	0	0.78	3.476793	3.057	0	0	0				
97/03/17	O500236	DNS Kel.STP	180	204	0	0	0	0.78	2.607594	2.955	0	0	0				
97/03/17	O500236	DNS Kel.STP	153	135	0	0	0	0.78	2.216455	1.956	0	0	0				
97/03/17	O500236	DNS Kel.STP	153	145	0	0	0	0.78	2.216455	2.101	0	0	0				
Total/Average			726	695	0	0	0		2.629324	2.517	0	0	0				
97/03/17	E223295	Rattlesnake	75	75	0	0	0	0.78	1.086498	1.086	0	0	0				
97/03/17	E223295	Rattlesnake	73	70	0	0	0	0.78	1.057524	1.014	0	0	0				
97/03/17	E223295	Rattlesnake	175	156	0	0	0	1.56	1.267581	1.13	0	0	0				
97/03/17	E223295	Rattlesnake	202	161	0	0	0	1.56	1.46315	1.166	0	0	0				
Total/Average			525	462	0	0	0		1.218688	1.099	0	0	0				
97/03/20	O500729	S.Squally Pt.	193	180	0	0	0	0.78	2.795921	2.608	0	0	0				
97/03/20	O500729	S.Squally Pt.	209	205	0	0	0	0.78	3.027707	2.97	0	0	0				
97/03/20	O500729	S.Squally Pt.	255	232	0	0	0	1.56	1.847046	1.68	0	0	0				
97/03/20	O500729	S.Squally Pt.	266	227	0	0	0	1.56	1.926723	1.644	0	0	0				
Total/Average			923	844	0	0	0		2.399349	2.226	0	0	0				
97/03/20	O500454	S.Prairie Cr.	268	176	0	0	0	1.56	1.941209	1.275	0	0	0				
97/03/20	O500454	S.Prairie Cr.	274	150	0	0	0	1.56	1.984669	1.086	0	0	0				
97/03/20	O500454	S.Prairie Cr.	141	98	0	0	0	0.78	2.042616	1.42	0	0	0				
97/03/20	O500454	S.Prairie Cr.	123	107	0	0	0	0.78	1.781856	1.55	0	0	0				
Total/Average			806	531	0	0	0		1.937587	1.333	0	0	0				
97/04/21	O500246	Kala.S.E.-W	215	158	0	0	0	0.78	3.114627	2.289	0	0	0				
97/04/21	O500246	Kala.S.E.-C	233	124	0	0	0	1.56	1.687693	0.898	0	0	0				
97/04/21	O500246	Kala.S.E.-E	256	154	0	0	0	1.56	1.854289	1.115	0	0	0				
Total/Average			704	436	0	0	0		2.21887	1.434	0	0	0				
97/04/21	O500847	Kala.D.B.-W	152	79	0	0	0	0.78	2.201969	1.144	0	0	0				
97/04/21	O500847	Kala.D.B.-C	444	211	0	0	0	1.56	3.216033	1.528	0	0	0				
97/04/21	O500847	Kala.D.B.-E	317	148	0	0	0	0.78	4.592263	2.144	0	0	0				
Total/Average			913	438	0	0	0		3.336755	1.606	0	0	0				
97/04/15	O500239	Arm.Arm-W	219	89	0	0	0	0.78	3.172573	1.289	0	0	0				
97/04/15	O500239	Arm.Arm-C	150	62	0	0	0	0.78	2.172995	0.898	0	0	0	present			
97/04/15	O500239	Arm.Arm-E	209	83	0	0	0	0.78	3.027707	1.202	0	0	0				
Total/Average			578	234	0	0	0		2.791092	1.13	0	0	0				
97/04/15	E206611	Vern.Out.-W	198	169	0	0	0	0.78	2.868354	2.448	0	0	0				
97/04/15	E206611	Vern.Out.-C	194	175	0	0	0	0.78	2.810407	2.535	0	0	0				
97/04/15	E206611	Vern.Out.-E	209	170	0	0	0	0.39	6.055336	4.925	0	0	0				
Total/Average			601	514	0	0	0		3.911366	3.303	0	0	0				
97/04/15	O500730	N.OK CentreW	154	82	0	0	0	1.56	1.115471	0.594	0	0	0				
97/04/15	O500730	N.OK Centre-C	199	126	0	0	0	0.78	2.88284	1.825	0	0	0				
97/04/15	O500730	N.OK Centre-E	124	102	0	0	0	0.78	1.796343	1.478	0	0	0				
Total/Average			477	310	0	0	0		1.931551	1.299	0	0	0				
97/04/15	O500456	UPS Kel.STP-W	185	104	0	0	0	1.56	1.340014	0.753	0	0	0				
97/04/15	O500456	UPS Kel.STP-C	187	154	0	0	0	0.78	2.709001	2.231	0	0	0				
97/04/15	O500456	UPS Kel.STP-E	132	90	0	0	0	0.78	1.912236	1.304	0	0	0				

Total/Average			504	348	0	0	0		1.987084	1.429	0	0	0				
97/04/16	O500236	DNS Kel.STP-W	169	109	0	0	0	0.78	2.448241	1.579	0	0	0				
97/04/16	O500236	DNS Kel.STP-C	201	204	0	0	0	0.78	2.911814	2.955	0	0	0				
97/04/16	O500236	DNS Kel.STP-E	158	103	0	0	0	0.78	2.288888	1.492	0	0	0				
Total/Average			528	416	0	0	0		2.549648	2.009	0	0	0				
97/04/10	E223295	Rattlesnake-W	181	157	0	0	0	1.56	1.311041	1.137	0	0	0				
97/04/10	E223295	Rattlesnake-C	188	135	0	0	0	1.56	1.361744	0.978	0	0	0				
97/04/10	E223295	Rattlesnake-E	159	130	0	0	0	1.56	1.151688	0.942	0	0	0				
Total/Average			528	422	0	0	0		1.274824	1.019	0	0	0				
97/04/10	O500729	S.Squally Pt.-W	254	273	0	0	0	1.56	1.839803	1.977	0	0	0				
97/04/10	O500729	S.Squally Pt.-C	118	86	0	0	0	0.78	1.709423	1.246	0	0	0				
97/04/10	O500729	S.Squally Pt.-E	110	76	0	0	0	0.78	1.59353	1.101	0	0	0				
Total/Average			482	435	0	0	0		1.714252	1.441	0	0	0				
97/04/17	O500454	S.Prairie Cr.-W	243	122	0	0	0	1.56	1.760126	0.884	0	0	0				
97/04/17	O500454	S.Prairie Cr.-C	248	137	0	0	0	1.56	1.796343	0.992	0	0	0				
97/04/17	O500454	S.Prairie Cr.-E	138	83	0	0	0	1.56	0.999578	0.601	0	0	0				
Total/Average			629	342	0	0	0		1.518682	0.826	0	0	0				
97/05/07	O500246	Kala.S.E.-W	138	172	0	0	0	0.78	1.999156	2.492	0	0	0				
97/05/07	O500246	Kala.S.E.-C	156	118	0	0	0	0.78	2.259915	1.709	0	0	0				
97/05/07	O500246	Kala.S.E.-E	229	269	0	0	0	0.78	3.31744	3.897	0	0	0				
Total/Average			523	559	0	0	0		2.525503	2.699	0	0	0				
97/05/07	O500847	Kala.D.B.-W	99	156	1	0	0	0.78	1.434177	2.26	0.014	0	0				
97/05/07	O500847	Kala.D.B.-C	180	97	0	0	0	0.39	5.215189	2.81	0	0	0				
97/05/07	O500847	Kala.D.B.-E	171	187	0	0	0	0.78	2.477215	2.709	0	0	0				
Total/Average			450	440	1	0	0		3.042193	2.593	0.005	0	0				
97/05/12	O500239	Arm.Arm-W	126	103	0	0	0	0.2	7.301264	5.968	0	0	0				
97/05/06	O500239	Arm.Arm-C	125	80	0	0	1	0.2	7.243318	4.636	0	0	0.0579	present			
97/05/06	O500239	Arm.Arm-E	169	133	0	1	0	0.2	9.792966	7.707	0	0.05795	0				
Total/Average			420	316	0	1	1		8.112516	6.104	0	0.01932	0.0193				
97/05/12	E206611	Vern.Out.-W	241	59	0	0	0	0.39	6.982558	1.709	0	0	0				
97/05/12	E206611	Vern.Out.-C	598	209	0	0	0	0.78	8.663008	3.028	0	0	0				
97/05/12	E206611	Vern.Out.-E	248	114	0	0	0	0.39	7.185371	3.303	0	0	0				
Total/Average			1087	382	0	0	0		7.610313	2.68	0	0	0				
97/05/12	O500730	N.OK CentreW	706	149	0	0	0	0.39	20.45513	4.317	0	0	0				
97/05/12	O500730	N.OK Centre-C	297	60	0	0	0	0.39	8.605061	1.738	0	0	0				
97/05/12	O500730	N.OK Centre-E	355	57	0	0	0	0.78	5.142756	0.826	0	0	0				
Total/Average			1358	266	0	0	0		11.40098	2.294	0	0	0				
97/05/12	O500456	UPS Kel.STP-W	277	57	0	0	1	0.78	4.012798	0.826	0	0	0.0145				
97/05/12	O500456	UPS Kel.STP-C	377	101	0	0	0	0.78	5.461462	1.463	0	0	0				
97/05/12	O500456	UPS Kel.STP-E	247	55	0	0	0	0.78	3.578199	0.797	0	0	0				
Total/Average			901	213	0	0	1		4.35082	1.029	0	0	0.0048				
97/05/06	O500236	DNS Kel.STP-W	306	115	0	0	0	0.39	8.865821	3.332	0	0	0				
97/05/06	O500236	DNS Kel.STP-C	744	200	0	0	0	0.78	10.77806	2.897	0	0	0				
97/05/06	O500236	DNS Kel.STP-E	299	106	0	0	0	0.39	8.663008	3.071	0	0	0				
Total/Average			1349	421	0	0	0		9.435629	3.1	0	0	0				
97/05/12	E223295	Rattlesnake-W	278	71	0	0	0	0.78	4.027285	1.029	0	0	0				
97/05/12	E223295	Rattlesnake-C	256	66	0	0	0	0.78	3.708579	0.956	0	0	0				
97/05/12	E223295	Rattlesnake-E	197	65	0	0	0	0.78	2.853867	0.942	0	0	0				
Total/Average			731	202	0	0	0		3.52991	0.975	0	0	0				
97/05/12	O500729	S.Squally Pt.-W	307	97	0	0	0	1.56	2.223699	0.703	0	0	0				
97/05/12	O500729	S.Squally Pt.-C	190	72	0	0	0	3.13	0.688115	0.261	0	0	0				
97/05/12	O500729	S.Squally Pt.-E	269	78	0	0	0	1.56	1.948452	0.565	0	0	0				
Total/Average			766	247	0	0	0		1.620089	0.509	0	0	0				
97/05/12	O500454	S.Prairie Cr.-W	422	65	0	0	0	0.78	6.11336	0.942	0	0	0				
97/05/12	O500454	S.Prairie Cr.-C	251	73	0	0	0	0.78	3.636146	1.058	0	0	0				
97/05/12	O500454	S.Prairie Cr.-E	241	51	0	0	0	0.78	3.491279	0.739	0	0	0				
Total/Average			914	189	0	0	0		4.413595	0.913	0	0	0				
97/06/09	O500246	Kala.S.E.-W	97	147	0	0	0	0.39	2.810407	4.259	0	0	0				
97/06/09	O500246	Kala.S.E.-C	90	276	3	1	0	0.39	2.607594	7.997	0.087	0.02897	0				
97/06/09	O500246	Kala.S.E.-E	98	241	1	0	0	0.39	2.839381	6.983	0.029	0	0				
Total/Average			285	664	4	1	0		2.752461	6.413	0.039	0.00966	0				
97/06/09	O500847	Kala.D.B.-W	120	294	4	3	0	0.39	3.476793	8.518	0.116	0.08692	0				
97/06/09	O500847	Kala.D.B.-C	102	212	3	1	0	0.2	5.910547	12.28	0.174	0.05795	0				
97/06/09	O500847	Kala.D.B.-E	108	307	1	1	0	0.39	3.129113	8.895	0.029	0.02897	0				
Total/Average			330	813	8	5	0		4.172151	9.899	0.106	0.05795	0				
97/06/16	O500239	Arm.Arm-W	176	300	12	6	21	0.2	10.19859	17.38	0.695	0.34768	1.2169	present	present		
97/06/16	O500239	Arm.Arm-C	153	382	14	27	65	0.2	8.865821	22.14	0.811	1.56456	3.7665	present	present		
97/06/16	O500239	Arm.Arm-E	197	414	13	20	32	0.2	11.41547	23.99	0.753	1.15893	1.8543	present	present		
Total/Average			526	1096	39	53	118		10.15996	21.17	0.753	1.02372	2.2792				
97/06/16	E206611	Vern.Out.-W	102	151	1	4	11	0.2	5.910547	8.75	0.058	0.23179	0.6374				
97/06/16	E206611	Vern.Out.-C	175	366	1	1	8	0.2	10.14064	21.21	0.058	0.05795	0.4636				
97/06/16	E206611	Vern.Out.-E	175	298	3	2	11	0.2	10.14064	17.27	0.174	0.11589	0.6374				
Total/Average			452	815	5	7	30		8.730612	15.74	0.097	0.13521	0.5795				
97/06/15	O500730	N.OK CentreW	187	175	1	0	1	0.2	10.836	10.14	0.058	0	0.0579				
97/06/15	O500730	N.OK Centre-C	262	286	2	3	2	0.39	7.590997	8.286	0.058	0.08692	0.0579				
97/06/15	O500730	N.OK Centre-E	177	195	0	0	4	0.39	5.128269	5.65	0	0	0.1159				
Total/Average			626	656	3	3	7		7.851756	8.026	0.039	0.02897	0.0773				
97/06/12	O500456	UPS Kel.STP-W	302	248	1	1	1	0.39	8.749928	7.185	0.029	0.02897	0.029				
97/06/12	O500456	UPS Kel.STP-C	382	332	0	0	0	0.39	11.06779	9.619	0	0	0	present			
97/06/12	O500456	UPS Kel.STP-E	340	307	0	2	0	0.39	9.850912	8.895	0	0.05795	0				
Total/Average			1024	887	1	3	1		9.889543	8.566	0.01	0.02897	0.0097				
97/06/12	O500236	DNS Kel.STP-W	337	273	1	0	0	0.39	9.763992	7.91	0.029	0	0	present			
97/06/12	O500236	DNS Kel.STP-C	268	201	0	1	4	0.39	7.764837	5.824	0	0.02897	0.1159	present			
97/06/12	O500236	DNS Kel.STP-E	321	207	0	2	2	0.39	9.30042	5.997	0	0.05795	0.0579	present			

Total/Average			926	681	1	3	6		8.943083	6.577	0.01	0.02897	0.0579				
97/06/11	E223295	Rattlesnake-W	262	166	0	0	0	0.39	7.590997	4.81	0	0	0				
97/06/11	E223295	Rattlesnake-C	269	237	0	0	0	0.39	7.79381	6.867	0	0	0	present			
97/06/11	E223295	Rattlesnake-E	278	214	0	0	0	0.39	8.054569	6.2	0	0	0				
Total/Average			809	617	0	0	0		7.813125	5.959	0	0	0				
97/06/11	O500729	S.Squally Pt.-W	232	125	0	0	0	0.39	6.721799	3.622	0	0	0				
97/06/11	O500729	S.Squally Pt.-C	224	152	0	2	0	0.39	6.490013	4.404	0	0.05795	0				
97/06/11	O500729	S.Squally Pt.-E	391	305	0	0	0	0.78	5.664274	4.418	0	0	0				
Total/Average			847	582	0	2	0		6.292029	4.148	0	0.01932	0				
97/06/11	O500454	S.Prairie Cr.-W	362	317	0	0	0	0.78	5.244162	4.592	0	0	0				
97/06/11	O500454	S.Prairie Cr.-C	474	339	0	0	1	0.78	6.866665	4.911	0	0	0.0145				
97/06/11	O500454	S.Prairie Cr.-E	374	227	0	1	0	0.78	5.418002	3.288	0	0.01449	0				
Total/Average			1210	883	0	1	1		5.842943	4.264	0	0.00483	0.0048				
			No. counted						% sample	No. per litre							
Date	Site No.	Location	*Diaptomus*	*Epischura*	*Cyclops*	*Daphnia*	*Diaph.*	*Bos.*	counted	*Diaptomus*	*Epischura*	*Cyclops*	*Daphnia*	*Diaph.*	*Bos.*	*Mysis*	*Leptodora*
97/07/07	O500246	Kala.S.E.-W	175	0	499	18	13	3	0.390625	5.07	0	14.4577	0.5215	0.377	0.09		
97/07/07	O500246	Kala.S.E.-C	126	0	401	16	17	2	0.390625	3.651	0	11.6183	0.4636	0.493	0.06		
97/07/07	O500246	Kala.S.E.-E	104	0	251	15	4	2	0.390625	3.013	0	7.27229	0.4346	0.116	0.06		
Total/Average			405	0	1151	49	34	7		3.911	0	11.1161	0.4732	0.328	0.07		
97/07/07	O500847	Kala.D.B.-W	101	0	377	20	10	1	0.390625	2.926	0	10.9229	0.5795	0.29	0.03		
97/07/07	O500847	Kala.D.B.-C	169	0	502	23	7	0	0.390625	4.896	0	14.5446	0.6664	0.203	0		
97/07/07	O500847	Kala.D.B.-E	87	0	259	10	13	2	0.195313	5.041	0	15.0082	0.5795	0.753	0.12		
Total/Average			357	0	1138	53	30	3		4.288	0	13.4919	0.6084	0.415	0.05		
97/07/07	0500247	Kala. Rattle-W															
97/07/07	0500247	Kala. Rattle-C	112	0	237	21	11	7	0.195313	6.49	0	13.7333	1.2169	0.637	0.41		
97/07/07	0500247	Kala. Rattle-E															
			112	0	237	21	11	7	0.195313	6.49	0	13.7333	1.2169	0.637	0.41		
97/07/09	O500239	Arm.Arm-W	507	4	1481	10	2	2	0.195313	29.38	0.232	85.8188	0.5795	0.116	0.12	present	present
97/07/09	O500239	Arm.Arm-C	294	1	956	6	4	0	0.195313	17.04	0.058	55.3969	0.3477	0.232	0	present	present
97/07/09	O500239	Arm.Arm-E	128	0	439	3	1	1	0.097656	14.83	0	50.8771	0.3477	0.116	0.12	present	present
Total/Average			929	5	2876	19	7	3		20.42	0.097	64.0309	0.4249	0.155	0.08		
97/07/09	E206611	Vern.Out.-W	93	1	237	5	6	1	0.390625	2.695	0.029	6.86667	0.1449	0.174	0.03		present
97/07/09	E206611	Vern.Out.-C	182	0	503	11	8	4	0.390625	5.273	0	14.5736	0.3187	0.232	0.12		
97/07/09	E206611	Vern.Out.-E	103	1	200	13	3	4	0.195313	5.968	0.058	11.5893	0.7533	0.174	0.23		present
Total/Average			378	2	940	29	17	9		4.645	0.029	11.0098	0.4056	0.193	0.13		
97/07/14	O500730	N.OK CentreW	267	3	436	19	2	4	0.195313	15.47	0.174	25.2647	1.101	0.116	0.23		present
97/07/14	O500730	N.OK Centre-C	263	3	461	11	5	10	0.390625	7.62	0.087	13.3567	0.3187	0.145	0.29		present
97/07/14	O500730	N.OK Centre-E	299	2	397	18	4	10	0.195313	17.33	0.116	23.0048	1.043	0.232	0.58		present
Total/Average			829	8	1294	48	11	24		13.47	0.126	20.542	0.8209	0.164	0.37		
97/07/14	O500456	UPS Kel.STP-W	201	4	586	22	4	66	0.390625	5.824	0.116	16.9783	0.6374	0.116	1.91		
97/07/14	O500456	UPS Kel.STP-C	109	1	307	9	1	18	0.195313	6.316	0.058	17.7896	0.5215	0.058	1.04	present	
97/07/14	O500456	UPS Kel.STP-E	174	6	547	12	6	48	0.390625	5.041	0.174	15.8484	0.3477	0.174	1.39	present	
Total/Average			484	11	1440	43	11	132		5.727	0.116	16.8721	0.5022	0.116	1.45		
97/07/15	O500236	DNS Kel.STP-W	109	8	442	2	1	54	0.390625	3.158	0.232	12.8062	0.0579	0.029	1.56	present	present
97/07/15	O500236	DNS Kel.STP-C	140	2	464	3	0	42	0.390625	4.056	0.058	13.4436	0.0869	0	1.22	present	
97/07/15	O500236	DNS Kel.STP-E	88	2	418	18	7	36	0.390625	2.55	0.058	12.1108	0.5215	0.203	1.04	present	present
Total/Average			337	12	1324	23	8	132		3.255	0.116	12.7869	0.2221	0.077	1.27		
97/07/10	E223295	Rattlesnake-W	176	0	458	3	8	28	0.195313	10.2	0	26.5395	0.1738	0.464	1.62		
97/07/10	E223295	Rattlesnake-C	111	0	248	0	4	15	0.195313	6.432	0	14.3707	0	0.232	0.87		
97/07/10	E223295	Rattlesnake-E	187	1	537	3	14	14	0.390625	5.418	0.029	15.5586	0.0869	0.406	0.41		
Total/Average			474	1	1243	6	26	57		7.35	0.01	18.823	0.0869	0.367	0.97		
97/07/10	O500729	S.Squally Pt.-W	240	0	455	4	12	15	0.390625	6.954	0	13.1828	0.1159	0.348	0.43		
97/07/10	O500729	S.Squally Pt.-C	171	2	486	1	7	15	0.390625	4.954	0.058	14.081	0.029	0.203	0.43		
97/07/10	O500729	S.Squally Pt.-E	101	1	309	1	6	9	0.195313	5.853	0.058	17.9055	0.0579	0.348	0.52		present
Total/Average			512	3	1250	6	25	39		5.92	0.039	15.0564	0.0676	0.299	0.46		
97/07/10	O500454	S.Prairie Cr.-W	122	0	366	1	14	21	0.390625	3.535	0	10.6042	0.029	0.406	0.61		
97/07/10	O500454	S.Prairie Cr.-C	163	2	436	1	19	38	0.390625	4.723	0.058	12.6323	0.029	0.55	1.1		
97/07/10	O500454	S.Prairie Cr.-E	177	1	439	0	16	24	0.390625	5.128	0.029	12.7193	0	0.464	0.7		
Total/Average			462	3	1241	2	49	83		4.462	0.029	11.9853	0.0193	0.473	0.8		
97/08/04	O500246	Kala.S.E.-W	84	1	398	21	39	11	0.390625	2.434	0.029	11.5314	0.6084	1.13	0.32		
97/08/04	O500246	Kala.S.E.-C	68	0	361	26	16	5	0.390625	1.97	0	10.4594	0.7533	0.464	0.14		
97/08/04	O500246	Kala.S.E.-E	65	2	322	17	22	9	0.390625	1.883	0.058	9.32939	0.4925	0.637	0.26		
Total/Average			217	3	1081	64	77	25		2.096	0.029	10.44	0.6181	0.744	0.24		
97/08/04	O500847	Kala.D.B.-W	87	3	436	8	23	7	0.390625	2.521	0.087	12.6323	0.2318	0.666	0.2		
97/08/04	O500847	Kala.D.B.-C	97	0	450	15	16	8	0.390625	2.81	0	13.038	0.4346	0.464	0.23		
97/08/04	O500847	Kala.D.B.-E	65	3	377	21	15	4	0.390625	1.883	0.087	10.9229	0.6084	0.435	0.12		
Total/Average			249	6	1263	44	54	19		2.405	0.058	12.1977	0.4249	0.522	0.18		
97/08/04	500247	Kala. Rattle-W	64	0	381	8	20	16	0.78125	0.927	0	5.51941	0.1159	0.29	0.23		
97/08/04	500247	Kala. Rattle-C	85	0	442	20	40	13	0.390625	2.463	0	12.8062	0.5795	1.159	0.38		
97/08/04	500247	Kala. Rattle-E	99	0	419	16	24	32	0.390625	2.868	0	12.1398	0.4636	0.695	0.93		
			248	0	1242	44	84	61		2.086	0	10.1551	0.3863	0.715	0.51		
97/08/10	O500239	Arm.Arm-W	171	3	632	11	7	1	0.195313	9.909	0.174	36.6222	0.6374	0.406	0.06	present	
97/08/10	O500239	Arm.Arm-C	154	2	660	6	4	0	0.195313	8.924	0.116	38.2447	0.3477	0.232	0	present	
97/08/10	O500239	Arm.Arm-E	169	1	836	8	7	0	0.195313	9.793	0.058	48.4433	0.4636	0.406	0	present	
Total/Average			494	6	2128	25	18	1		9.542	0.116	41.1034	0.4829	0.348	0.02		
97/08/10	E206611	Vern.Out.-W	224	7	637	4	7	2	0.390625	6.49	0.203	18.456	0.1159	0.203	0.06		present
97/08/10	E206611	Vern.Out.-C	228	3	571	12	14	1	0.390625	6.606	0.087	16.5437	0.3477	0.406	0.03		present
97/08/10	E206611	Vern.Out.-E	221	2	537	8	8	0	0.390625	6.403	0.058	15.5586	0.2318	0.232	0		
Total/Average			673	12	1745	24	29	3		6.5	0.116	16.8528	0.2318	0.28	0.03		
97/08/11	O500730	N.OK CentreW	103	1	190	7	2	2	0.390625	2.984	0.029	5.50492	0.2028	0.058	0.06		present
97/08/11	O500730	N.OK Centre-C	194	1	347	18	6	0	0.390625	5.621	0.029	10.0537	0.5215	0.174	0		present
97/08/11	O500730	N.OK Centre-E	210	4	395	16	9	1	0.390625	6.084	0.116	11.4444	0.4636	0.261	0.03		

Total/Average			507	6	932	41	17	3		4.896	0.058	9.00103	0.396	0.164	0.03		
97/08/13	O500456	UPS Kel.STP-W	179	4	421	27	7	1	0.390625	5.186	0.116	12.1977	0.7823	0.203	0.03		present
97/08/13	O500456	UPS Kel.STP-C	167	6	393	36	8	0	0.390625	4.839	0.174	11.3865	1.043	0.232	0		
97/08/13	O500456	UPS Kel.STP-E	136	3	322	37	16	0	0.390625	3.94	0.087	9.32939	1.072	0.464	0		present
Total/Average			482	13	1136	100	31	1		4.655	0.126	10.9712	0.9658	0.299	0.01		
97/08/13	O500236	DNS Kel.STP-W	287	3	506	30	12	0	0.390625	8.315	0.087	14.6605	0.8692	0.348	0		
97/08/13	O500236	DNS Kel.STP-C	252	4	473	29	11	0	0.390625	7.301	0.116	13.7044	0.8402	0.319	0		
97/08/13	O500236	DNS Kel.STP-E	207	6	415	25	8	1	0.390625	5.997	0.174	12.0239	0.7243	0.232	0.03		
Total/Average			746	13	1394	84	31	1		7.205	0.126	13.4629	0.8113	0.299	0.01		
97/08/07	E223295	Rattlesnake-W	148	1	387	31	4	0	0.390625	4.288	0.029	11.2127	0.8982	0.116	0		
97/08/07	E223295	Rattlesnake-C	153	3	423	22	6	0	0.390625	4.433	0.087	12.2557	0.6374	0.174	0		present
97/08/07	E223295	Rattlesnake-E	180	6	479	31	8	0	0.390625	5.215	0.174	13.8782	0.8982	0.232	0		
Total/Average			481	10	1289	84	18	0		4.645	0.097	12.4488	0.8113	0.174	0		
97/08/07	O500729	S.Squally Pt.-W	225	3	490	61	7	0	0.390625	6.519	0.087	14.1969	1.7674	0.203	0		present
97/08/07	O500729	S.Squally Pt.-C	150	3	352	59	4	0	0.390625	4.346	0.087	10.1986	1.7094	0.116	0		
97/08/07	O500729	S.Squally Pt.-E	sample spilled in transit!!!														
Total/Average			375	6	842	120	11	0		5.432	0.087	12.1977	1.7384	0.159	0		
97/08/07	O500454	S.Prairie Cr.-W	223	2	339	62	8	0	0.390625	6.461	0.058	9.82194	1.7963	0.232	0		
97/08/07	O500454	S.Prairie Cr.-C	219	1	381	53	5	0	0.390625	6.345	0.029	11.0388	1.5356	0.145	0		present
97/08/07	O500454	S.Prairie Cr.-E	246	3	408	62	9	0	0.390625	7.127	0.087	11.8211	1.7963	0.261	0		present
Total/Average			688	6	1128	177	22	0		6.645	0.058	10.8939	1.7094	0.212	0		
97/08/27	O500246	Kala.S.E.-W	117	4	367	9	14	4	0.39063	3.39	0.116	10.6331	0.2608	0.406	0.12		
97/08/27	O500246	Kala.S.E.-C	128	1	297	2	20	3	0.39063	3.709	0.029	8.60495	0.0579	0.579	0.09		
97/08/27	O500246	Kala.S.E.-E	109	1	366	3	28	2	0.39063	3.158	0.029	10.6041	0.0869	0.811	0.06		
Total/Average			354	6	1030	14	62	9		3.419	0.058	9.94736	0.1352	0.599	0.09		
97/08/27	O500847	Kala.D.B.-W	233	2	693	6	35	4	0.78125	3.375	0.029	10.0392	0.0869	0.507	0.06		
97/08/27	O500847	Kala.D.B.-C	91	3	282	3	20	0	0.78125	1.318	0.043	4.08523	0.0435	0.29	0		
97/08/27	O500847	Kala.D.B.-E	137	3	405	5	12	1	0.39063	3.969	0.087	11.734	0.1449	0.348	0.03		
Total/Average			461	8	1380	14	67	5		2.888	0.053	8.6195	0.0917	0.381	0.03		
97/08/27	500247	Kala. Rattle-W	72	3	264	3	27	1	0.39063	2.086	0.087	7.64885	0.0869	0.782	0.03		
97/08/27	500247	Kala. Rattle-C	109	2	349	6	24	0	0.39063	3.158	0.058	10.1115	0.1738	0.695	0		
97/08/27	500247	Kala. Rattle-E	174	1	615	12	30	6	0.78125	2.521	0.014	8.90928	0.1738	0.435	0.09		
			355	6	1228	21	81	7		2.588	0.053	8.88989	0.1449	0.637	0.04		
97/09/03	O500239	Arm.Arm-W	194	2	478	0	5	1	0.09766	22.48	0.232	55.3948	0	0.579	0.12	present	
97/09/03	O500239	Arm.Arm-C	104	3	328	1	1	0	0.09766	12.05	0.348	38.0115	0.1159	0.116	0	present	
97/09/03	O500239	Arm.Arm-E	84	2	251	0	0	0	0.09766	9.735	0.232	29.088	0	0	0	present	
Total/Average			382	7	1057	1	6	1		14.76	0.27	40.8314	0.0386	0.232	0.04		
97/09/03	E206611	Vern.Out.-W	191	7	371	0	6	1	0.39063	5.534	0.203	10.7489	0	0.174	0.03		
97/09/03	E206611	Vern.Out.-C	239	6	475	2	10	3	0.39063	6.925	0.174	13.7621	0.0579	0.29	0.09		
97/09/03	E206611	Vern.Out.-E	182	12	384	3	7	4	0.39063	5.273	0.348	11.1256	0.0869	0.203	0.12		
Total/Average			612	25	1230	5	23	8		5.91	0.241	11.8789	0.0483	0.222	0.08		
97/09/02	O500730	N.OK CentreW	90	6	174	0	2	0	0.39063	2.608	0.174	5.04128	0	0.058	0		
97/09/02	O500730	N.OK Centre-C	209	11	346	0	4	0	0.39063	6.055	0.319	10.0246	0	0.116	0		
97/09/02	O500730	N.OK Centre-E	174	5	324	1	8	1	0.39063	5.041	0.145	9.38722	0.029	0.232	0.03		
Total/Average			473	22	844	1	14	1		4.568	0.212	8.15104	0.0097	0.135	0.01		
97/09/04	O500456	UPS Kel.STP-W	182	3	342	0	7	2	0.39063	5.273	0.087	9.90873	0	0.203	0.06		
97/09/04	O500456	UPS Kel.STP-C	192	8	296	2	15	2	0.39063	5.563	0.232	8.57598	0.0579	0.435	0.06		
97/09/04	O500456	UPS Kel.STP-E	200	7	303	1	12	4	0.39063	5.795	0.203	8.77879	0.029	0.348	0.12		
Total/Average			574	18	941	3	34	8		5.543	0.174	9.08783	0.029	0.328	0.08		
97/09/11	O500236	DNS Kel.STP-W	145	7	300	0	15	9	0.39063	4.201	0.203	8.69187	0	0.435	0.26		
97/09/11	O500236	DNS Kel.STP-C	155	7	333	0	11	10	0.39063	4.491	0.203	9.64798	0	0.319	0.29		
97/09/11	O500236	DNS Kel.STP-E	197	13	357	0	12	7	0.39063	5.708	0.377	10.3433	0	0.348	0.2		
Total/Average			497	27	990	0	38	26		4.8	0.261	9.56106	0	0.367	0.25		
97/09/09	E223295	Rattlesnake-W	223	10	484	0	24	11	0.39063	6.461	0.29	14.0229	0	0.695	0.32		
97/09/09	E223295	Rattlesnake-C	119	6	314	0	11	3	0.39063	3.448	0.174	9.09749	0	0.319	0.09		
97/09/09	E223295	Rattlesnake-E	184	5	486	2	11	5	0.39063	5.331	0.145	14.0808	0.0579	0.319	0.14		
Total/Average			526	21	1284	2	46	19		5.08	0.203	12.4004	0.0193	0.444	0.18		
97/09/09	O500729	S.Squally Pt.-W	147	8	348	1	19	8	0.39063	4.259	0.232	10.0826	0.029	0.55	0.23		
97/09/09	O500729	S.Squally Pt.-C	205	9	401	1	8	4	0.39063	5.939	0.261	11.6181	0.029	0.232	0.12		
97/09/09	O500729	S.Squally Pt.-E	186	9	330	0	15	4	0.39063	5.389	0.261	9.56106	0	0.435	0.12		
Total/Average			538	26	1079	2	42	16		5.196	0.251	10.4206	0.0193	0.406	0.15		
97/09/01	O500454	S.Prairie Cr.-W	201	5	230	6	13	0	0.39063	5.824	0.145	6.66377	0.1738	0.377	0		
97/09/01	O500454	S.Prairie Cr.-C	204	7	344	15	1	1	0.39063	5.91	0.203	9.96668	0.4346	0.029	0.03		
97/09/01	O500454	S.Prairie Cr.-E	185	5	287	9	4	2	0.39063	5.36	0.145	8.31522	0.2608	0.116	0.06		
Total/Average			590	17	861	30	18	3		5.698	0.164	8.31522	0.2897	0.174	0.03		
97/10/14	O500246	Kala.S.E.-W	119	2	226	0	11	12	0.78125	1.724	0.029	3.27398	0	0.159	0.17		
97/10/14	O500246	Kala.S.E.-C	157	0	266	1	9	0	0.39063	4.549	0	7.70679	0.029	0.261	0		
97/10/14	O500246	Kala.S.E.-E	245	0	518	0	27	0	0.78125	3.549	0	7.50408	0	0.391	0		
Total/Average			521	2	1010	1	47	12		3.274	0.01	6.16162	0.0097	0.27	0.06		
97/10/14	O500847	Kala.D.B.-W	137	1	319	0	11	9	0.39063	3.969	0.029	9.24236	0	0.319	0.26		
97/10/14	O500847	Kala.D.B.-C	94	0	303	0	8	6	0.39063	2.723	0	8.77879	0	0.232	0.17		
97/10/14	O500847	Kala.D.B.-E	123	0	220	0	10	2	0.39063	3.564	0	6.37404	0	0.29	0.06		
Total/Average			354	1	842	0	29	17		3.419	0.01	8.13173	0	0.28	0.16		
97/10/14	0500247	Kala. Rattle-W							0.39063	0	0	0	0	0	0		
97/10/14	0500247	Kala. Rattle-C	124	0	226	0	5	5	0.39063	3.593	0	6.54788	0	0.145	0.14		
97/10/14	0500247	Kala. Rattle-E	80	2	266	0	14	0	0.39063	2.318	0.058	7.70679	0	0.406	0		
			204	2	492	0	19	5		2.955	0.029	7.12733	0	0.183	0.05		
97/10/15	O500239	Arm.Arm-W	138	0	284	16	0	20	0.39063	3.998	0	8.2283	0.4636	0	0.58	present	
97/10/15	O500239	Arm.Arm-C	162	3	338	17	10	26	0.39063	4.694	0.087	9.79284	0.4925	0.29	0.75	present	
97/10/15	O500239	Arm.Arm-E	159	2	377	16	8	17	0.39063	4.607	0.058	10.9228	0.4636	0.232	0.49	present	
Total/Average			459	5	999	49	18	63		4.433	0.048	9.64798	0.4732	0.174	0.61		
97/10/15	E206611	Vern.Out.-W	164	7	318	0	10	11	0.39063	4.752	0.203	9.21338	0	0.29	0.32		
97/10/15	E206611	Vern.Out.-C	136	12	326	1	7	20	0.39063	3.94	0.348	9.44517	0.029	0.203	0.58		
97/10/15	E206611	Vern.Out.-E	132	1	256	1	4	13	0.39063	3.824	0.029	7.41706	0.029	0.116	0.38		

Total/Average			432	20	900	2	21	44		4.172	0.193	8.69187	0.0193	0.203	0.42		
97/10/15	O500730	N.OK CentreW	143	2	311	0	9	16	0.39063	4.143	0.058	9.01057	0	0.261	0.46		
97/10/15	O500730	N.OK Centre-C	220	8	327	0	9	9	0.39063	6.374	0.232	9.47414	0	0.261	0.26		
97/10/15	O500730	N.OK Centre-E	221	9	317	0	6	20	0.39063	6.403	0.261	9.18441	0	0.174	0.58		
Total/Average			584	19	955	0	24	45		5.64	0.183	9.22304	0	0.232	0.43		
97/10/15	O500456	UPS Kel.STP-W	91	1	113	0	1	15	0.39063	2.637	0.029	3.27394	0	0.029	0.43		
97/10/15	O500456	UPS Kel.STP-C	144	11	182	0	4	12	0.39063	4.172	0.319	5.27307	0	0.116	0.35		
97/10/15	O500456	UPS Kel.STP-E	177	5	219	0	10	53	0.39063	5.128	0.145	6.34507	0	0.29	1.54		
Total/Average			412	17	514	0	15	80		3.979	0.164	4.96402	0	0.145	0.77		
97/10/16	O500236	DNS Kel.STP-W	138	4	252	0	6	18	0.39063	3.998	0.116	7.30117	0	0.174	0.52		
97/10/16	O500236	DNS Kel.STP-C	142	2	228	0	6	10	0.39063	4.114	0.058	6.60582	0	0.174	0.29		
97/10/16	O500236	DNS Kel.STP-E	298	11	368	0	8	31	0.39063	8.634	0.319	10.662	0	0.232	0.9		
Total/Average			578	17	848	0	20	59		5.582	0.164	8.18967	0	0.193	0.57		
97/10/16	E223295	Rattlesnake-W	247	6	299	0	3	19	0.39063	7.156	0.174	8.6629	0	0.087	0.55		
97/10/16	E223295	Rattlesnake-C	187	5	242	0	1	8	0.39063	5.418	0.145	7.01144	0	0.029	0.23		
97/10/16	E223295	Rattlesnake-E	199	6	311	0	1	39	0.39063	5.766	0.174	9.01057	0	0.029	1.13		
Total/Average			633	17	852	0	5	66		6.113	0.164	8.2283	0	0.048	0.64		
97/11/04	O500246	Kala.S.E.-W	208	0	423	0	9	1	0.39063	6.026	0	12.2555	0	0.261	0.03		
97/11/04	O500246	Kala.S.E.-C	354	0	519	0	8	1	0.78125	5.128	0	7.51856	0	0.116	0.01		
97/11/04	O500246	Kala.S.E.-E	151	0	275	1	3	0	0.39063	4.375	0	7.96755	0.029	0.087	0		
Total/Average			713	0	1217	1	20	2		5.177	0	9.24722	0.0097	0.155	0.01		
97/11/04	O500847	Kala.D.B.-W	66	0	215	0	4	1	0.39063	1.912	0	6.22917	0	0.116	0.03		
97/11/04	O500847	Kala.D.B.-C	97	0	200	0	2	0	0.39063	2.81	0	5.79458	0	0.058	0		
97/11/04	O500847	Kala.D.B.-E	84	0	237	0	4	0	0.39063	2.434	0	6.86658	0	0.116	0		
Total/Average			247	0	652	0	10	1		2.385	0	6.29678	0	0.097	0.01		
97/11/04	O500847	Kala. Rattle-W	136	1	249	0	8	0	0.39063	3.94	0.029	7.21425	0	0.232	0		
97/11/04	O500847	Kala. Rattle-C	201	1	481	2	9	4	0.78125	2.912	0.014	6.96807	0.029	0.13	0.06		
97/11/04	O500847	Kala. Rattle-E	159	0	436	0	4	2	0.78125	2.303	0	6.31617	0	0.058	0.03		
			496	2	1166	2	21	6		3.052	0.014	6.83283	0.0097	0.14	0.03		
97/11/11	O500239	Arm.Arm-W	225	0	230	112	5	111	0.39063	6.519	0	6.66377	3.245	0.145	3.22		
97/11/11	O500239	Arm.Arm-C	247	0	219	101	0	51	0.39063	7.156	0	6.34507	2.9263	0	1.48	present	
97/11/11	O500239	Arm.Arm-E	259	0	181	87	6	144	0.39063	7.504	0	5.24409	2.5206	0.174	4.17		
Total/Average			731	0	630	300	11	306		7.06	0	6.08431	2.8973	0.106	2.96		
97/11/11	E206611	Vern.Out.-W	220	1	279	1	3	8	0.39063	6.374	0.029	8.08344	0.029	0.087	0.23		
97/11/11	E206611	Vern.Out.-C	274	2	503	0	1	6	0.78125	3.969	0.029	7.28678	0	0.014	0.09		
97/11/11	E206611	Vern.Out.-E	240	0	490	1	6	15	0.78125	3.477	0	7.09845	0.0145	0.087	0.22		
Total/Average			734	3	1272	2	10	29		4.607	0.019	7.48956	0.0145	0.063	0.18		
97/11/11	O500730	N.OK CentreW	202	4	211	0	1	9	0.39063	5.853	0.116	6.11328	0	0.029	0.26		
97/11/11	O500730	N.OK Centre-C	196	3	245	1	1	23	0.39063	5.679	0.087	7.09836	0.029	0.029	0.67		
97/11/11	O500730	N.OK Centre-E	251	10	193	2	3	8	0.39063	7.272	0.29	5.59177	0.0579	0.087	0.23		
Total/Average			649	17	649	3	5	40		6.268	0.164	6.2678	0.029	0.048	0.39		
97/11/12	O500456	UPS Kel.STP-W	211	2	420	0	1	5	0.39063	6.113	0.058	12.1686	0	0.029	0.14		
97/11/12	O500456	UPS Kel.STP-C	197	1	308	0	1	7	0.39063	5.708	0.029	8.92365	0	0.029	0.2		
97/11/12	O500456	UPS Kel.STP-E	271	2	346	1	1	17	0.39063	7.852	0.058	10.0246	0.029	0.029	0.49		
Total/Average			679	5	1074	1	3	29		6.558	0.048	10.3723	0.0097	0.029	0.28		
97/11/12	O500236	DNS Kel.STP-W	104	7	302	0	1	1	0.78125	1.507	0.101	4.37496	0	0.014	0.01		
97/11/12	O500236	DNS Kel.STP-C	286	4	810	0	2	2	1.5625	2.072	0.029	5.86709	0	0.014	0.01		
97/11/12	O500236	DNS Kel.STP-E	127	1	420	0	0	2	0.78125	1.84	0.014	6.08439	0	0	0.03		
Total/Average			517	12	1532	0	3	5		1.806	0.048	5.44215	0	0.01	0.02		
97/11/12	E223295	Rattlesnake-W	222	1	218	0	0	0	0.39063	6.432	0.029	6.31609	0	0	0		
97/11/12	E223295	Rattlesnake-C	349	4	480	0	0	1	0.78125	5.056	0.058	6.95359	0	0	0.01		
97/11/12	E223295	Rattlesnake-E	194	2	184	0	0	0	0.39063	5.621	0.058	5.33101	0	0	0		
Total/Average			765	7	882	0	0	1		5.703	0.048	6.20023	0	0	0		
97/11/12	O500729	S.Squally Pt.-W	196	2	253	0	1	2	0.39063	5.679	0.058	7.33014	0	0.029	0.06		
97/11/12	O500729	S.Squally Pt.-C	204	0	227	0	0	1	0.39063	2.955	0	3.28847	0	0	0.01		
97/11/12	O500729	S.Squally Pt.-E	261	1	213	0	1	0	0.78125	3.781	0.014	3.08565	0	0.014	0		
Total/Average			661	3	693	0	2	3		4.138	0.024	4.56809	0	0.014	0.02		
97/11/06	O500454	S.Prairie Cr.-W	172	0	213	0	1	1	0.39063	4.983	0	6.17123	0	0.029	0.03		
97/11/06	O500454	S.Prairie Cr.-C	192	2	128	0	2	4	0.39063	5.563	0.058	3.70853	0	0.058	0.12		
97/11/06	O500454	S.Prairie Cr.-E	210	1	165	0	0	0	0.39063	6.084	0.029	4.78053	0	0	0		
Total/Average			574	3	506	0	3	5		5.543	0.029	4.88676	0	0.029	0.05		
97/12/07	O500246	Kala.S.E.-W	322	0	606	0	0	4	0.78125	4.665	0	8.7789	0	0	0.06		
97/12/07	O500246	Kala.S.E.-C	286	0	429	0	0	0	0.78125	4.143	0	6.21477	0	0	0		
97/12/07	O500246	Kala.S.E.-E	305	0	406	0	0	0	0.78125	4.418	0	5.88157	0	0	0		
Total/Average			913	0	1441	0	0	4		4.409	0	6.95841	0	0	0.02		
97/12/07	O500847	Kala.D.B.-W	295	0	404	0	0	0	0.78125	4.274	0	5.8526	0	0	0		
97/12/07	O500847	Kala.D.B.-C	350	0	375	0	0	0	0.78125	5.07	0	5.43249	0	0	0		
97/12/07	O500847	Kala.D.B.-E	261	0	353	0	0	0	0.78125	3.781	0	5.11378	0	0	0		
Total/Average			906	0	1132	0	0	0		4.375	0	5.46629	0	0	0		
97/12/07	0500247	Kala. Rattle-W	144	0	252	0	0	0	0.78125	2.086	0	3.65063	0	0	0		
97/12/07	0500247	Kala. Rattle-C	143	0	239	0	0	0	0.78125	2.072	0	3.46231	0	0	0		
97/12/07	0500247	Kala. Rattle-E	176	0	188	0	0	0	0.78125	2.55	0	2.72349	0	0	0		
			463	0	679	0	0	0		2.236	0	3.27881	0	0	0		
97/12/06	O500239	Arm.Arm-W	125	1	124	128	0	41	0.19532	7.243	0.058	7.1851	7.4169	0	2.38	present	
97/12/06	O500239	Arm.Arm-C	176	0	126	118	0	48	0.19532	10.2	0	7.30098	6.8374	0	2.78		
97/12/06	O500239	Arm.Arm-E	165	0	118	114	0	60	0.19532	9.561	0	6.83743	6.6057	0	3.48		
Total/Average			466	1	368	360	0	149		9.001	0.019	7.10784	6.9533	0	2.88		
97/12/06	E206611	Vern.Out.-W	186	0	176	0	0	1	0.39063	5.389	0	5.09923	0	0	0.03		
97/12/06	E206611	Vern.Out.-C	176	0	222	1	0	7	0.39063	5.099	0	6.43198	0.029	0	0.2		
97/12/06	E206611	Vern.Out.-E	183	0	199	0	0	2	0.39063	5.302	0	5.76561	0	0	0.06		
Total/Average			545	0	597	1	0	10		5.263	0	5.76561	0.0097	0	0.1		
97/12/06	O500730	N.OK CentreW	270	1	367	0	0	2	0.78125	3.911	0.014	5.3166	0	0	0.03		
97/12/06	O500730	N.OK Centre-C	357	0	376	1	0	0	0.78125	5.172	0	5.44697	0.0145	0	0		
97/12/06	O500730	N.OK Centre-E	432	2	371	0	0	1	0.78125	6.258	0.029	5.37454	0	0	0.01		

Total/Average			1059	3	1114	1	0	3		5.114	0.014	5.37937	0.0048	0	0.01		
97/12/06	O500456	UPS Kel.STP-W	373	1	538	0	0	3	0.78125	5.404	0.014	7.79381	0	0	0.04		
97/12/06	O500456	UPS Kel.STP-C	341	1	505	0	1	2	0.78125	4.94	0.014	7.31575	0	0.014	0.03		
97/12/06	O500456	UPS Kel.STP-E	314	0	393	0	0	0	0.78125	4.549	0	5.69325	0	0	0		
Total/Average			1028	2	1436	0	1	5		4.964	0.01	6.93427	0	0.005	0.02		
97/12/04	O500236	DNS Kel.STP-W	155	0	239	0	0	3	0.39063	4.491	0	6.92452	0	0	0.09		
97/12/04	O500236	DNS Kel.STP-C	190	0	247	0	0	1	0.39063	5.505	0	7.15631	0	0	0.03		
97/12/04	O500236	DNS Kel.STP-E	177	0	212	0	0	1	0.39063	5.128	0	6.14225	0	0	0.03		
Total/Average			522	0	698	0	0	5		5.041	0	6.74103	0	0	0.05		
97/12/04	E223295	Rattlesnake-W	335	1	240	0	0	2	0.39063	9.706	0.029	6.9535	0	0	0.06		
97/12/04	E223295	Rattlesnake-C	265	0	225	0	0	0	0.39063	7.678	0	6.5189	0	0	0		
97/12/04	E223295	Rattlesnake-E	223	0	191	0	0	1	0.39063	6.461	0	5.53382	0	0	0.03		
Total/Average			823	1	656	0	0	3		7.948	0.01	6.33541	0	0	0.03		
97/12/10	O500729	S.Squally Pt.-W	139	0	196	0	0	1	0.39063	4.027	0	5.67869	0	0	0.03		
97/12/10	O500729	S.Squally Pt.-C	292	0	377	0	0	0	0.78125	4.23	0	5.46146	0	0	0		
97/12/10	O500729	S.Squally Pt.-E	128	0	164	0	0	0	0.39063	3.709	0	4.75156	0	0	0		
Total/Average			559	0	737	0	0	1		3.989	0	5.29724	0	0	0.01		
97/12/08	O500454	S.Prairie Cr.-W															
97/12/08	O500454	S.Prairie Cr.-C	176	0	167	0	0	0	0.39063	5.099	0	4.83847	0	0	0		
97/12/08	O500454	S.Prairie Cr.-E	231	0	181	0	0	0	0.39063	6.693	0	5.24409	0	0	0		
Total/Average			407	0	348	0	0	0		5.896	0	5.04128	0	0	0		
			No. counted						% sample			No. per litre					
Date	Site No.	Location	*Diaptom*	*Epischura*	*Cyclops*	*Daphnia*	*Diaph.*	*Bos.*	counted	*Diaptom*	*Epischura*	*Cyclops*	*Daphnia*	*Diaph.*	*Bos.*	*Mysis*	
98/02/03	E206611	Vern.Out.-W	263	0	196	0	0	1	1.5625	1.905	0	1.41969	0	0	0.01		
98/02/03	E206611	Vern.Out.-C	276	0	234	0	0	0	1.5625	1.999	0	1.69494	0	0	0		
98/02/03	E206611	Vern.Out.-E	416	0	411	0	0	1	3.125	1.507	0	1.4885	0	0	0		
Total/Average			955	0	841	0	0	2		1.804	0	1.53438	0	0	0		
98/02/03	O500730	N.OK CentreW	291	0	226	0	0	0	3.125	1.054	0	0.81849	0	0	0		
98/02/03	O500730	N.OK Centre-C	290	0	163	0	0	0	3.125	1.05	0	0.59033	0	0	0		
98/02/03	O500730	N.OK Centre-E	304	0	192	0	0	0	3.125	1.101	0	0.69536	0	0	0		
Total/Average			885	0	581	0	0	0		1.068	0	0.70139	0	0	0		
98/02/05	O500456	UPS Kel.STP-W	316	0	152	0	0	2	3.125	1.144	0	0.55049	0	0	0.01		
98/02/05	O500456	UPS Kel.STP-C	234	0	231	0	0	0	3.125	0.847	0	0.8366	0	0	0		
98/02/05	O500456	UPS Kel.STP-E	122	0	105	0	0	0	3.125	0.442	0	0.38027	0	0	0		
Total/Average			672	0	488	0	0	2		0.811	0	0.58912	0	0	0		
98/02/02	O500236	DNS Kel.STP-W	1103	0	562	0	0	0	3.125	3.995	0	2.03537	0	0	0		
98/02/02	O500236	DNS Kel.STP-C	1070	0	581	0	0	0	3.125	3.875	0	2.10418	0	0	0		
98/02/02	O500236	DNS Kel.STP-E	181	0	162	0	0	1	1.5625	1.311	0	1.17342	0	0	0.01		
Total/Average			2354	0	1305	0	0	1		3.06	0	1.77099	0	0	0		
98/02/09	E223295	Rattlesnake-W	304	0	320	0	0	0	3.125	1.101	0	1.15893	0	0	0		
98/02/09	E223295	Rattlesnake-C	602	0	466	0	0	0	3.125	2.18	0	1.68769	0	0	0		
98/02/09	E223295	Rattlesnake-E	600	0	504	0	0	0	3.125	2.173	0	1.82532	0	0	0		
Total/Average			1506	0	1290	0	0	0		1.818	0	1.55731	0	0	0		
98/02/09	O500729	S.Squally Pt.-W	212	0	158	0	0	0	1.5625	1.536	0	1.14444	0	0	0		
98/02/09	O500729	S.Squally Pt.-C	373	0	295	0	0	1	3.125	1.351	0	1.06839	0	0	0		
98/02/09	O500729	S.Squally Pt.-E	368	0	262	0	0	0	3.125	1.333	0	0.94887	0	0	0		
Total/Average			953	0	715	0	0	1		1.406	0	1.0539	0	0	0		
98/02/09	O500454	S.Prairie Cr.-W	410	0	383	0	0	0	3.125	1.485	0	1.3871	0	0	0		
98/02/09	O500454	S.Prairie Cr.-C	350	0	246	0	0	0	3.125	1.268	0	0.89093	0	0	0		
98/02/09	O500454	S.Prairie Cr.-E	448	0	342	0	0	0	3.125	1.623	0	1.23861	0	0	0		
Total/Average			1208	0	971	0	0	0		1.458	0	1.17221	0	0	0		
Feb. 23-Mar 12																	
			No. counted						% sample			No. per litre					
Date	Site No.	Location	*Diaptom*	*Epischura*	*Cyclops*	*Daphnia*	*Diaph.*	*Bos.*	counted	*Diaptom*	*Epischura*	*Cyclops*	*Daphnia*	*Diaph.*	*Bos.*		
98/02/23	O500246	Kala.S.E.-W	359	0	199	0	0	0	6.25	0.65	0	0.36036	0	0	0		
98/02/23	O500246	Kala.S.E.-C	427	0	288	0	0	0	3.125	1.546	0	1.04304	0	0	0		
98/02/23	O500246	Kala.S.E.-E	341	0	331	0	0	0	1.5625	2.47	0	2.39754	0	0	0		
Total/Average			1127	0	818	0	0	0		1.556	0	1.26698	0	0	0		
98/02/23	O500847	Kala.D.B.-W	366	0	296	0	0	0	3.125	1.326	0	1.07201	0	0	0		
98/02/23	O500847	Kala.D.B.-C	209	0	173	0	0	0	3.125	0.757	0	0.62655	0	0	0		
98/02/23	O500847	Kala.D.B.-E	429	0	269	0	0	0	3.125	1.554	0	0.97423	0	0	0		
Total/Average			1004	0	738	0	0	0		1.212	0	0.89093	0	0	0		
98/02/23	O500847	Kala. Rattle-W	377	0	249	0	0	0	1.5625	2.731	0	1.80359	0	0	0		
98/02/23	O500847	Kala. Rattle-C	404	0	331	0	0	0	1.5625	2.926	0	2.39754	0	0	0		
98/02/23	O500847	Kala. Rattle-E	331	0	329	0	0	0	1.5625	2.398	0	2.38305	0	0	0		
			1112	0	909	0	0	0		2.685	0	2.19473	0	0	0		
98/03/11	E206611	Vern.Out.-W	227	0	107	0	0	0	0.78125	3.288	0	1.55007	0	0	0		
98/03/11	E206611	Vern.Out.-C	515	0	134	0	0	0	0.78125	7.461	0	1.94121	0	0	0		
98/03/11	E206611	Vern.Out.-E	484	0	178	0	0	0	0.78125	7.012	0	2.57862	0	0	0		
Total/Average			1226	0	419	0	0	0		5.92	0	2.0233	0	0	0		
98/03/12	O500730	N.OK CentreW	261	0	52	0	0	0	1.5625	1.891	0	0.37665	0	0	0		
98/03/12	O500730	N.OK Centre-C	274	0	79	0	0	0	1.5625	1.985	0	0.57222	0	0	0		
98/03/12	O500730	N.OK Centre-E	467	0	108	0	0	0	3.125	1.691	0	0.39114	0	0	0		
Total/Average			1002	0	239	0	0	0		1.855	0	0.44667	0	0	0		
98/03/09	O500456	UPS Kel.STP-W	245	0	42	0	0	0	6.25	0.444	0	0.07605	0	0	0		
98/03/09	O500456	UPS Kel.STP-C	322	0	54	0	0	1	3.125	1.166	0	0.19557	0	0	0		
98/03/09	O500456	UPS Kel.STP-E	313	0	43	0	0	0	3.125	1.134	0	0.15573	0	0	0		
Total/Average			880	0	139	0	0	1		0.914	0	0.14245	0	0	0		
98/03/09	O500236	DNS Kel.STP-W	340	0	147	0	0	0	1.5625	2.463	0	1.06477	0	0	0		
98/03/09	O500236	DNS Kel.STP-C	248	0	82	0	0	0	1.5625	1.796	0	0.59395	0	0	0		
98/03/09	O500236	DNS Kel.STP-E	329	0	191	0	0	0	3.125	1.192	0	0.69174	0	0	0		
Total/Average			917	0	420	0	0	0		1.817	0	0.78349	0	0	0		
98/03/10	E223295	Rattlesnake-W	197	0	124	0	0	0	3.125	0.713	0	0.44909	0	0	0		
98/03/10	E223295	Rattlesnake-C	436	0	296	0	0	0	3.125	1.579	0	1.07201	0	0	0		
98/03/10	E223295	Rattlesnake-E	346	0	222	0	0	0	3.125	1.253	0	0.80401	0	0	0		

Total/Average			979	0	642	0	0	0		1.182	0	0.77503	0	0	0		
98/03/10	O500729	S.Squally Pt.-W	253	0	189	0	0	0	3.125	0.916	0	0.68449	0	0	0		
98/03/10	O500729	S.Squally Pt.-C	245	0	246	0	0	0	3.125	0.887	0	0.89093	0	0	0		
98/03/10	O500729	S.Squally Pt.-E	229	0	119	0	0	0	3.125	0.829	0	0.43098	0	0	0		
Total/Average			727	0	554	0	0	0		0.878	0	0.6688	0	0	0		
98/03/10	O500454	S.Prairie Cr.-W	402	0	338	0	0	0	3.125	1.456	0	1.22412	0	0	0		
98/03/10	O500454	S.Prairie Cr.-C	310	0	246	0	0	0	3.125	1.123	0	0.89093	0	0	0		
98/03/10	O500454	S.Prairie Cr.-E	285	0	196	0	0	0	3.125	1.032	0	0.70985	0	0	0		
Total/Average			997	0	780	0	0	0		1.204	0	0.94163	0	0	0		
			No. counted						% sample			No. per litre					
Date	Site No.	Location	*Diaptom*	*Epischura*	*Cyclops*	*Daphnia*	*Diaph.*	*Bos.*	counted	*Diapto*	*Epischura*	*Cyclops*	*Daphnia*	*Diaph.*	*Bos.*		
98/03/23	O500246	Kala.S.E.-W	518	0	189	0	0	0	3.125	1.876	0	0.68449	0	0	0		
98/03/23	O500246	Kala.S.E.-C	272	0	136	0	0	0	3.125	0.985	0	0.49255	0	0	0		
98/03/23	O500246	Kala.S.E.-E	302	0	237	0	0	0	3.125	1.094	0	0.85833	0	0	0		
Total/Average			1092	0	562	0	0	0		1.318	0	0.67846	0	0	0		
98/03/23	O500847	Kala.D.B.-W	511	0	323	0	0	0	3.125	1.851	0	1.1698	0	0	0		
98/03/23	O500847	Kala.D.B.-C	346	0	223	0	0	0	3.125	1.253	0	0.80763	0	0	0		
98/03/23	O500847	Kala.D.B.-E	426	0	222	0	0	0	3.125	1.543	0	0.80401	0	0	0		
Total/Average			1283	0	768	0	0	0		1.549	0	0.92714	0	0	0		
98/03/23	O500847	Kala. Rattle-W	356	0	297	0	0	0	1.5625	2.579	0	2.15127	0	0	0		
98/03/23	O500847	Kala. Rattle-C	283	0	194	0	0	0	1.5625	2.05	0	1.4052	0	0	0		
98/03/23	O500847	Kala. Rattle-E	268	0	198	0	0	0	1.5625	1.941	0	1.43418	0	0	0		
			907	0	689	0	0	0		2.19	0	1.66355	0	0	0		
98/04/02	O500239	Arm.Arm-W	391	0	292	10	0	3	1.5625	2.832	0	2.11505	0.0724	0	0.02	present	
98/04/02	O500239	Arm.Arm-C	209	0	117	7	1	1	0.78125	3.028	0	1.69494	0.1014	0.014	0.01	present	
98/04/02	O500239	Arm.Arm-E	415	0	224	5	0	3	1.5625	3.006	0	1.6225	0.0362	0	0.02	present	
Total/Average			1015	0	633	22	1	7		2.955	0	1.81083	0.07	0.005	0.02		
98/04/02	E206611	Vern.Out.-W	689	0	128	0	0	0	1.5625	4.991	0	0.92714	0	0	0		
98/04/02	E206611	Vern.Out.-C	619	0	122	0	0	1	1.5625	4.484	0	0.88368	0	0	0.01		
98/04/02	E206611	Vern.Out.-E	580	0	140	0	0	0	3.125	2.101	0	0.50703	0	0	0		
Total/Average			1888	0	390	0	0	1		3.858	0	0.77262	0	0	0		
98/04/04	O500730	N.OK CentreW	407	0	44	0	0	0	3.125	1.474	0	0.15935	0	0	0		
98/04/04	O500730	N.OK Centre-C	294	0	52	0	0	0	1.5625	2.13	0	0.37665	0	0	0		
98/04/04	O500730	N.OK Centre-E	457	0	50	0	0	0	1.5625	3.31	0	0.36217	0	0	0		
Total/Average			1158	0	146	0	0	0		2.305	0	0.29939	0	0	0		
98/04/04	O500456	UPS Kel.STP-W	696	0	70	0	0	0	3.125	2.521	0	0.25352	0	0	0		
98/04/04	O500456	UPS Kel.STP-C	429	0	106	0	0	0	3.125	1.554	0	0.3839	0	0	0		
98/04/04	O500456	UPS Kel.STP-E	246	0	59	0	0	0	3.125	0.891	0	0.21368	0	0	0		
Total/Average			1371	0	235	0	0	0		1.655	0	0.2837	0	0	0		
98/03/31	O500236	DNS Kel.STP-W	458	0	108	0	0	0	0.78125	6.635	0	1.56456	0	0	0		
98/03/31	O500236	DNS Kel.STP-C	374	0	65	0	0	0	1.5625	2.709	0	0.47082	0	0	0		
98/03/31	O500236	DNS Kel.STP-E	473	0	109	0	0	0	1.5625	3.426	0	0.78952	0	0	0		
Total/Average			1305	0	282	0	0	0		4.257	0	0.94163	0	0	0		
98/03/31	E223295	Rattlesnake-W	207	0	35	0	0	0	3.125	0.75	0	0.12676	0	0	0		
98/03/31	E223295	Rattlesnake-C	320	0	78	0	0	0	3.125	1.159	0	0.28249	0	0	0		
98/03/31	E223295	Rattlesnake-E	427	0	102	0	0	0	3.125	1.546	0	0.36941	0	0	0		
Total/Average			954	0	215	0	0	0		1.152	0	0.25955	0	0	0		
98/03/31	O500729	S.Squally Pt.-W	594	0	104	0	0	0	3.125	2.151	0	0.37665	0	0	0		
98/03/31	O500729	S.Squally Pt.-C	555	0	86	0	0	0	3.125	2.01	0	0.31146	0	0	0		
98/03/31	O500729	S.Squally Pt.-E	338	0	52	0	0	0	3.125	1.224	0	0.18833	0	0	0		
Total/Average			1487	0	242	0	0	0		1.795	0	0.29215	0	0	0		
98/03/31	O500454	S.Prairie Cr.-W	431	0	72	0	0	0	1.5625	3.122	0	0.52152	0	0	0		
98/03/31	O500454	S.Prairie Cr.-C	332	0	90	0	0	0	1.5625	2.405	0	0	0	0	0		
98/03/31	O500454	S.Prairie Cr.-E	290	0	101	0	0	0	1.5625	2.101	0	0.73158	0	0	0		
Total/Average			1053	0	263	0	0	0		2.542	0	0.4177	0	0	0		
			No. counted						% sample			No. per litre					
Date	Site No.	Location	*Diaptom*	*Epischura*	*Cyclops*	*Daphnia*	*Diaph.*	*Bos.*	counted	*Diapto*	*Epischura*	*Cyclops*	*Daphnia*	*Diaph.*	*Bos.*		
98/04/20	O500847	Kala.D.B.-W	411	0	309	0	0	0	1.5625	2.977	0	2.23819	0	0	0		
98/04/20	O500847	Kala.D.B.-C	319	0	255	0	0	0	1.5625	2.311	0	1.84705	0	0	0		
98/04/20	O500847	**Kala.D.B.-E	257	0	121	0	0	0	1.5625	1.862	0	0.87644	0	0	0		
Total/Average			987	0	685	0	0	0		2.383	0	1.65389	0	0	0		
98/04/28	O500239	Arm.Arm-W	516	5	252	29	0	14	0.78125	7.475	0.072	3.65063	0.4201	0	0.2	present	
98/04/28	O500239	Arm.Arm-C	612	0	232	21	3	16	0.78125	8.866	0	3.3609	0.3042	0.043	0.23	present	
98/04/28	O500239	Arm.Arm-E	591	0	276	38	1	2	0.78125	8.562	0	3.99831	0.5505	0.014	0.03	present	
Total/Average			1719	5	760	88	4	32		8.301	0.024	3.66995	0.4249	0.019	0.15		
98/04/28	E206611	Vern.Out.-W	1235	0	369	1	0	1	1.5625	8.945	0	2.67278	0.0072	0	0.01		
98/04/28	E206611	Vern.Out.-C	1222	0	379	1	0	0	1.5625	8.851	0	2.74522	0.0072	0	0		
98/04/28	E206611	Vern.Out.-E	1034	0	227	1	0	0	1.5625	7.49	0	1.64423	0.0072	0	0		
Total/Average			3491	0	975	3	0	1		8.429	0	2.35408	0.0072	0	0		
98/04/28	O500730	N.OK CentreW	465	0	103	0	0	0	0.78125	6.736	0	1.49212	0	0	0		
98/04/28	O500730	N.OK Centre-C	438	0	108	0	0	0	0.78125	6.345	0	1.56456	0	0	0		
98/04/28	O500730	N.OK Centre-E	529	0	104	0	0	0	0.78125	7.663	0	1.50661	0	0	0		
Total/Average			1432	0	315	0	0	0		6.915	0	1.5211	0	0	0		
98/04/22	E223295	Rattlesnake-W	432	0	50	0	0	1	1.5625	3.129	0	0.36217	0	0	0.01		
98/04/22	E223295	Rattlesnake-C	301	0	44	0	0	0	1.5625	2.18	0	0.31871	0	0	0		
98/04/22	E223295	Rattlesnake-E	378	0	46	0	0	0	1.5625	2.738	0	0.33319	0	0	0		

Total/Average			1111	0	140	0	0	1		2.682	0	0.33802	0	0	0		
98/04/22	O500454	S.Prairie Cr.-W	294	0	21	0	0	0	1.5625	2.13	0	0.15211	0	0	0		
98/04/22	O500454	S.Prairie Cr.-C	324	0	36	0	0	0	1.5625	2.347	0	0.26076	0	0	0		
98/04/22	O500454	S.Prairie Cr.-E	330	0	47	0	0	0	1.5625	2.39	0	0.34044	0	0	0		
Total/Average			948	0	104	0	0	0		2.289	0	0.2511	0	0	0		
**haul taken after dusk - full of mysids!!!																	
			No. counted						% sample			No. per litre					
Date	Site No.	Location	*Diaptom*	*Epischura*	*Cyclops*	*Daphnia*	*Diaph.*	*Bos.*	counted	*Diapto*	*Epischura*	*Cyclops*	*Daphnia*	*Diaph.*	*Bos.*		
98/05/26	O500847	Kala.D.B.-W	195	0	517	7	0	0	0.78125	2.825	0	7.48959	0.1014	0	0		
98/05/26	O500847	Kala.D.B.-C	173	0	653	1	0	0	0.78125	2.506	0	9.45977	0.0145	0	0		
98/05/26	O500847	Kala.D.B.-E	237	0	882	6	4	0	1.5625	1.717	0	6.38861	0.0435	0.029	0		
Total/Average			605	0	2052	14	4	0		2.349	0	7.77932	0.0531	0.01	0		
98/06/10	O500239	Arm.Arm-W	386	0	759	45	46	1	0.78125	5.592	0	10.9954	0.6519	0.666	0.01	present	
98/06/10	O500239	Arm.Arm-C	375	1	671	57	29	0	0.78125	5.432	0.014	9.72053	0.8257	0.42	0	present	
98/06/10	O500239	Arm.Arm-E	461	1	724	34	49	1	0.78125	6.678	0.014	10.4883	0.4925	0.71	0.01	present	
Total/Average			1222	2	2154	136	124	2		5.901	0.01	10.4014	0.6567	0.599	0.01		
98/06/10	E206611	Vern.Out.-1W	323	0	234	29	15	8	0.78125	4.679	0	3.38987	0.4201	0.217	0.12		
98/06/10	E206611	Vern.Out.-C	315	0	230	33	11	1	0.78125	4.563	0	3.33193	0.4781	0.159	0.01		
98/06/10	E206611	Vern.Out.-2W	360	0	232	32	6	2	0.78125	5.215	0	3.3609	0.4636	0.087	0.03		
Total/Average			998	0	696	94	32	11		4.819	0	3.3609	0.4539	0.155	0.05		
98/06/10	O500730	N.OK CentreW	311	0	425	12	2	3	0.78125	4.505	0	6.15682	0.1738	0.029	0.04		
98/06/10	O500730	N.OK Centre-C	317	0	409	15	3	0	0.78125	4.592	0	5.92503	0.2173	0.043	0		
98/06/10	O500730	N.OK Centre-E	249	0	355	13	2	3	0.78125	3.607	0	5.14276	0.1883	0.029	0.04		
Total/Average			877	0	1189	40	7	6		4.235	0	5.74154	0.1932	0.034	0.03		
98/05/28	E223295	Rattlesnake-W	476	0	310	0	1	0	1.5625	3.448	0	2.24543	0	0.007	0		
98/05/28	E223295	Rattlesnake-C	517	0	232	0	0	0	1.5625	3.745	0	1.68045	0	0	0		
98/05/28	E223295	Rattlesnake-E	264	0	233	0	0	0	1.5625	1.912	0	1.68769	0	0	0		
Total/Average			1257	0	775	0	1	0		3.035	0	1.87119	0	0.002	0		
98/05/28	O500454	S.Prairie Cr.-W	568	0	75	0	0	0	3.125	2.057	0	0.27162	0	0	0		
98/05/28	O500454	S.Prairie Cr.-C	630	0	109	0	1	0	3.125	2.282	0	0.39476	0	0.004	0		
98/05/28	O500454	S.Prairie Cr.-E	733	0	107	0	0	0	3.125	2.655	0	0.38752	0	0	0		
Total/Average			1931	0	291	0	1	0		2.331	0	0.3513	0	0.001	0		
			No. counted						% sample			No. per litre					
Date	Site No.	Location	*Diaptom*	*Epischura*	*Cyclops*	*Daphnia*	*Diaph.*	*Bos.*	counted	*Diapto*	*Epischura*	*Cyclops*	*Daphnia*	*Diaph.*	*Bos.*		
98/06/17	O500847	Kala.D.B.-W	257	0	802	40	19	0	1.5625	1.862	0	5.80914	0.2897	0.138	0		
98/06/17	O500847	Kala.D.B.-C	273	2	1002	23	12	0	1.5625	1.977	0.014	7.2578	0.1666	0.087	0		
98/06/17	O500847	Kala.D.B.-E	191	0	1150	35	15	0	1.5625	1.383	0	8.32982	0.2535	0.109	0		
Total/Average			721	2	2954	98	46	0		1.741	0.005	7.13225	0.2366	0.111	0		
98/07/06	O500239	Arm.Arm-W	424	7	812	21	18	1	0.78125	6.142	0.101	11.7631	0.3042	0.261	0.01	present	
98/07/06	O500239	Arm.Arm-C	227	0	383	13	6	2	0.390625	3.462	0.13	5.15724	0.7388	0.246	0	present	
98/07/06	O500239	Arm.Arm-E	414	6	841	22	35	4	0.78125	5.997	0.087	12.1833	0.3187	0.507	0.06	present	
Total/Average			1065	13	2036	56	59	7		5.201	0.106	9.70122	0.4539	0.338	0.02		
98/07/06	E206611	Vern.Out.-1W	243	8	355	31	12	0	0.78125	3.52	0.116	5.14276	0.4491	0.174	0		
98/07/06	E206611	Vern.Out.-C	239	9	356	51	17	0	0.78125	3.462	0.13	5.15724	0.7388	0.246	0		
98/07/06	E206611	Vern.Out.-2W	258	9	408	43	15	1	0.78125	3.738	0.13	5.91055	0.6229	0.217	0.01		
Total/Average			740	26	1119	125	44	1		3.573	0.126	5.40352	0.6036	0.212	0		
98/07/06	O500730	N.OK CentreW	473	8	527	39	25	4	1.5625	3.426	0.058	3.81723	0.2825	0.181	0.03		
98/07/06	O500730	N.OK Centre-C	291	2	321	24	13	2	0.78125	4.216	0.029	4.65021	0.3477	0.188	0.03		
98/07/06	O500730	N.OK Centre-E	487	10	789	72	23	0	1.5625	3.527	0.072	5.71498	0.5215	0.167	0		
Total/Average			1251	20	1637	135	61	6		3.723	0.053	4.72747	0.3839	0.179	0.02		
98/06/23	E223295	Rattlesnake-W	345	0	718	1	1	2	1.5625	2.499	0	5.2007	0.0072	0.007	0.01		
98/06/23	E223295	Rattlesnake-C	307	0	513	1	1	2	1.5625	2.224	0	3.71582	0.0072	0.007	0.01		
98/06/23	E223295	Rattlesnake-E	336	0	508	1	1	5	1.5625	2.434	0	3.67961	0.0072	0.007	0.04		
Total/Average			988	0	1739	3	3	9		2.385	0	4.19871	0.0072	0.007	0.02		
98/06/22	O500454	S.Prairie Cr.-W	227	1	455	0	0	7	1.5625	1.644	0.007	3.29571	0	0	0.05		
98/06/22	O500454	S.Prairie Cr.-C	230	0	504	0	0	2	1.5625	1.666	0	3.65063	0	0	0.01		
98/06/22	O500454	S.Prairie Cr.-E	173	2	497	0	0	3	1.5625	1.253	0.014	3.59993	0	0	0.02		
Total/Average			630	3	1456	0	0	12		1.521	0.007	3.51542	0	0	0.03		
			No. counted						% sample			No. per litre					
Date	Site No.	Location	*Diaptom*	*Epischura*	*Cyclops*	*Daphnia*	*Diaph.*	*Bos.*	counted	*Diapto*	*Epischura*	*Cyclops*	*Daphnia*	*Diaph.*	*Bos.*		
98/07/30	O500847	Kala.D.B.-W	429	5	1042	9	141	43	1.5625	3.107	0.036	7.54754	0.0652	1.021	0.31		
98/07/30	O500847	Kala.D.B.-C	343	1	938	4	122	35	1.5625	2.484	0.007	6.79423	0.029	0.884	0.25		
98/07/30	O500847	Kala.D.B.-E	363	1	997	4	88	50	1.5625	2.629	0.007	7.22159	0.029	0.637	0.36		
Total/Average			1135	7	2977	17	351	128		2.74	0.017	7.18779	0.041	0.847	0.31		
98/07/29	O500239	Arm.Arm-W	375	7	661	3	28	8	0.78125	5.432	0.101	9.57567	0.0435	0.406	0.12	present	
98/07/29	O500239	Arm.Arm-C	357	9	712	1	21	12	0.78125	5.172	0.13	10.3145	0.0145	0.304	0.17	present	
98/07/29	O500239	Arm.Arm-E	382	5	811	7	39	3	0.78125	5.534	0.072	11.7487	0.1014	0.565	0.04	present	
Total/Average			1114	21	2184	11	88	23		5.379	0.101	10.5463	0.0531	0.425	0.11		
98/07/29	E206611	Vern.Out.-1W	524	11	653	13	78	5	1.5625	3.795	0.08	4.72989	0.0942	0.565	0.04		
98/07/29	E206611	Vern.Out.-C	567	16	631	9	58	4	1.5625	4.107	0.116	4.57053	0.0652	0.42	0.03		
98/07/29	E206611	Vern.Out.-2W	432	11	566	9	45	2	1.5625	3.129	0.08	4.09972	0.0652	0.326	0.01		
Total/Average			1523	38	1850	31	181	11		3.677	0.092	4.46671	0.0748	0.437	0.03		
98/07/29	O500730	N.OK CentreW	523	13	629	12	30	3	1.5625	3.788	0.094	4.55605	0.0869	0.217	0.02		
98/07/29	O500730	N.OK Centre-C	426	11	556	18	49	1	1.5625	3.086	0.08	4.02728	0.1304	0.355	0.01		
98/07/29	O500730	N.OK Centre-E	471	15	716	12	26	1	1.5625	3.412	0.109	5.18622	0.0869	0.188	0.01		
Total/Average			1420	39	1901	42	105	5		3.429	0.094	4.58985	0.1014	0.254	0.01		
98/07/28	E223295	Rattlesnake-W	294	3	687	34	9	1	1.5625	2.13	0.022	4.97616	0.2463	0.065	0.01		
98/07/28	E223295	Rattlesnake-C	296	5	655	48	20	1	1.5625	2.144	0.036	4.74437	0.3477	0.145	0.01		
98/07/28	E223295	Rattlesnake-E	301	7	721	46	24	4	1.5625	2.18	0.051	5.22243	0.3332	0.174	0.03		

Total/Average			891	15	2063	128	53	6		2.151	0.036	4.98099	0.309	0.128	0.01		
98/07/28	O500454	S.Prairie Cr.-W	335	6	571	11	11	0	1.5625	2.427	0.043	4.13593	0.0797	0.08	0		
98/07/28	O500454	S.Prairie Cr.-C	311	8	468	6	15	2	1.5625	2.253	0.058	3.38987	0.0435	0.109	0.01		
98/07/28	O500454	S.Prairie Cr.-E	261	6	511	19	11	0	1.5625	1.891	0.043	3.70134	0.1376	0.08	0		
Total/Average			907	20	1550	36	37	2		2.19	0.048	3.74238	0.0869	0.089	0		
			No. counted						% sample	No. per litre							
Date	Site No.	Location	*Diaptom*	*Epischura*	*Cyclops*	*Daphnia*	*Diaph.*	*Bos.*	counted	*Diaptom*	*Epischura*	*Cyclops*	*Daphnia*	*Diaph.*	*Bos.*		
98/08/26	O500847	Kala.D.B.-W	667	19	1600	0	259	5	3.125	2.416	0.069	5.79465	0	0.938	0.02		
98/08/26	O500847	Kala.D.B.-C	169	5	453	0	51	0	0.78125	2.448	0.072	6.56245	0	0.739	0		
98/08/26	O500847	Kala.D.B.-E	164	2	327	0	39	0	0.78125	2.376	0.029	4.73713	0	0.565	0		
Total/Average			1000	26	2380	0	349	5		2.413	0.057	5.69808	0	0.747	0.01		
98/08/23	O500239	Arm.Arm-W	267	4	453	0	43	14	0.78125	3.868	0.058	6.56245	0	0.623	0.2	present	
98/08/23	O500239	Arm.Arm-C	252	12	340	0	27	11	0.78125	3.651	0.174	4.92546	0	0.391	0.16	present	
98/08/23	O500239	Arm.Arm-E	306	17	488	2	43	19	1.5625	2.216	0.123	3.53474	0.0145	0.311	0.14	present	
Total/Average			825	33	1281	2	113	44		3.245	0.118	5.00755	0.0048	0.442	0.17		
98/08/23	E206611	Vern.Out.-1W	459	22	552	0	26	29	1.5625	3.325	0.159	3.99831	0	0.188	0.21		
98/08/23	E206611	Vern.Out.-C	481	21	529	2	37	32	1.5625	3.484	0.152	3.83172	0.0145	0.268	0.23		
98/08/23	E206611	Vern.Out.-2W	468	21	621	0	20	30	1.5625	3.39	0.152	4.4981	0	0.145	0.22		
Total/Average			1408	64	1702	2	83	91		3.4	0.155	4.10938	0.0048	0.2	0.22		
98/08/23	O500730	N.OK CentreW	345	13	511	0	31	25	1.5625	2.499	0.094	3.70134	0	0.225	0.18		
98/08/23	O500730	N.OK Centre-C	351	11	525	0	33	48	1.5625	2.542	0.08	3.80274	0	0.239	0.35		
98/08/23	O500730	N.OK Centre-E	348	13	558	0	22	117	1.5625	2.521	0.094	4.04177	0	0.159	0.85		
Total/Average			1044	37	1594	0	86	190		2.521	0.089	3.84862	0	0.208	0.46		
98/08/24	O500236	DNS Kel.STP-W	485	21	488	7	26	16	1.5625	3.513	0.152	3.53474	0.0507	0.188	0.12		
98/08/24	O500236	DNS Kel.STP-C	484	23	432	5	27	25	1.5625	3.506	0.167	3.12911	0.0362	0.196	0.18		
98/08/24	O500236	DNS Kel.STP-E	461	18	551	8	16	19	1.5625	3.339	0.13	3.99107	0.0579	0.116	0.14		
Total/Average			1430	62	1471	20	69	60		3.453	0.15	3.55164	0.0483	0.167	0.14		
98/08/24	E223295	Rattlesnake-W	282	20	550	4	31	18	1.5625	2.043	0.145	3.98382	0.029	0.225	0.13		
98/08/24	E223295	Rattlesnake-C	349	12	495	9	42	23	1.5625	2.528	0.087	3.58544	0.0652	0.304	0.17		
98/08/24	E223295	Rattlesnake-E	303	14	499	13	24	30	1.5625	2.195	0.101	3.61442	0.0942	0.174	0.22		
Total/Average			934	46	1544	26	97	71		2.255	0.111	3.72789	0.0628	0.234	0.17		
98/08/25	O500454	S.Prairie Cr.-W	313	7	622	6	34	7	1.5625	2.267	0.051	4.50534	0.0435	0.246	0.05		
98/08/25	O500454	S.Prairie Cr.-C	308	6	619	2	33	5	1.5625	2.231	0.043	4.48361	0.0145	0.239	0.04		
98/08/25	O500454	S.Prairie Cr.-E	379	10	628	5	25	4	1.5625	2.745	0.072	4.5488	0.0362	0.181	0.03		
Total/Average			1000	23	1869	13	92	16		2.414	0.056	4.51259	0.0314	0.222	0.04		
			No. counted						% sample	No. per litre							
Date	Site No.	Location	*Diaptom*	*Epischura*	*Cyclops*	*Daphnia*	*Diaph.*	*Bos.*	counted	*Diaptom*	*Epischura*	*Cyclops*	*Daphnia*	*Diaph.*	*Bos.*		
98/09/24	O500847	Kala.D.B.-W	282	21	591	0	43	8	1.5625	2.043	0.152	4.2808	0	0.311	0.06		
98/09/24	O500847	Kala.D.B.-C	335	11	748	0	39	3	1.5625	2.427	0.08	5.418	0	0.282	0.02		
98/09/24	O500847	Kala.D.B.-E	240	7	518	0	53	1	1.5625	1.738	0.051	3.75204	0	0.384	0.01		
Total/Average			857	39	1857	0	135	12		2.069	0.094	4.48361	0	0.326	0.03		
98/10/01	O500239	Arm.Arm-W	584	13	305	1	17	5	1.5625	4.23	0.094	2.20921	0.0072	0.123	0.04	present	
98/10/01	O500239	Arm.Arm-C	548	2	348	3	5	7	1.5625	3.969	0.014	2.52067	0.0217	0.036	0.05	present	
98/10/01	O500239	Arm.Arm-E	687	11	333	0	16	4	1.5625	4.976	0.08	2.41202	0	0.116	0.03	present	
Total/Average			1819	26	986	4	38	16		4.392	0.063	2.38064	0.0097	0.092	0.04		
98/10/04	E206611	Vern.Out.-1W	376	7	381	0	14	8	1.5625	2.723	0.051	2.7597	0	0.101	0.06		
98/10/04	E206611	Vern.Out.-C	438	5	385	0	14	5	1.5625	3.173	0.036	2.78868	0	0.101	0.04		
98/10/04	E206611	Vern.Out.-2W	486	7	456	0	13	4	1.5625	3.52	0.051	3.30295	0	0.094	0.03		
Total/Average			1300	19	1222	0	41	17		3.139	0.046	2.95044	0	0.099	0.04		
98/10/04	O500730	N.OK CentreW	485	6	482	0	11	4	1.5625	3.513	0.043	3.49128	0	0.08	0.03		
98/10/04	O500730	N.OK Centre-C	492	13	462	0	11	3	1.5625	3.564	0.094	3.34641	0	0.08	0.02		
98/10/04	O500730	N.OK Centre-E	359	7	428	0	13	21	1.5625	2.6	0.051	3.10014	0	0.094	0.15		
Total/Average			1336	26	1372	0	35	28		3.226	0.063	3.31261	0	0.085	0.07		
98/10/06	E223295	Rattlesnake-W	359	16	688	0	5	2	1.5625	2.6	0.116	4.9834	0	0.036	0.01		
98/10/06	E223295	Rattlesnake-C	339	14	665	1	4	0	1.5625	2.455	0.101	4.81681	0.0072	0.029	0		
98/10/06	E223295	Rattlesnake-E	358	7	654	0	0	1	1.5625	2.593	0.051	4.73713	0	0	0.01		
Total/Average			1056	37	2007	1	9	3		2.55	0.089	4.84578	0.0024	0.022	0.01		
98/10/06	O500454	S.Prairie Cr.-W	287	11	721	1	2	0	1.5625	2.079	0.08	5.22243	0.0072	0.014	0		
98/10/06	O500454	S.Prairie Cr.-C	296	12	732	1	6	0	1.5625	2.144	0.087	5.30211	0.0072	0.043	0		
98/10/06	O500454	S.Prairie Cr.-E	283	9	574	1	11	0	1.5625	2.05	0.065	4.15766	0.0072	0.08	0		
			866	32	2027	3	19	0		2.091	0.077	4.89407	0.0072	0.046	0		
			No. counted						% sample	No. per litre							
Date	Site No.	Location	*Diaptom*	*Epischura*	*Cyclops*	*Daphnia*	*Diaph.*	*Bos.*	counted	*Diaptom*	*Epischura*	*Cyclops*	*Daphnia*	*Diaph.*	*Bos.*		
98/10/25	O500847	Kala.D.B.-W	533	6	884	0	25	0	3.125	1.93	0.022	3.20155	0	0.091	0		
98/10/25	O500847	Kala.D.B.-C	446	3	863	0	33	1	3.125	1.615	0.011	3.12549	0	0.12	0		
98/10/25	O500847	Kala.D.B.-E	315	9	832	0	22	2	3.125	1.141	0.033	3.01322	0	0.08	0.01		
Total/Average			1294	18	2579	0	80	3		1.562	0.022	3.11342	0	0.097	0		
98/10/21	O500239	Arm.Arm-W	433	5	209	33	6	35	1.5625	3.136	0.036	1.51385	0.239	0.043	0.25	present	
98/10/21	O500239	Arm.Arm-C	453	6	202	36	10	30	1.5625	3.281	0.043	1.46315	0.2608	0.072	0.22	present	
98/10/21	O500239	Arm.Arm-E	595	4	213	19	19	33	1.5625	4.31	0.029	1.54283	0.1376	0.138	0.24	present	
Total/Average			1481	15	624	88	35	98		3.576	0.036	1.50661	0.2125	0.085	0.24		
98/10/21	E206611	Vern.Out.-1W	316	3	320	0	13	7	1.5625	2.289	0.022	2.31786	0	0.094	0.05		
98/10/21	E206611	Vern.Out.-C	424	7	345	1	7	7	1.5625	3.071	0.051	2.49894	0.0072	0.051	0.05		
98/10/21	E206611	Vern.Out.-2W	324	5	405	0	5	7	1.5625	2.347	0.036	2.93354	0	0.036	0.05		
Total/Average			1064	15	1070	1	25	21		2.569	0.036	2.58345	0.0024	0.06	0.05		
98/10/20	O500730	N.OK CentreW	458	4	467	0	6	5	1.5625	3.317	0.029	3.38263	0	0.043	0.04		
98/10/20	O500730	N.OK Centre-C	477	5	491	0	5	3	1.5625	3.455	0.036	3.55647	0	0.036	0.02		
98/10/20	O500730	N.OK Centre-E	487	4	402	0	4	6	1.5625	3.527	0.029	2.91181	0	0.029	0.04		

Total/Average			1422	13	1360	0	15	14		3.433	0.031	3.28364	0	0.036	0.03		
98/10/27	E223295	Rattlesnake-W	476	15	589	0	0	2	1.5625	3.448	0.109	4.26631	0	0	0.01		
98/10/27	E223295	Rattlesnake-C	528	9	630	2	2	1	1.5625	3.824	0.065	4.56329	0.0145	0.014	0.01		
98/10/27	E223295	Rattlesnake-E	386	10	627	0	1	1	1.5625	2.796	0.072	4.54156	0	0.007	0.01		
Total/Average			1390	34	1846	2	3	4		3.356	0.082	4.45705	0.0048	0.007	0.01		
98/10/27	O500454	S.Prairie Cr.-W	373	4	385	0	1	1	1.5625	2.702	0.029	2.78868	0	0.007	0.01		
98/10/27	O500454	S.Prairie Cr.-C	400	3	389	0	2	0	1.5625	2.897	0.022	2.81765	0	0.014	0		
98/10/27	O500454	S.Prairie Cr.-E	353	7	528	1	2	2	1.5625	2.557	0.051	3.82447	0.0072	0.014	0.01		
Total/Average			1126	14	1302	1	5	3		2.719	0.034	3.1436	0.0024	0.012	0.01		
			No. counted						% sample			No. per litre					
Date	Site No.	Location	*Diaptomus*	*Epischura*	*Cyclops*	*Daphnia*	*Diaph.*	*Bos.*	counted	*Diaptomus*	*Epischura*	*Cyclops*	*Daphnia*	*Diaph.*	*Bos.*	*Mysis*	
98/11/30	O500239	Arm.Arm-W	398	1	60	40	0	4	1.5625	2.883	0.007	0.4346	0.2897	0	0.03	present	
98/11/30	O500239	Arm.Arm-C	545	2	86	52	2	2	1.5625	3.948	0.014	0.62293	0.3767	0.014	0.01	present	
98/11/30	O500239	Arm.Arm-E	695	0	110	30	1	3	1.5625	5.034	0	0.79676	0.2173	0.007	0.02	present	
Total/Average			1638	3	256	122	3	9		3.955	0.007	0.6181	0.2946	0.007	0.02		
98/11/30	E206611	Vern.Out.-1W	503	1	346	0	0	1	1.5625	3.643	0.007	2.50619	0	0	0.01		
98/11/30	E206611	Vern.Out.-C	374	1	349	0	0	3	1.5625	2.709	0.007	2.52792	0	0	0.02		
98/11/30	E206611	Vern.Out.-2W	1101	0	611	0	0	11	3.125	3.987	0	2.21283	0	0	0.04		
Total/Average			1978	2	1306	0	0	15		3.447	0.005	2.41565	0	0	0.02	0.0229	
98/11/30	O500730	N.OK CentreW	622	2	468	0	0	7	1.5625	4.505	0.014	3.38987	0	0	0.05		
98/11/30	O500730	N.OK Centre-C	412	1	288	0	1	3	1.5625	2.984	0.007	2.08608	0	0.007	0.02		
98/11/30	O500730	N.OK Centre-E	496	2	387	0	0	3	1.5625	3.593	0.014	2.80316	0	0	0.02		
Total/Average			1530	5	1143	0	1	13		3.694	0.012	2.7597	0	0.002	0.03	0.0338	
98/12/02	O500236	DNS Kel.STP-W	387	3	332	0	0	1	1.5625	2.803	0.022	2.40478	0	0	0.01		
98/12/02	O500236	DNS Kel.STP-C	363	3	318	0	0	5	1.5625	2.629	0.022	2.30338	0	0	0.04		
98/12/02	O500236	DNS Kel.STP-E	394	6	316	0	0	7	1.5625	2.854	0.043	2.28889	0	0	0.05		
Total/Average			1144	12	966	0	0	13		2.762	0.029	2.33235	0	0	0.03	0.0314	
98/12/08	O500454	S.Prairie Cr.-W	346	0	539	0	0	1	6.25	0.627	0	0.97604	0	0	0		
98/12/08	O500454	S.Prairie Cr.-C	401	0	627	0	0	0	6.25	0.726	0	1.13539	0	0	0		
98/12/08	O500454	S.Prairie Cr.-E	499	0	718	0	0	2	6.25	0.904	0	1.30018	0	0	0		
Total/Average			1246	0	1884	0	0	3		0.752	0	1.1372	0	0	0	0.0018	
											2.675	2.16122	0	6E-04	0.02	0.0225	

Date	Station	Location	Depth	Nitrogen				pH	Phosphorus		Silica	Chlorophyll a
	No.		(m)	ammonia	nitrite	nitrite+nitrate	total		total	total dissolved	reactive	
				(mg/L)	(mg/L)	(mg/L)	(mg/L)		(mg/L)	(mg/L)	(mg/L)	(ug/L)
96/07/24	O500246	Kala.S.E.	1-10	0.013	<0.002	0.004	0.28	8.61	0.011	0.014	5.3	1.6
96/07/24	O500246	Kala.S.E.	20	0.005	<0.002	0.032	0.3	8.27	0.009	0.013	6.9	
96/07/24	O500246	Kala.S.E.	45	0.003	<0.002	0.102	0.31	8.18	0.006	0.007	7.9	
96/07/24	O500847	Kala.D.B.	1-10	0.009	<0.002	<0.002	0.27	8.61	0.014	0.012	5.3	1.6
96/07/24	O500847	Kala.D.B.	20	0.009	<0.002	0.052	0.3	7.2	0.018	0.018	7.2	
96/07/24	O500847	Kala.D.B.	45	0.005	<0.002	0.105	0.32	7.8	0.013	0.013	7.8	
96/07/23	O500239	Arm.Arm	1-10	0.011	<0.002	0.002	0.31	8.55	0.014	0.016	7	3.9
96/07/23	O500239	Arm.Arm	20	0.003	<0.002	0.113	0.31	7.85	0.022	0.027	7.7	
96/07/23	O500239	Arm.Arm	45	0.002	<0.002	0.178	0.4	7.83	0.049	0.054	8.3	
96/07/23	E206611	Vern.Out.	1-10	0.007	<0.002	<0.002	0.24	8.47	0.008	0.007	6.5	2.2
96/07/23	E206611	Vern.Out.	20	0.005	<0.002	0.015	0.09	8.07	0.009	0.014	6.5	
96/07/23	E206611	Vern.Out.	45	0.003	0.003	0.051	0.2	8.12	0.006	0.009	6.5	
96/07/23	O500730	N.OK.Centre	1-10	0.007	<0.002	<0.002	0.23	8.39	0.008	0.007	6.4	1.4
96/07/23	O500730	N.OK.Centre	20	0.006	<0.002	0.005	0.19	8.15	0.009	0.009	6.5	
96/07/23	O500730	N.OK.Centre	45	0.003	0.004	0.051	0.21	8.12	0.005	0.008	6.5	
96/07/23	O500456	UPS Kel.STP	1-10	0.006	<0.002	<0.002	0.22	8.39	0.007	0.007	6.4	1.4
96/07/23	O500456	UPS Kel.STP	20	0.008	<0.002	0.028	0.22	8.18	0.007	0.012	6.5	
96/07/23	O500456	UPS Kel.STP	45	0.003	<0.002	0.051	0.21	8.15	0.006	0.006	6.5	
96/07/22	O500236	DNS Kel.STP	1-10	0.007	<0.002	0.002	0.19	8.34	0.007	0.003	6.2	1.2
96/07/22	O500236	DNS Kel.STP	20	0.005	<0.002	0.03	0.21	8.17	0.011	0.003	6.3	
96/07/22	O500236	DNS Kel.STP	45	0.004	<0.002	0.047	0.2	8.05	0.004	0.006	6.3	
96/07/22	E223295	Rattlesnake	1-10	0.009	<0.002	<0.002	0.19	8.38	0.017	0.003	6.3	0.9
96/07/22	E223295	Rattlesnake	20	0.013	<0.002	0.027	0.2	8.20	0.01	0.004	6.2	
96/07/22	E223295	Rattlesnake	45	0.012	<0.002	0.04	0.21	8.19	0.008	0.003	6.3	
96/07/22	O500729	S.Squally Pt.	1-10	0.009	<0.002	0.004	0.19	8.31	0.009	0.004	6.2	1.3
96/07/22	O500729	S.Squally Pt.	20	0.03	<0.002	0.02	0.19	8.21	0.01	0.004	6.1	
96/07/22	O500729	S.Squally Pt.	45	0.022	<0.002	0.037	0.21	8.18	0.008	0.005	6.2	
96/07/22	O500454	S.Prairie Cr.	1-10	0.006	<0.002	<0.002	0.22	8.38	0.015	0.011	6.2	0.8
96/07/22	O500454	S.Prairie Cr.	20	0.006	<0.002	<0.002	0.17	8.29	0.015	0.013	6.1	
96/07/22	O500454	S.Prairie Cr.	45	0.009	<0.002	0.046	0.21	8.11	0.013	0.014	6.3	
96/08/19	O500246	Kala.S.E.	1-10	0.012	<0.002	0.008	0.34	8.57	0.009	0.006	5.3	1.0
96/08/19	O500246	Kala.S.E.	20	0.015	<0.002	0.039	0.31	8.16	0.013	0.006	7.3	
96/08/19	O500246	Kala.S.E.	45	0.006	<0.002	0.128	0.34	8.12	0.009	0.007	8.1	
96/08/19	O500847	Kala.D.B.	1-10	0.008	<0.002	0.008	0.28	8.59	0.008	0.005	5.4	1.3
96/08/19	O500847	Kala.D.B.	20	0.01	<0.002	0.054	0.31	8.14	0.011	0.006	7.3	
96/08/19	O500847	Kala.D.B.	45	0.005	<0.002	0.128	0.3	8.12	0.008	0.008	8	
96/08/20	O500239	Arm.Arm	1-10	0.01	<0.002	<0.002	0.18	8.49	0.013	0.007	6.9	2.9
96/08/20	O500239	Arm.Arm	20	0.003	0.002	0.122	0.24	7.80	0.017	0.011	8.3	
96/08/20	O500239	Arm.Arm	45	0.002	<0.002	0.264	0.39	7.78	0.069	0.059	9.2	
96/08/20	E206611	Vern.Out.	1-10	0.013	<0.002	0.027	0.14	8.49	0.009	0.004	6.5	1.8
96/08/20	E206611	Vern.Out.	20	0.006	<0.002	0.032	0.16	8.10	0.01	0.003	6.6	
96/08/20	E206611	Vern.Out.	45	0.003	<0.002	0.064	0.17	8.16	0.008	0.004	6.6	
96/08/20	O500730	N.OK.Centre	1-10	0.006	<0.002	0.011	0.18	8.50	0.012	0.004	6.3	1.8
96/08/20	O500730	N.OK.Centre	20	0.006	<0.002	0.007	0.16	8.17	0.008	0.005	6.4	
96/08/20	O500730	N.OK.Centre	45	0.003	<0.002	0.073	0.17	8.14	0.009	0.005	6.6	
96/08/21	O500456	UPS Kel.STP	1-10	0.006	<0.002	0.009	0.17	8.42	0.009	0.005	6.3	1.8
96/08/21	O500456	UPS Kel.STP	20	0.019	<0.002	0.011	0.15	8.28	0.009	0.004	6.4	
96/08/21	O500456	UPS Kel.STP	45	0.01	<0.002	0.045	0.14	8.22	0.008	0.005	6.5	
96/08/21	O500236	DNS Kel.STP	1-10	0.009	<0.002	0.005	0.2	8.46	0.009	0.006	6.3	1.3
96/08/21	O500236	DNS Kel.STP	20	0.004	<0.002	0.017	0.15	8.25	0.008	0.006	6.3	
96/08/21	O500236	DNS Kel.STP	45	0.003	<0.002	0.058	0.17	8.24	0.007	0.006	6.4	
96/08/21	E223295	Rattlesnake	1-10	0.005	<0.002	0.01	0.15	8.49	0.008	0.005	6.2	1.5
96/08/21	E223295	Rattlesnake	20	0.005	<0.002	0.008	0.16	8.31	0.01	0.006	6.2	
96/08/21	E223295	Rattlesnake	45	0.003	<0.002	0.051	0.16	8.22	0.007	0.005	6.4	

96/08/23	O500729	S.Squally Pt.	1-10	0.01	0.004	0.003	0.19	8.43	0.009	0.004	7.1	1.2
96/08/23	O500729	S.Squally Pt.	20	0.009	<0.002	0.016	0.2	8.21	0.007	0.004	7	
96/08/23	O500729	S.Squally Pt.	45	0.003	<0.002	0.058	0.18	8.11	0.006	0.004	7.1	
96/08/23	O500454	S.Prairie Cr.	1-10	0.007	<0.002	0.019	0.17	8.42	0.007	0.004	7.1	1.0
96/08/23	O500454	S.Prairie Cr.	20	0.009	0.003	0.008	0.19	8.22	0.009	0.004	7	
96/08/23	O500454	S.Prairie Cr.	45	0.003	0.003	0.061	0.21	8.15	0.006	0.005	7.1	
96/09/19	O500246	Kala.S.E.	1-10	0.014	<0.002	0.002	0.28	8.54	<0.002	0.006	5.6	1.6
96/09/19	O500246	Kala.S.E.	20	0.013	<0.002	0.06	0.3	8.12	0.008	0.007	7.5	
96/09/19	O500246	Kala.S.E.	45	0.026	<0.002	0.124	0.38	8.11	0.014	0.008	8.1	
96/09/19	O500847	Kala.D.B.	1-10	<0.002	<0.002	<0.002	0.28	8.55	<0.002	0.007	5.6	1.6
96/09/19	O500847	Kala.D.B.	20	0.04	0.002	0.032	0.27	8.16	0.006	0.007	7.1	
96/09/19	O500847	Kala.D.B.	45	0.015	<0.002	0.119	0.35	8.14	0.006	0.007	7.9	
96/09/16	O500239	Arm.Arm	1-10	0.012	<0.002	0.033	0.22	8.46	0.021	0.004	7.1	2.6
96/09/16	O500239	Arm.Arm	20	0.026	<0.002	0.123	0.31	7.75	0.021	0.01	8.7	
96/09/16	O500239	Arm.Arm	45	0.015	<0.002	0.285	0.47	7.55	0.092	0.078	10.1	
96/09/16	E206611	Vern.Out.	1-10	0.009	<0.002	<0.002	0.2	8.49	0.012	0.004	6.6	1.6
96/09/16	E206611	Vern.Out.	20	0.006	<0.002	<0.002	0.18	8.26	0.011	0.003	6.5	
96/09/16	E206611	Vern.Out.	45	0.004	<0.002	0.059	0.2	8.02	0.01	0.004	6.6	
96/09/17	O500730	N.OK.Centre	1-10	0.004	<0.002	0.002	0.2	8.41	0.009	0.003	6.5	1.6
96/09/17	O500730	N.OK.Centre	20	0.004	0.002	0.009	0.17	8.08	0.032	0.006	6.7	
96/09/17	O500730	N.OK.Centre	45	0.004	<0.002	0.057	0.2	8.11	0.009	0.008	6.6	
96/09/17	O500456	UPS Kel.STP	1-10	0.004	0.002	0.007	0.2	8.40	0.009	0.003	6.4	1.3
96/09/17	O500456	UPS Kel.STP	20	0.004	<0.002	0.017	0.32	8.19	0.009	0.002	6.5	
96/09/17	O500456	UPS Kel.STP	45	0.004	0.003	0.063	0.28	8.03	0.006	<0.002	6.6	
96/09/18	O500236	DNS Kel.STP	1-10	0.014	0.006	<0.002	0.18	8.41	0.008	0.002	6.4	1.3
96/09/18	O500236	DNS Kel.STP	20	0.011	0.006	0.014	0.19	8.12	0.006	0.004	6.5	
96/09/18	O500236	DNS Kel.STP	45	0.007	0.007	0.073	0.2	8.06	0.006	0.005	6.6	
96/09/18	E223295	Rattlesnake	1-10	0.006	0.006	<0.002	0.18	8.44	0.007	0.003	6.4	1.1
96/09/18	E223295	Rattlesnake	20	0.004	0.008	0.006	0.16	8.18	0.007	<0.002	6.3	
96/09/18	E223295	Rattlesnake	45	0.004	0.006	0.065	0.2	8.05	0.005	0.002	6.5	
96/09/18	O500729	S.Squally Pt.	1-10	<0.002	0.006	<0.002	0.19	8.39	0.007	<0.002	6.4	1.1
96/09/18	O500729	S.Squally Pt.	20	<0.002	0.006	<0.002	0.17	8.32	0.006	<0.002	6.4	
96/09/18	O500729	S.Squally Pt.	45	<0.002	0.007	0.067	0.19	8.11	0.005	<0.002	6.5	
96/09/18	O500454	S.Prairie Cr.	1-10	0.028	0.004	<0.002	0.19	8.41	0.006	<0.002	6.4	1.1
96/09/18	O500454	S.Prairie Cr.	20	<0.002	0.004	0.003	0.18	8.15	0.006	<0.002	6.4	
96/09/18	O500454	S.Prairie Cr.	45	<0.002	0.004	0.068	0.2	8.04	0.005	<0.002	6.4	
96/10/15	O500847	Kala.D.B.	1-10	0.017	<0.002	<0.002	0.25	8.49	0.006	0.002	5.7	2.2
96/10/15	O500847	Kala.D.B.	20	0.01	<0.002	0.025	0.26	8.32	0.006	0.004	6.6	
96/10/15	O500847	Kala.D.B.	45	0.003	0.002	0.119	0.31	8.19	0.004	0.003	7.9	
96/10/23	O500239	Arm.Arm	1-10	0.005	0.003	0.004	0.26	8.34	0.014	0.004	7.3	4.1
96/10/23	O500239	Arm.Arm	20	0.004	0.003	0.182	0.27	7.94	0.019	0.011	8.6	
96/10/23	O500239	Arm.Arm	45	0.003	0.003	0.291	0.47	7.66	0.103	0.09	10.6	
96/10/17	E206611	Vern.Out.	1-10	0.003	<0.002	<0.002	0.18	8.39	0.015	0.005	6.4	1.2
96/10/17	E206611	Vern.Out.	20	0.009	<0.002	<0.002	0.19	8.36	0.004	0.003	6.6	
96/10/17	E206611	Vern.Out.	45	0.004	<0.002	0.062	0.2	8.05	0.003	0.005	6.5	
96/10/17	O500730	N.OK.Centre	1-10	<0.002	<0.002	<0.002	0.18	8.40	0.004	0.002	6.4	1.6
96/10/17	O500730	N.OK.Centre	20	0.004	<0.002	<0.002	0.18	8.39	0.006	0.002	6.5	
96/10/17	O500730	N.OK.Centre	45	<0.002	<0.002	0.059	0.2	8.04	0.007	0.002	6.6	
96/10/17	O500456	UPS Kel.STP	1-10	<0.002	<0.002	0.002	0.2	8.34	0.005	0.002	6.4	1.8
96/10/17	O500456	UPS Kel.STP	20	0.004	<0.002	0.002	0.18	8.33	0.005	<0.002	6.4	
96/10/17	O500456	UPS Kel.STP	45	<0.002	<0.002	0.048	0.19	8.06	0.007	0.004	6.5	
96/10/17	O500236	DNS Kel.STP	1-10	<0.002	<0.002	<0.002	0.19	8.38	0.008	0.004	6.3	1.4
96/10/17	O500236	DNS Kel.STP	20	<0.002	<0.002	0.019	0.18	8.15	0.008	0.006	6.3	
96/10/17	O500236	DNS Kel.STP	45	<0.002	<0.002	0.056	0.19	8.09	0.012	0.004	6.6	
96/10/17	E223295	Rattlesnake	1-10	<0.002	<0.002	<0.002	0.19	8.36	0.006	<0.002	6.4	1.4
96/10/17	E223295	Rattlesnake	20	<0.002	<0.002	0.027	0.19	8.21	0.009	0.003	6.4	
96/10/17	E223295	Rattlesnake	45	<0.002	<0.002	0.065	0.2	8.08	0.008	0.002	6.5	

96/10/16	O500729	S.Squally Pt.	1-10	0.005	<0.002	0.019	0.2	8.24	0.005	0.002	6.4	1.2
96/10/16	O500729	S.Squally Pt.	20	0.005	<0.002	0.03	0.18	8.23	0.004	0.003	6.4	
96/10/16	O500729	S.Squally Pt.	45	0.003	<0.002	0.052	0.2	8.15	0.004	0.004	6.5	
96/10/16	O500454	S.Prairie Cr.	1-10	0.01	<0.002	0.031	0.2	8.14	0.004	<0.002	6.5	1.0
96/10/16	O500454	S.Prairie Cr.	20	0.003	<0.002	0.05	0.2	8.07	0.004	0.002	6.4	
96/10/16	O500454	S.Prairie Cr.	45	0.002	<0.002	0.063	0.21	8.05	0.004	0.002	6.5	
96/11/25	E206611	Vern.Out.	1-10	<0.002	<0.002	0.029	0.19	8.18	0.014	0.006	6.5	1.5
96/11/25	E206611	Vern.Out.	20	<0.002	<0.002	0.027	0.2	8.17	0.013	0.007	6.5	
96/11/25	E206611	Vern.Out.	45	<0.002	<0.002	0.025	0.18	8.16	0.007	0.006	6.5	
96/11/25	O500730	N.OK.Centre	1-10	<0.002	<0.002	0.023	0.2	8.19	0.014	0.014	6.5	1.6
96/11/25	O500730	N.OK.Centre	20	<0.002	<0.002	0.023	0.18	8.17	0.014	0.006	6.5	
96/11/25	O500730	N.OK.Centre	45	<0.002	<0.002	0.027	0.18	8.20	0.013	0.005	6.5	
96/11/25	O500456	UPS Kel.STP	1-10	<0.002	<0.002	0.021	0.19	8.21	0.016	0.006	6.4	1.8
96/11/25	O500456	UPS Kel.STP	20	<0.002	<0.002	0.02	0.19	8.19	0.014	0.007	6.5	
96/11/25	O500456	UPS Kel.STP	45	<0.002	<0.002	0.048	0.19	8.14	0.015	0.007	6.6	
97/02/10	E206611	Vern.Out.	1-10	0.006	<0.002	0.052	0.21	8.14	0.013	0.008	6.7	1.8
97/02/10	E206611	Vern.Out.	20	0.008	<0.002	0.065	0.21	8.08	0.01	0.007	6.7	
97/02/10	E206611	Vern.Out.	45	0.005	<0.002	0.066	0.21	8.09	0.01	0.011	6.8	
97/02/10	O500730	N.OK.Centre	1-10	0.007	<0.002	0.055	0.22	8.14	0.012	0.007	6.7	1.9
97/02/10	O500730	N.OK.Centre	20	0.013	<0.002	0.061	0.2	8.09	0.012	0.008	6.7	
97/02/10	O500730	N.OK.Centre	45	0.008	<0.002	0.065	0.2	8.05	0.01	0.008	6.8	
97/02/17	O500456	UPS Kel.STP	1-10	0.002	<0.002	0.056	0.21		0.01	0.007		1.3
97/02/17	O500456	UPS Kel.STP	20	0.002	<0.002	0.064	0.21	8.11	0.008	0.009	6.5	
97/02/17	O500456	UPS Kel.STP	45	<0.002	<0.002	0.068	0.21	8.09	0.01	0.01	6.6	
97/02/17	O500236	DNS Kel.STP	1-10	0.009	<0.002	0.06	0.2	8.16	0.009	0.006	6.4	1.6
97/02/17	O500236	DNS Kel.STP	20	0.005	<0.002	0.061	0.21	8.12	0.009	0.009	6.4	
97/02/17	O500236	DNS Kel.STP	45	0.003	<0.002	0.062	0.21	8.16	0.008	0.007	6.4	
97/02/11	E223295	Rattlesnake	1-10	0.005	<0.002	0.057	0.2	8.18	0.008	0.009	6.4	1.8
97/02/11	E223295	Rattlesnake	20	0.004	<0.002	0.058	0.22	8.11	0.008	0.006	6.3	
97/02/11	E223295	Rattlesnake	45	0.005	<0.002	0.066	0.21	8.14	0.008	0.006	6.5	
97/02/11	O500729	S.Squally Pt.	1-10	0.003	<0.002	0.052	0.21	8.16	0.008	0.005		1.5
97/02/11	O500729	S.Squally Pt.	20	0.003	<0.002	0.059	0.21	8.15	0.009	0.006	6.4	
97/02/11	O500729	S.Squally Pt.	45	0.003	<0.002	0.064	0.21	8.13	0.008	0.007	6.4	
97/02/11	O500454	S.Prairie Cr.	1-10	0.003	<0.002	0.054	0.21	8.15	0.009	0.006	6.4	1.4
97/02/11	O500454	S.Prairie Cr.	20	0.017	<0.002	0.059	0.22	8.16	0.006	0.006	6.4	
97/02/11	O500454	S.Prairie Cr.	45	0.008	<0.002	0.063	0.21	8.13	0.009	0.005	6.4	
97/03/13	O500847	Kala.D.B.	1-10	0.008	<0.002	0.089	0.31	8.18	0.011	0.004	7.6	2.7
97/03/13	O500847	Kala.D.B.	20	0.007	<0.002	0.121	0.34	8.17	0.012	0.004	7.8	
97/03/13	O500847	Kala.D.B.	45	0.004	<0.002	0.115	0.31	8.16	0.011	0.006	7.9	
97/03/16	E206611	Vern.Out.	1-10	<0.002	<0.002	0.045	0.21	8.21	0.009	0.006	6.5	1.5
97/03/16	E206611	Vern.Out.	20	<0.002	<0.002	0.044	0.2	8.2	0.009	0.006	6.5	
97/03/16	E206611	Vern.Out.	45	0.002	<0.002	0.047	0.2	8.19	0.009	0.006	6.5	
97/03/16	O500730	N.OK.Centre	1-10	<0.002	<0.002	0.05	0.21	8.13	0.007	0.006	6.5	1.2
97/03/16	O500730	N.OK.Centre	20	0.004	<0.002	0.051	0.2	8.19	0.009	0.007	6.6	
97/03/16	O500730	N.OK.Centre	45	0.002	<0.002	0.052	0.2	8.18	0.009	0.005	6.6	
97/03/17	O500456	UPS Kel.STP	1-10	0.007	<0.002	0.054	0.2	8.16	0.008	0.006	6.6	0.9
97/03/17	O500456	UPS Kel.STP	20	<0.002	<0.002	0.055	0.19	8.09	0.009	0.006	6.5	
97/03/17	O500456	UPS Kel.STP	45	<0.002	<0.002	0.055	0.19	8.06	0.009	0.006	6.6	
97/03/17	O500236	DNS Kel.STP	1-10	<0.002	<0.002	0.053	0.21	8.15	0.009	0.005	6.5	1.4
97/03/17	O500236	DNS Kel.STP	20	0.002	<0.002	0.054	0.21	8.13	0.009	0.009	6.4	
97/03/17	O500236	DNS Kel.STP	45	<0.002	<0.002	0.055	0.21	8.12	0.001	0.006	6.5	
97/03/17	E223295	Rattlesnake	1-10	<0.002	<0.002	0.057	0.2	8.16	0.007	0.005	6.5	1.0
97/03/17	E223295	Rattlesnake	20	0.004	<0.002	0.058	0.21	8.14	0.008	0.007	6.6	
97/03/17	E223295	Rattlesnake	45	0.002	<0.002	0.058	0.2	8.13	0.008	0.006	6.5	
97/03/20	O500729	S.Squally Pt.	1-10	0.004	<0.002	0.059	0.2	8.21	0.007	0.005	6.4	1.0
97/03/20	O500729	S.Squally Pt.	20	<0.002	<0.002	0.059	0.2	8.14	0.008	0.005	6.4	
97/03/20	O500729	S.Squally Pt.	45	<0.002	<0.002	0.059	0.2	8.17	0.008	0.005	6.4	

97/03/20	O500454	S.Prairie Cr.	1-10	0.002	<0.002	0.057	0.21	8.21	0.008	0.005	6.4	1.1
97/03/20	O500454	S.Prairie Cr.	20	<0.002	<0.002	0.057	0.2	8.18	0.007	0.005	6.4	
97/03/20	O500454	S.Prairie Cr.	45	0.009	<0.002	0.057	0.2	8.19	0.008	0.005	6.4	
97/04/21	O500246	Kala.S.E.	1-10	<0.005	<0.002	0.098	0.32	8.26	0.012	0.008	7.3	3.6
97/04/21	O500246	Kala.S.E.	20									
97/04/21	O500246	Kala.S.E.	45									
97/04/21	O500847	Kala.D.B.	1-10	<0.005	<0.002	0.101	0.34	8.24	0.013	0.01	7.4	3.0
97/04/21	O500847	Kala.D.B.	20									
97/04/21	O500847	Kala.D.B.	45									
97/04/15	O500239	Arm.Arm	1-10	<0.005	<0.002	0.02	0.32	8.26	0.031	0.008	6.4	7.9
97/04/15	O500239	Arm.Arm	20	<0.005	<0.002	0.082	0.4	8.15	0.035	0.011	7.0	
97/04/15	O500239	Arm.Arm	45	<0.005	<0.002	0.337	0.68	7.92	0.068	0.049	9.3	
97/04/15	E206611	Vern.Out.	1-10	<0.005	<0.002	0.026	0.25	8.18	0.015	0.007	6.0	3.7
97/04/15	E206611	Vern.Out.	20	<0.005	<0.002	0.025	0.22	8.19	0.012	0.009	6.0	
97/04/15	E206611	Vern.Out.	45	<0.005	<0.002	0.026	0.22	8.18	0.011	0.008	6.1	
97/04/15	O500730	N.OK.Centre	1-10	<0.005	<0.002	0.048	0.22	8.11	0.014	0.007	6.3	1.9
97/04/15	O500730	N.OK.Centre	20	<0.005	<0.002	0.05	0.21	8.1	0.017	0.009	6.3	
97/04/15	O500730	N.OK.Centre	45	<0.005	<0.002	0.049	0.21	8.1	0.015	0.008	6.3	
97/04/15	O500456	UPS Kel.STP	1-10	<0.005	<0.002	0.048	0.23	8.13	0.011	0.007	6.4	2.0
97/04/15	O500456	UPS Kel.STP	20	<0.005	<0.002	0.056	0.24	8.12	0.011	0.008	6.3	
97/04/15	O500456	UPS Kel.STP	45	<0.005	<0.002	0.051	0.22	8.1	0.012	0.007	6.3	
97/04/16	O500236	DNS Kel.STP	1-10	<0.005	<0.002	0.04	0.21	8.17	0.01	0.008	6.0	2.6
97/04/16	O500236	DNS Kel.STP	20	<0.005	<0.002	0.041	0.22	8.15	0.01	0.006	6.0	
97/04/16	O500236	DNS Kel.STP	45	<0.005	<0.002	0.04	0.22	8.17	0.009	0.007	6.0	
97/04/10	E223295	Rattlesnake	1-10	<0.005	<0.002	0.048	0.2	8.22	0.01	0.007	6.0	1.8
97/04/10	E223295	Rattlesnake	20	<0.005	<0.002	0.053	0.21	8.2	0.009	0.007	6.0	
97/04/10	E223295	Rattlesnake	45	<0.005	<0.002	0.053	0.2	8.21	0.01	0.006	6.0	
97/04/10	O500729	S.Squally Pt.	1-10	<0.005	<0.002	0.04	0.2	8.24	0.01	0.006	5.9	1.8
97/04/10	O500729	S.Squally Pt.	20	0.007	<0.002	0.043	0.2	8.2	0.01	0.006	6.0	
97/04/10	O500729	S.Squally Pt.	45	<0.005	<0.002	0.043	0.21	8.22	0.009	0.007	6.0	
97/04/17	O500454	S.Prairie Cr.	1-10	<0.005	<0.002	0.038	0.21	8.21	0.009	0.006	6.0	2.3
97/04/17	O500454	S.Prairie Cr.	20	<0.005	<0.002	0.041	0.19	8.21	0.009	0.007	6.0	
97/04/17	O500454	S.Prairie Cr.	45	<0.005	<0.002	0.039	0.22	8.22	0.011	0.007	6.0	
97/05/07	O500246	Kala.S.E.	1-10	0.014	<0.002	0.061	0.33	8.27	0.01	0.007	7.5	4.9
97/05/07	O500246	Kala.S.E.	20	0.009	<0.002	0.084	0.32	8.17	0.008	0.006	7.8	
97/05/07	O500246	Kala.S.E.	45	0.008	<0.002	0.096	0.31	8.14	0.008	0.007	8.1	
97/05/07	O500847	Kala.D.B.	1-10	0.006	<0.002	0.062	0.33	8.26	0.012	0.007	7.5	5.3
97/05/07	O500847	Kala.D.B.	20	0.031	<0.002	0.086	0.35	8.15	0.014	0.007	7.7	
97/05/07	O500847	Kala.D.B.	45	0.016	<0.002	0.086	0.31	8.14	0.009	0.006	7.9	
97/05/06	O500239	Arm.Arm	1-10	0.009	<0.002	<0.002	0.31	8.43	0.024	0.008	6.2	7.0
97/05/06	O500239	Arm.Arm	20	0.013	<0.002	0.144	0.37	8.07	0.025	<0.002	7.7	
97/05/06	O500239	Arm.Arm	45	0.008	<0.002	0.271	0.51	7.99	0.042	0.034	8.7	
97/05/06	E206611	Vern.Out.	1-10	0.008	<0.002	0.013	0.2	8.22	0.007	0.007	6.4	3.0
97/05/06	E206611	Vern.Out.	20	0.006	<0.002	0.043	0.23	8.18	0.007	0.005	6.3	
97/05/06	E206611	Vern.Out.	45	0.005	<0.002	0.05	0.2	8.13	0.006	0.007	6.5	
97/05/12	O500730	N.OK.Centre	1-10	0.015	<0.002	0.008	0.19	8.37	0.013	0.008	6.9	2.6
97/05/12	O500730	N.OK.Centre	20	0.011	<0.002	0.015	0.19	6.21	0.01	0.006	6.8	
97/05/12	O500730	N.OK.Centre	45	0.008	<0.002	0.056	0.19	8.36	0.007	0.007	7.2	
97/05/12	O500456	UPS Kel.STP	1-10	0.011	<0.002	0.015	0.2	8.05	0.012	0.007	7.2	2.3
97/05/12	O500456	UPS Kel.STP	20	0.007	<0.002	0.044	0.17	7.77	0.012	0.007	7.4	
97/05/12	O500456	UPS Kel.STP	45	0.011	<0.002	0.06	0.18	8.01	0.01	0.007	7.3	
97/05/06	O500236	DNS Kel.STP	1-10	0.005	<0.002	0.025	0.2	8.19	0.007	0.006	6.9	1.8
97/05/06	O500236	DNS Kel.STP	20	0.021	<0.002	0.023	0.2	8.25	0.006	0.005	6.3	
97/05/06	O500236	DNS Kel.STP	45	0.012	<0.002	0.033	0.2	8.21	0.006	0.006	6.4	
97/05/12	E223295	Rattlesnake	1-10	0.009	<0.002	0.029	0.2	8.17	0.01	0.007	7	2.3
97/05/12	E223295	Rattlesnake	20	0.006	<0.002	0.037	0.19	8.3	0.007	0.006	6.8	
97/05/12	E223295	Rattlesnake	45	0.009	<0.002	0.048	0.2	8.26	0.007	0.009	7	

97/05/12	O500729	S.Squally Pt.	1-10	0.007	<0.002	0.032	0.21	8.34	0.007	0.006	6.8	2.4
97/05/12	O500729	S.Squally Pt.	20									
97/05/12	O500729	S.Squally Pt.	45									
97/05/12	O500454	S.Prairie Cr.	1-10	0.012	<0.002	0.026	0.18	8.37	0.008	0.007	6.8	2.1
97/05/12	O500454	S.Prairie Cr.	20	0.007	<0.002	0.031	0.21	8.31	0.008	0.007	6.7	
97/05/12	O500454	S.Prairie Cr.	45	0.006	<0.002	0.035	0.19	8.3	0.007	0.005	6.8	
97/06/09	O500246	Kala.S.E.	1-10	0.008	<0.002	0.002	0.27	8.47	0.017	0.006	4.9	3.8
97/06/09	O500246	Kala.S.E.	20	0.023	<0.002	0.079	0.28	8.2	0.016	0.015	7	
97/06/09	O500246	Kala.S.E.	45	0.016	0.006	0.12	0.31	8.14	0.019	0.007	7.9	
97/06/09	O500847	Kala.D.B.	1-10	<0.005	<0.002	0.003	0.3	8.51	0.018	0.007	5	4.2
97/06/09	O500847	Kala.D.B.	20	0.021	<0.002	0.078	0.32	8.23	0.015	0.008	6.9	
97/06/09	O500847	Kala.D.B.	45	0.024	0.006	0.116	0.32	8.16	0.014	0.009	8	
97/06/15	O500239	Arm.Arm	1-10	<0.005	<0.002	0.003	0.31	8.56	0.024	0.008	8.6	5.5
97/06/15	O500239	Arm.Arm	20	0.009	<0.002	0.109	0.35	7.89	0.025	0.013	8.5	
97/06/15	O500239	Arm.Arm	45	<0.005	<0.002	0.172	0.37	7.88	0.036	0.024	8.8	
97/06/16	E206611	Vern.Out.	1-10	<0.005	<0.002	<0.002	0.21	8.49	0.016	0.005	7.1	3.7
97/06/16	E206611	Vern.Out.	20	0.005	<0.002	<0.002	0.2	8.26	0.017	0.008	7.2	
97/06/16	E206611	Vern.Out.	45	0.011	<0.002	0.05	0.21	8.09	0.011	0.013	7.2	
97/06/16	O500730	N.OK.Centre	1-10	<0.005	<0.002	<0.002	0.2	8.18	0.014	0.006	7	3.4
97/06/16	O500730	N.OK.Centre	20	<0.005	<0.002	0.009	0.18	8.18	0.011	0.006	6.8	
97/06/16	O500730	N.OK.Centre	45	<0.005	<0.002	0.057	0.18	8.07	0.009	0.006	6.9	
97/06/12	O500456	UPS Kel.STP	1-10	0.007	<0.002	<0.002	0.2	8.44	0.015	0.007	6.8	2.8
97/06/12	O500456	UPS Kel.STP	20	0.007	<0.002	0.009	0.17	8.21	0.012	0.007	6.8	
97/06/12	O500456	UPS Kel.STP	45	0.009	<0.002	0.055	0.18	8.12	0.01	0.006	6.9	
97/06/12	O500236	DNS Kel.STP	1-10	<0.005	<0.002	<0.002	0.18	8.37	0.015	0.008	7	3.0
97/06/12	O500236	DNS Kel.STP	20	0.005	<0.002	0.011	0.18	8.21	0.013	0.008	7	
97/06/12	O500236	DNS Kel.STP	45	0.001	<0.002	0.049	0.18	8.15	0.011	0.006	6.9	
97/06/11	E223295	Rattlesnake	1-10	<0.005	<0.002	<0.002	0.17	8.32	0.013	0.007	6.8	2.6
97/06/11	E223295	Rattlesnake	20	0.011	<0.002	0.033	0.18	8.18	0.01	0.005	6.7	
97/06/11	E223295	Rattlesnake	45	0.024	<0.002	0.049	0.18	8.15	0.011	0.006	6.7	
97/06/11	O500729	S.Squally Pt.	1-10	<0.005	<0.002	<0.002	0.14	8.32	0.012	0.007	6.6	2.7
97/06/11	O500729	S.Squally Pt.	20	0.006	<0.002	0.017	0.22	8.22	0.011	0.007	6.6	
97/06/11	O500729	S.Squally Pt.	45	0.015	<0.002	0.05	0.18	8.17	0.014	0.01	6.6	
97/06/11	O500454	S.Prairie Cr.	1-10	0.005	<0.002	0.002	0.18	8.34	0.011	0.009	7	2.4
97/06/11	O500454	S.Prairie Cr.	20	0.011	<0.002	0.031	0.18	8.15	0.011	0.008	6.6	
97/06/11	O500454	S.Prairie Cr.	45	0.013	<0.002	0.049	0.18	8.16	0.011	0.007	6.6	
97/07/06	O500246	Kala.S.E.	1-10	<0.005	<0.002	0.004	0.27		0.017	0.012		2.8
97/07/06	O500246	Kala.S.E.	20									
97/07/06	O500246	Kala.S.E.	45									
97/07/07	O500847	Kala.D.B.	1-10	<0.005	<0.002	<0.002	0.23		0.013	0.007	5.0	2.1
97/07/07	O500847	Kala.D.B.	20									
97/07/07	O500847	Kala.D.B.	45									
97/07/14	O500239	Arm.Arm	1-10	<0.005	<0.002	<0.002	0.23		0.017	0.017	7.9	5.7
97/07/14	O500239	Arm.Arm	20	<0.005	0.003	0.114	0.29		0.023	0.023		
97/07/14	O500239	Arm.Arm	45	<0.005	0.002	0.224	0.4		0.042	0.042		
97/07/14	E206611	Vern.Out.	1-10	<0.005	0.002	0.004	0.24		0.014	0.014		3.2
97/07/14	E206611	Vern.Out.	20	<0.005	0.003	0.023	0.19		0.009	0.009		
97/07/14	E206611	Vern.Out.	45	<0.005	<0.002	0.064	0.06		0.007	0.007		
97/07/14	O500730	N.OK.Centre	1-10	<0.005	<0.002	0.002	0.16		0.009	0.009	6.8	2.8
97/07/14	O500730	N.OK.Centre	20	0.01	<0.002	0.003	0.17		0.012	0.012		
97/07/14	O500730	N.OK.Centre	45	<0.005	<0.002	0.061	0.19		0.004	0.004		
97/07/14	O500456	UPS Kel.STP	1-10	<0.005	<0.002	0.003	0.19		0.011	0.011		2.5
97/07/14	O500456	UPS Kel.STP	20	<0.005	<0.002	0.02	0.18		0.016	0.016		
97/07/14	O500456	UPS Kel.STP	45	<0.005	<0.002	0.068	0.19		0.012	0.012		
97/07/15	O500236	DNS Kel.STP	1-10	<0.005	<0.002	0.004	0.18		0.025	0.025	7.3	2.7
97/07/15	O500236	DNS Kel.STP	20	<0.005	<0.002	0.057	0.19		0.009	0.009		
97/07/15	O500236	DNS Kel.STP	45	<0.005	0.003	0.072	0.19		0.08	0.008		

97/07/10	E223295	Rattlesnake	1-10	<0.005	<0.002	<0.002	0.18		0.011	0.01		2.1
97/07/10	E223295	Rattlesnake	20	<0.005	<0.002	0.025	0.19		0.01	0.01		
97/07/10	E223295	Rattlesnake	45	<0.005	0.007	0.061	0.19		0.011	0.01		
97/07/10	O500729	S.Squally Pt.	1-10	<0.005	<0.002	<0.002	0.19		0.011	0.009		2.4
97/07/10	O500729	S.Squally Pt.	20	0.006	<0.002	0.019	0.2		0.014	0.011		
97/07/10	O500729	S.Squally Pt.	45	<0.005	<0.002	0.062	0.2		0.009	0.01		
97/07/10	O500454	S.Prairie Cr.	1-10	<0.005	<0.002	<0.002	0.18		0.009	0.011	7.1	2.3
97/07/10	O500454	S.Prairie Cr.	20	<0.005	<0.002	0.011	0.18		0.01	0.009		
97/07/10	O500454	S.Prairie Cr.	45	<0.005	0.008	0.059	0.2		0.009	0.009		
97/08/04	O500246	Kala.S.E.	1-10	<0.005	<0.002	0.004	0.23		0.013	0.007		2.1
97/08/04	O500246	Kala.S.E.	20	0.006	<0.002	0.051	0.27		0.016	0.006		
97/08/04	O500246	Kala.S.E.	45	<0.005	<0.002	0.135	0.29		0.016	0.008		
97/08/04	O500847	Kala.D.B.	1-10	0.005	<0.002	0.002	0.24		0.012	0.006	5.2	1.8
97/08/04	O500847	Kala.D.B.	20	0.007	<0.002	0.069	0.28		0.018	0.008		
97/08/04	O500847	Kala.D.B.	45	<0.005	<0.002	0.132	0.29		0.011	0.01		
97/08/10	O500239	Arm.Arm	1-10	<0.005	<0.002	<0.002	0.33		0.036	0.009	7.1	4.3
97/08/10	O500239	Arm.Arm	20	<0.005	<0.002	0.109	0.36		0.04	0.021		
97/08/10	O500239	Arm.Arm	45	<0.005	<0.002	0.234	0.52		0.082	0.055		
97/08/10	E206611	Vern.Out.	1-10	<0.005	<0.002	0.004	0.28		0.024	0.012		2.3
97/08/10	E206611	Vern.Out.	20	<0.005	<0.002	0.011	0.27		0.027	0.009		
97/08/10	E206611	Vern.Out.	45	<0.005	<0.002	0.06	0.27		0.025	0.01		
97/08/11	O500730	N.OK.Centre	1-10	<0.005	<0.002	<0.002	0.27		0.028	0.014	6.6	1.8
97/08/11	O500730	N.OK.Centre	20	<0.005	<0.002	<0.002	0.26		0.024	0.016		
97/08/11	O500730	N.OK.Centre	45	<0.005	<0.002	0.055	0.27		0.03	0.013		
97/08/13	O500456	UPS Kel.STP	1-10	<0.005	<0.002	0.006	0.2		0.02	0.005		5.9
97/08/13	O500456	UPS Kel.STP	20	<0.005	<0.002	0.006	0.2		0.019	0.004		
97/08/13	O500456	UPS Kel.STP	45	<0.005	<0.002	0.069	0.24		0.014	0.004		
97/08/13	O500236	DNS Kel.STP	1-10	<0.005	<0.002	<0.002	0.2		0.023	0.004		5.6
97/08/13	O500236	DNS Kel.STP	20	<0.005	<0.002	<0.002	0.2		0.017	0.003		
97/08/13	O500236	DNS Kel.STP	45	<0.005	<0.002	0.071	0.22		0.015	0.004		
97/08/07	E223295	Rattlesnake	1-10	0.011	<0.002	<0.002	0.17		0.01	0.008		1.3
97/08/07	E223295	Rattlesnake	20	0.009	<0.002	0.009	0.16		0.01	0.007		
97/08/07	E223295	Rattlesnake	45	<0.005	<0.002	0.063	0.18		0.007	0.01		
97/08/07	O500729	S.Squally Pt.	1-10	0.008	<0.002	<0.002	0.17		0.01	0.009		1.1
97/08/07	O500729	S.Squally Pt.	20	0.008	<0.002	0.012	0.18		0.01	0.009		
97/08/07	O500729	S.Squally Pt.	45	0.005	<0.002	0.067	0.19		0.008	0.008		
97/08/07	O500454	S.Prairie Cr.	1-10	0.008	<0.002	0.002	0.17		0.009	0.009	6.5	0.8
97/08/07	O500454	S.Prairie Cr.	20	0.008	<0.002	0.021	0.17		0.009	0.008		
97/08/07	O500454	S.Prairie Cr.	45	<0.005	<0.002	0.065	0.18		0.007	0.009		
97/08/27	O500246	Kala.S.E.	1-10	0.007	<0.002	<0.002	0.28		0.007	0.002	5.1	1.1
97/08/27	O500246	Kala.S.E.	20	0.019	<0.002	0.013	0.26		0.013	0.004		
97/08/27	O500246	Kala.S.E.	45	<0.005	<0.002	0.137	0.33		0.009	0.005		
97/08/27	O500847	Kala.D.B.	1-10	0.006	<0.002	0.003	0.27		0.007	0.003	5.0	4.8
97/08/27	O500847	Kala.D.B.	20	0.011	<0.002	0.04	0.28		0.011	0.005		
97/08/27	O500847	Kala.D.B.	45	<0.005	<0.002	0.139	0.33		0.009	0.004		
97/09/03	O500239	Arm.Arm	1-10	<0.005	<0.002	<0.002	0.26		0.014	0.005	7.2	7.3
97/09/03	O500239	Arm.Arm	20	<0.005	<0.002	0.118	0.32		0.081	0.007		
97/09/03	O500239	Arm.Arm	45	<0.005	<0.002	0.278	0.47		0.008	0.008		
97/09/03	E206611	Vern.Out.	1-10	<0.005	<0.002	<0.002	0.22		0.009	0.004		<0.4
97/09/03	E206611	Vern.Out.	20	0.007	<0.002	<0.002	0.21		0.009	0.004		
97/09/03	E206611	Vern.Out.	45	<0.005	<0.002	0.065	0.19		0.005	0.004		
97/09/03	O500730	N.OK.Centre	1-10	<0.005	<0.002	0.005	0.22		0.009	0.004	6.7	1.8
97/09/03	O500730	N.OK.Centre	20	<0.005	<0.002	0.007	0.17		0.007	0.003		
97/09/03	O500730	N.OK.Centre	45	<0.005	<0.002	0.061	0.2		0.006	0.004		
97/09/04	O500456	UPS Kel.STP	1-10	<0.005	<0.002	0.002	0.2		0.006	0.004		2.5
97/09/04	O500456	UPS Kel.STP	20	<0.005	<0.002	0.063	0.2		0.006	0.004		
97/09/04	O500456	UPS Kel.STP	45	<0.005	<0.002	0.063	0.2		0.006	0.004		

97/09/08	O500236	DNS Kel.STP	1-10	<0.005	<0.005	0.002	0.18		0.008	0.007		1.6
97/09/08	O500236	DNS Kel.STP	20	<0.005	<0.005		0.21		0.007	0.006		
97/09/08	O500236	DNS Kel.STP	45	<0.005	<0.005		0.21		0.007	0.006		
97/09/08	E223295	Rattlesnake	1-10	<0.005	<0.002	<0.002	0.19		0.008	0.004		0.8
97/09/08	E223295	Rattlesnake	20	<0.005	<0.002	<0.002	0.19		0.011	0.004		
97/09/08	E223295	Rattlesnake	45	<0.005	<0.002	0.063	0.2		0.007	0.004		
97/09/08	O500729	S.Squally Pt.	1-10	<0.005	<0.002	<0.002	0.2		0.008	0.004		1.8
97/09/08	O500729	S.Squally Pt.	20	<0.005	<0.002	<0.002	0.2		0.009	0.005		
97/09/08	O500729	S.Squally Pt.	45	<0.005	<0.002	0.066	0.21		0.007	0.003		
97/09/01	O500454	S.Prairie Cr.	1-10	<0.005	<0.002	<0.002	0.19		0.009	0.004	6.6	1.2
97/09/01	O500454	S.Prairie Cr.	20	<0.005	<0.002	<0.002	0.18		0.014	0.003		
97/09/01	O500454	S.Prairie Cr.	45	<0.005	<0.002	0.066	0.21		0.007	<0.002		
97/10/14	O500246	Kala.S.E.	1-10	<0.005	<0.002	0.003	0.4		0.016	0.006		2.7
97/10/14	O500246	Kala.S.E.	20	<0.005	<0.002	<0.002	0.26		0.012	0.005		
97/10/14	O500246	Kala.S.E.	45	<0.005	<0.002	0.169	0.3		0.013	0.007		
97/10/14	O500847	Kala.D.B.	1-10	<0.005	<0.002	<0.002	0.5		0.013	0.008	5.6	<0.4
97/10/14	O500847	Kala.D.B.	20	<0.005	<0.002	0.012	0.4		0.013	0.005		
97/10/14	O500847	Kala.D.B.	45	<0.005	<0.002	0.168	0.3		0.013	0.006		
97/10/15	O500239	Arm.Arm	1-10	<0.005	<0.002	<0.002	0.3		0.018	0.008	7.4	4.3
97/10/15	O500239	Arm.Arm	20	<0.005	<0.002	0.041	0.24		0.019	0.009		
97/10/15	O500239	Arm.Arm	45	<0.005	<0.002	0.328	0.6		0.105	0.008		
97/10/15	E206611	Vern.Out.	1-10	<0.005	<0.002	<0.002	0.3		0.012	0.009		4.0
97/10/15	E206611	Vern.Out.	20	0.005	<0.002	0.024	0.2		0.011	0.006		
97/10/15	E206611	Vern.Out.	45	<0.005	<0.002	0.074	0.2		0.01	0.008		
97/10/15	O500730	N.OK.Centre	1-10	<0.005	<0.002	0.003	0.3		0.011	0.006	6.8	4.8
97/10/15	O500730	N.OK.Centre	20	<0.005	<0.002	<0.002	0.2		0.01	0.007		
97/10/15	O500730	N.OK.Centre	45	<0.005	<0.002	0.063	0.2		0.008	0.007		
97/10/15	O500456	UPS Kel.STP	1-10	<0.005	<0.002	0.006	0.3		0.011	0.009		3.2
97/10/15	O500456	UPS Kel.STP	20	<0.005	<0.002	0.007	0.2		0.01	0.008		
97/10/15	O500456	UPS Kel.STP	45	<0.005	<0.002	0.078	0.2		0.01	0.011		
97/10/16	O500236	DNS Kel.STP	1-10	<0.005	<0.002	0.005	0.2		0.013	0.007		2.4
97/10/16	O500236	DNS Kel.STP	20	<0.005	<0.002	0.015	0.2		0.01	0.007		
97/10/16	O500236	DNS Kel.STP	45	<0.005	<0.002	0.08	0.3		0.011	0.009		
97/10/16	E223295	Rattlesnake	1-10	<0.005	<0.002	<0.002	0.3		0.011	0.008		3.8
97/10/16	E223295	Rattlesnake	20	<0.005	<0.002	0.017	0.2		0.01	0.006		
97/10/16	E223295	Rattlesnake	45	<0.005	<0.002	0.075	0.2		0.009	0.006		
97/11/04	O500246	Kala.S.E.	1-10	0.006	<0.002	0.02	0.37		0.01	0.005		3.2
97/11/04	O500246	Kala.S.E.	20	<0.005	<0.002	<0.002	0.26		0.012	0.005		
97/11/04	O500246	Kala.S.E.	45	<0.005	<0.002	0.169	0.3		0.013	0.007		
97/11/04	O500847	Kala.D.B.	1-10	<0.005	<0.002	0.02	0.34		0.008	0.005	6.1	2.9
97/11/04	O500847	Kala.D.B.	20	<0.005	<0.002	0.157	0.41		0.006	0.007		
97/11/04	O500847	Kala.D.B.	45	0.005	<0.002	0.048	0.34		0.008	0.005		
97/11/11	O500239	Arm.Arm	1-10	0.007	<0.002	0.03	0.23		0.019	0.009	7.3	2.5
97/11/11	O500239	Arm.Arm	20	0.007	<0.002	0.03	0.21		0.019	0.009		
97/11/11	O500239	Arm.Arm	45	<0.005	<0.002	0.315	0.46		0.104	0.097		
97/11/13	E206611	Vern.Out.	1-10	0.006	<0.005		0.2		0.016	<0.002		2.3
97/11/13	E206611	Vern.Out.	20	<0.002	<0.005		0.17		0.017	<0.002		
97/11/13	E206611	Vern.Out.	45	<0.002	<0.005		0.19		0.013	<0.002		
97/11/11	O500730	N.OK.Centre	1-10	<0.005	<0.002	0.012	0.17		0.008	0.004	6.3	1.7
97/11/11	O500730	N.OK.Centre	20	0.006	<0.002	0.013	0.16		0.007	0.012		
97/11/11	O500730	N.OK.Centre	45	<0.005	<0.002	0.071	0.17		0.003	0.008		
97/11/12	O500456	UPS Kel.STP	1-10	0.01	<0.002	0.013	0.17		0.015	0.016		3.0
97/11/12	O500456	UPS Kel.STP	20	0.007	<0.002	0.019	0.19		0.015	0.01		
97/11/12	O500456	UPS Kel.STP	45	<0.005	<0.002	0.067	0.19		0.014	0.009		
97/11/12	O500236	DNS Kel.STP	1-10	0.007	<0.002	0.033	0.18		0.015	0.011		1.6
97/11/12	O500236	DNS Kel.STP	20	0.006	<0.002	0.065	0.17		0.016	0.009		
97/11/12	O500236	DNS Kel.STP	45	0.006	<0.002	0.072	0.17		0.029	0.01		

97/11/12	E223295	Rattlesnake	1-10	0.011	<0.002	0.044	0.16		0.016	0.011		4.0
97/11/12	E223295	Rattlesnake	20	0.01	<0.002	0.045	0.16		0.014	0.009		
97/11/12	E223295	Rattlesnake	45	0.011	<0.002	0.047	0.17		0.016	0.009		
97/11/12	O500729	S.Squally Pt.	1-10	<0.005	<0.002	0.039	0.16		0.011	0.009		2.0
97/11/12	O500729	S.Squally Pt.	20	0.009	<0.002	0.042	0.16		0.013	0.01		
97/11/12	O500729	S.Squally Pt.	45	0.012	<0.002	0.062	0.17		0.014	0.009		
97/11/06	O500454	S.Prairie Cr.	1-10	<0.005	<0.002	0.048	0.25		0.007	0.004	6.1	1.6
97/11/06	O500454	S.Prairie Cr.	20	<0.005	<0.002	0.049	0.25		0.007	0.004		
97/11/06	O500454	S.Prairie Cr.	45	<0.005	<0.002	0.07	0.27		0.006	0.004		
97/12/07	O500246	Kala.S.E.	1-10	0.007	<0.002	0.07	0.32		0.011	0.006		1.3
97/12/07	O500246	Kala.S.E.	20	0.007	<0.002	0.071	0.31		0.01	0.006		
97/12/07	O500246	Kala.S.E.	45	0.007	<0.002	0.073	0.32		0.009	0.006		
97/12/07	O500847	Kala.D.B.	1-10	0.008	<0.002	0.072	0.35		0.01	0.005	7.2	1.1
97/12/07	O500847	Kala.D.B.	20	0.011	<0.002	0.073	0.32		0.009	0.006		
97/12/07	O500847	Kala.D.B.	45	<0.005	<0.002	0.154	0.35		0.009	0.007		
97/12/06	O500239	Arm.Arm	1-10	0.042	<0.002	0.074	0.33		0.031	0.024	8.9	4.5
97/12/06	O500239	Arm.Arm	20	<0.005	<0.002	0.074	0.29		0.029	0.022		
97/12/06	O500239	Arm.Arm	45	0.007	<0.002	0.073	0.3		0.029	0.022		
97/12/06	E206611	Vern.Out.	1-10	<0.005	<0.002	0.033	0.23		0.009	0.004		2.4
97/12/06	E206611	Vern.Out.	20	0.006	<0.002	0.033	0.25		0.01	0.007		
97/12/06	E206611	Vern.Out.	45	0.008	<0.002	0.032	0.22		0.009	0.005		
97/12/06	O500730	N.OK.Centre	1-10	<0.005	<0.002	0.037	0.22		0.008	0.006	7.3	1.4
97/12/06	O500730	N.OK.Centre	20	<0.005	<0.002	0.037	0.23		0.008	0.005		
97/12/06	O500730	N.OK.Centre	45	<0.005	<0.002	0.04	0.21		0.009	0.006		
97/12/06	O500456	UPS Kel.STP	1-10	<0.005	<0.002	0.048	0.23		0.008	0.005		1.6
97/12/06	O500456	UPS Kel.STP	20	<0.005	<0.002	0.048	0.21		0.008	0.006		
97/12/06	O500456	UPS Kel.STP	45	<0.005	<0.002	0.05	0.23		0.009	0.006		
97/12/04	O500236	DNS Kel.STP	1-10	<0.005	<0.002	0.048	0.19		0.01	0.009		1.9
97/12/04	O500236	DNS Kel.STP	20	<0.005	<0.002	0.047	0.21		0.009	0.005		
97/12/04	O500236	DNS Kel.STP	45	<0.005	<0.002	0.045	0.21		0.009	0.006		
97/12/04	E223295	Rattlesnake	1-10	<0.005	<0.002	0.045	0.21		0.009	0.011		1.1
97/12/04	E223295	Rattlesnake	20	0.005	<0.002	0.046	0.22		0.011	0.006		
97/12/04	E223295	Rattlesnake	45	<0.005	<0.002	0.048	0.22		0.01	0.007		
97/12/11	O500729	S.Squally Pt.	1-10	<0.005	<0.002	0.059	0.24		0.008	0.005		0.8
97/12/11	O500729	S.Squally Pt.	20	<0.005	<0.002	0.067	0.22		0.008	0.005		
97/12/11	O500729	S.Squally Pt.	45	<0.005	<0.002	0.067	0.23		0.008	0.005		
97/12/09	O500454	S.Prairie Cr.	1-10	<0.005	<0.002	0.053	0.22		0.008	0.005	7.3	1.4
97/12/09	O500454	S.Prairie Cr.	20	<0.005	<0.002	0.053	0.22		0.008	0.006		
97/12/09	O500454	S.Prairie Cr.	45	<0.005	<0.002	0.058	0.23		0.009	0.005		
Date	Station	Location	Depth	Nitrogen				Phosphorus		Silica	Chlorophyll A	
	No.		(m)	ammonia	nitrite	nitrite+nitrate	total	total	total dissolved	reactive		
				(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)	
98/02/03	E206611	Vern.Out.	1-10	<.005	<.002	0.048	0.25	0.011	0.008		0.6	
98/02/03	E206611	Vern.Out.	20	<.005	<.002	0.048	0.26	0.013	0.009			
98/02/03	E206611	Vern.Out.	45	<.005	<.002	0.049	0.23	0.012	0.007			
98/02/03	O500730	N.OK.Centre	1-10	<.005	<.002	0.075	0.24	0.011	0.009	7.2	0.5	pH=8.07
98/02/03	O500730	N.OK.Centre	20	<.005	<.002	0.051	0.29	0.013	0.008			
98/02/03	O500730	N.OK.Centre	45	<.005	<.002	0.051	0.28	0.012	0.007			
			20-45	<.005	<.002	0.071	0.27	0.012	0.009	7.3		pH=8.07
98/02/05	O500456	UPS Kel.STP	1-10	<.005	<.002	0.048	0.21	0.01	0.007		1.1	
98/02/05	O500456	UPS Kel.STP	20	<.005	<.002	0.402	0.21	0.01	0.007			
98/02/05	O500456	UPS Kel.STP	45	<.005	<.002	0.049	0.22	0.012	0.009			
			20-45	<.005	<.002	0.051	0.21	0.012	0.009			
98/02/02	O500236	DNS Kel.STP	1-10	<.005	<.002	0.074	0.23	0.009	0.007		0.5	
98/02/02	O500236	DNS Kel.STP	20	<.005	<.002	0.077	0.23	0.012	0.007			
98/02/02	O500236	DNS Kel.STP	45	<.005	<.002	0.075	0.22	0.012	0.006			
			20-45	<.005	<.002	0.075	0.25	0.013	0.007			
98/02/09	E223295	Rattlesnake	1-10	<.005	<.002	0.052	0.25	0.007	0.003		0.8	
98/02/09	E223295	Rattlesnake	20	<.005	<.002	0.052	0.2	0.005	0.005			
98/02/09	E223295	Rattlesnake	45	<.005	<.002	0.053	0.2	0.006	0.003			

98/02/09	O500729	S.Squally Pt.	1-10	<.005	<.002	0.0582	0.19	0.007	0.004		1.1	
98/02/09	O500729	S.Squally Pt.	20	<.005	<.002	0.052	0.17	0.008	0.004			
98/02/09	O500729	S.Squally Pt.	45	<.005	<.002	0.053	0.2	0.007	0.004			
			20-45	<.005	<.002	0.053	0.19	0.007	0.003			
98/02/09	O500454	S.Prairie Cr.	1-10	<.005	<.002	0.052	0.23	0.006	0.003	7.2		
98/02/09	O500454	S.Prairie Cr.	20	<.005	<.002	0.052	0.2	0.008	0.004			
98/02/09	O500454	S.Prairie Cr.	45	<.005	<.002	0.051	0.19	0.008	0.003			
98/02/09	O500454	S.Prairie Cr.	20-45	<.005	<.002	0.052	0.25	0.008	0.004	7.3		
							0.226	0.010				
Date	Station	Location	Depth	Nitrogen				Phosphorus		Silica	Chlorophyll A	
	No.		(m)	ammonia	nitrite	nitrite+nitrate	total	total	total dissolved	reactive		
				(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)	
98/02/23	O500246	Kala.S.E.	1-10	<.005	<.002	0.129	0.33	0.006	0.005		2.1	
98/02/23	O500246	Kala.S.E.	20	<.005	<.002	0.131	0.32	0.005	<.002			
98/02/23	O500246	Kala.S.E.	45	<.005	<.002	0.133	0.33	0.004	<.002			
98/02/23	O500246	Kala.S.E.	20-45	<.005	<.002	0.134	0.34	0.007	0.004			
98/02/23	O500847	Kala.D.B.	1-10	<.005	<.002	0.14	0.35	0.005	<.002	8.9	2.0	
98/02/23	O500847	Kala.D.B.	20	<.005	<.002	0.139	0.33	0.005	<.002			
98/02/23	O500847	Kala.D.B.	45	<.005	<.002	0.14	0.33	0.005	<.002			
98/02/23	O500847	Kala.D.B.	20-45	<.005	<.002	0.14	0.36	0.004	<.002	8.9		
							0.336	0.005				
98/03/11	E206611	Vern.Out.	1-10	<.005	<.002	0.053	0.3	0.009	0.003		2.3	
98/03/11	E206611	Vern.Out.	20	<.005	<.002	0.056	0.25	0.014	<.002			
98/03/11	E206611	Vern.Out.	45	<.005	<.002	0.06	0.24	0.006	0.003			
98/03/12	O500730	N.OK.Centre	1-10	<.005	<.002	0.066	0.24	0.004	0.003	6.9	1.5	
98/03/12	O500730	N.OK.Centre	20	<.005	<.002	0.07	0.22	0.007	0.007			
98/03/12	O500730	N.OK.Centre	45	<.005	<.002	0.068	0.24	0.005	0.005			
98/03/09	O500456	UPS Kel.STP	1-10	<.005	<.002	0.06	0.26	0.006	0.006		<0.4	
98/03/09	O500456	UPS Kel.STP	20	<.005	<.002	0.066	0.26	0.006	0.007			
98/03/09	O500456	UPS Kel.STP	45	<.005	<.002	0.064	0.24	0.006	<.002			
98/03/09	O500236	DNS Kel.STP	1-10	<.005	<.002	0.07	0.22	0.005	0.006		2.4	
98/03/09	O500236	DNS Kel.STP	20	<.005	<.002	0.071	0.24	0.006	0.008			
98/03/09	O500236	DNS Kel.STP	45	<.005	<.002	0.068	0.22	0.005	0.009			
98/03/10	E223295	Rattlesnake	1-10	<.005	<.002	0.069	0.22	0.012	0.006		1.9	
98/03/10	E223295	Rattlesnake	20	<.005	<.002	0.069	0.31	0.007	0.006			
98/03/10	E223295	Rattlesnake	45	<.005	<.002	0.071	0.21	0.011	0.012			
98/03/10	O500729	S.Squally Pt.	1-10	<.005	<.002	0.064	0.21	0.005	0.003		2.0	
98/03/10	O500729	S.Squally Pt.	20	<.005	<.002	0.066	0.22	0.006	0.006			
98/03/10	O500729	S.Squally Pt.	45	<.005	<.002	0.066	0.25	0.005	0.007			
98/03/10	O500454	S.Prairie Cr.	1-10	<.005	<.002	0.062	0.2	0.008	0.005	6.7	1.6	
98/03/10	O500454	S.Prairie Cr.	20	<.005	<.002	0.066	0.23	0.007	0.005			
98/03/10	O500454	S.Prairie Cr.	45	<.005	<.002	0.064	0.22	0.006	0.005			
							0.238	0.007				
Date	Station	Location	Depth	Nitrogen				Phosphorus		Silica	Chlorophyll A	
	No.		(m)	ammonia	nitrite	nitrite+nitrate	total	total	total dissolved	reactive		
				(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)	
98/03/23	O500246	Kala.S.E.	1-10	0.022	<.002	0.071	0.32	0.007	0.002		3.1	
98/03/23	O500246	Kala.S.E.	20	<.005	<.002	0.056	0.33	0.004	<.002			
98/03/23	O500246	Kala.S.E.	45	<.005	<.002	0.006	0.32	0.009	<.002			
98/03/23	O500847	Kala.D.B.	1-10	0.007	0.004	0.289	0.35	0.006	0.002	7.5	11.3	
98/03/23	O500847	Kala.D.B.	20	0.006	<.002	0.119	0.31	0.005	<.002			
98/03/23	O500847	Kala.D.B.	45	0.006	<.002	0.12	0.32	0.005	<.002			
							0.325	0.006				
98/04/02	O500239	Arm.Arm	1-10	<.005	<.002	0.007	0.27	0.02	<.002	5.3	6.5	
98/04/02	O500239	Arm.Arm	20	0.009	<.002	0.026	0.37	0.02	<.002			
98/04/02	O500239	Arm.Arm	45	<.005	<.002	0.134	0.37	0.028	0.01			
98/04/02	O500239	Arm.Arm	20-45	0.008	<.002	0.09	0.34	0.024	0.003	7.1		
							0.338	0.023	0.0065			
98/04/02	E206611	Vern.Out.	1-10	<.005	<.002	0.029	0.19	0.006	<.002		8.1	
98/04/02	E206611	Vern.Out.	20	<.005	<.002	0.038	0.2	0.009	<.002			
98/04/02	E206611	Vern.Out.	45	0.007	<.002	0.049	0.2	0.004	<.002			
98/04/04	O500730	N.OK.Centre	1-10	<.005	<.002	0.024	0.22	0.008	<.002	6.2	7.5	
98/04/04	O500730	N.OK.Centre	20	<.005	<.002	0.05	0.23	0.007	<.002			
98/04/04	O500730	N.OK.Centre	45	<.005	<.002	0.069	0.23	0.007	<.002			
98/04/04	O500456	UPS Kel.STP	1-10	<.005	<.002	0.037	0.21	0.009	<.002		7.8	
98/04/04	O500456	UPS Kel.STP	20	<.005	<.002	0.046	0.2	0.007	<.002			
98/04/04	O500456	UPS Kel.STP	45	<.005	<.002	0.065	0.23	0.011	<.002			
98/03/31	O500236	DNS Kel.STP	1-10	<.005	<.002	0.047	0.2	0.003	<.002		5.4	

98/03/31	O500236	DNS Kel.STP	20	<.005	<.002	0.047	0.21	0.01	<.002			
98/03/31	O500236	DNS Kel.STP	45	<.005	<.002	0.056	0.21	0.004	0.002			
98/03/31	E223295	Rattlesnake	1-10	<.005	<.002	0.057	0.2	0.002	<.002		8.9	
98/03/31	E223295	Rattlesnake	20	<.005	<.002	0.063	0.2	0.002	<.002			
98/03/31	E223295	Rattlesnake	45	<.005	<.002	0.067	0.19	0.003	<.002			
98/03/31	O500729	S.Squally Pt.	1-10	<.005	<.002	0.057	0.19	<.002	<.002		6.4	
98/03/31	O500729	S.Squally Pt.	20	<.005	<.002	0.057	0.2	0.002	0.005			
98/03/31	O500729	S.Squally Pt.	45	<.005	<.002	0.064	0.19	0.003	0.003			
98/03/31	O500454	S.Prairie Cr.	1-10	<.005	<.002	0.058	0.18	0.003	<.002	6.5	9.1	
98/03/31	O500454	S.Prairie Cr.	20	<.005	<.002	0.054	0.2	0.002	<.002			
98/03/31	O500454	S.Prairie Cr.	45	<.005	<.002	0.06	0.19	0.002	<.002			
							0.203	0.005				
Date	Station	Location	Depth	Nitrogen				Phosphorus		Silica	Chlorophyll A	
	No.		(m)	ammonia	nitrite	nitrite+nitrate	total	total	total dissolved	reactive		
				(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)	
98/04/20	O500847	Kala.D.B.	1-10	<.005	<.002	0.083	0.42	0.01	<.005	7.1	6.9	
	O500847	Kala.D.B.	20	<.005	<.002	0.091	0.46	0.01	<.002			
	O500847	Kala.D.B.	45	0.009	<.002	0.118	0.48	0.01	<.002			
							0.261	0.006				
98/04/28	O500239	Arm.Arm	1-10	<.005	<.002	<.002	0.37	0.009	<.002	4.4	4.3	
98/04/28	O500239	Arm.Arm	20	<.005	<.002	0.076	0.4	0.008	<.002			
98/04/28	O500239	Arm.Arm	45	<.005	<.002	0.146	0.46	0.012	<.002			
							0.41	0.01				
98/04/28	O500730	N.OK.Centre	1-10	<.005	<.002	0.002	0.26	0.006	<.002	5.2	4.3	
98/04/28	O500730	N.OK.Centre	20	<.005	<.002	0.009	0.24	0.004	<.002			
98/04/28	O500730	N.OK.Centre	45	<.005	<.002	0.056	0.27	0.004	<.002			
98/04/22	E223295	Rattlesnake	1-10	<.005	<.002	0.047	0.27	<.002	<.002		5.3	
98/04/22	E223295	Rattlesnake	20	<.005	<.002	0.056	0.32	0.003	<.002			
98/04/22	E223295	Rattlesnake	45	<.005	<.002	0.07	0.3	0.008	<.002			
98/04/22	O500454	S.Prairie Cr.	1-10	<.005	<.002	0.044	0.29	0.007	<.002	6.2	4.8	
98/04/22	O500454	S.Prairie Cr.	20	<.005	<.002	0.051	0.27	0.006	<.002			
98/04/22	O500454	S.Prairie Cr.	45	<.005	<.002	0.063	0.27	0.006	<.002			
							0.277	0.005				
Date	Station	Location	Depth	Nitrogen				Phosphorus		Silica	Chlorophyll A	
	No.		(m)	ammonia	nitrite	nitrite+nitrate	total	total	total dissolved	reactive		
				(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)	
98/05/26	O500847	Kala.D.B.	1-10	0.018	<.002	0.002	0.31	0.01	0.003	6.2	4.8	
98/05/26	O500847	Kala.D.B.	20	0.023	0.003	0.103	0.39	0.008	0.004			
98/05/26	O500847	Kala.D.B.	45	<.005	<.002	0.164	0.38	0.005	0.005			
							0.36	0.008				
98/06/10	O500239	Arm.Arm	1-10	<.005	<.002	<.002	0.22	0.009	0.005	6.6	2.2	
98/06/10	O500239	Arm.Arm	20	<.005	<.002	0.079	0.27	0.011	0.005			
98/06/10	O500239	Arm.Arm	45	<.005	<.002	0.214	0.41	0.037	0.028			
							0.3	0.019				
98/06/10	E206611	Vern.Out.	1-10	<.005	<.002	<.002	0.21				3.5	
98/06/10	E206611	Vern.Out.	20	0.008	<.002	0.016	0.18					
98/06/10	E206611	Vern.Out.	45	<.005	<.002	0.063	0.2					
98/06/10	O500730	N.OK.Centre	1-10	<.005	<.002	0.004	0.2	0.007	0.003	6.2	2.4	
98/06/10	O500730	N.OK.Centre	20	<.005	<.002	0.012	0.18	0.006	0.005			
98/06/10	O500730	N.OK.Centre	45	<.005	<.002	0.066	0.2	0.005	0.003			
98/05/28	E223295	Rattlesnake	1-10	<.005	<.002	0.03	0.24	0.002	0.002		2.1	
98/05/28	E223295	Rattlesnake	20	0.006	<.002	0.038	0.21	0.002	0.002			
98/05/28	E223295	Rattlesnake	45	<.005	<.002	0.079	0.25	0.004	0.003			
98/05/28	O500454	S.Prairie Cr.	1-10	<.005	<.002	0.056	0.23	<.002	0.002	6.6	1.4	
98/05/28	O500454	S.Prairie Cr.	20	<.005	0.022	0.07	0.24	0.002	0.002			
98/05/28	O500454	S.Prairie Cr.	45	<.005	0.022	0.085	0.24	0.002	0.002			
							0.215	0.003				
Date	Station	Location	Depth	Nitrogen				Phosphorus		Silica	Chlorophyll A	
	No.		(m)	ammonia	nitrite	nitrite+nitrate	total	total	total dissolved	reactive		
				(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)	
98/07/06	O500239	Arm.Arm	1-10	<0.005	<0.002	<0.002	0.23	0.011	0.003	6.3	3.7	
98/07/06	O500239	Arm.Arm	20	<0.005	<0.002	0.076	0.3	0.013	0.006			
98/07/06	O500239	Arm.Arm	45	<0.005	<0.002	0.236	0.46	0.038	0.032			
98/07/06	E206611	Vern.Out.	1-10	<0.005	<0.002	<0.002	0.21	0.007	0.003		2.7	
98/07/06	E206611	Vern.Out.	20	<0.005	<0.002	0.017	0.18	0.006	0.004			
98/07/06	E206611	Vern.Out.	45	<0.005	<0.002	0.075	0.2	0.005	0.003			
98/07/06	O500730	N.OK.Centre	1-10	<0.005	<0.002	<0.002	0.17	0.008	0.004	6.2	3.5	
98/07/06	O500730	N.OK.Centre	20	<0.005	<0.002	0.021	0.17	0.006	0.004			
98/07/06	O500730	N.OK.Centre	45	<0.005	<0.002	0.076	0.2	0.005	0.003			

98/06/23	E223295	Rattlesnake	1-10	<0.005	<0.002	<0.002	0.15	0.004	0.003		3.0	
98/06/23	E223295	Rattlesnake	20	<0.005	<0.002	0.033	0.18	0.004	0.003			
98/06/23	E223295	Rattlesnake	45	<0.005	<0.002	0.077	0.25	0.005	0.003			
98/06/22	O500454	S.Prairie Cr.	1-10	<0.005	<0.002	<0.002	0.18	0.007	0.006		1.9	
98/06/22	O500454	S.Prairie Cr.	20	0.008	<0.002	0.035	0.21	0.005	0.003			
98/06/22	O500454	S.Prairie Cr.	45	<0.005	<0.002	0.081	0.22	0.004	0.002			
Date	Station	Location	Depth	Nitrogen				Phosphorus		Silica	Chlorophyll A	
	No.		(m)	ammonia	nitrite	nitrite+nitrate	total	total	total dissolved	reactive		
				(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)	
98/07/30	O500847	Kala.D.B.	1-10	<0.005	<0.002	<0.002	0.22	0.006	0.006		1.1	
98/07/30	O500847	Kala.D.B.	20	0.01	<.002	0.072	0.3	0.009	0.005			
98/07/30	O500847	Kala.D.B.	45	0.006	<.002	0.193	0.29	0.009	0.006			
							0.27	0.008				
98/07/29	O500239	Arm.Arm	1-10	<0.005	<0.002	<0.002	0.21	0.006	0.004		2.9	
98/07/29	O500239	Arm.Arm	20	<0.005	<0.002	0.097	0.26	0.012	0.006			
98/07/29	O500239	Arm.Arm	45	<0.005	0.002	0.265	0.46	0.048	0.041			
							0.31	0.022				
98/07/29	E206611	Vern.Out.	1-10	<0.005	<0.002	<0.002	0.19	0.007	0.005		0.8	
98/07/29	E206611	Vern.Out.	20	<0.005	<0.002	0.013	0.23	0.007	0.004			
98/07/29	E206611	Vern.Out.	45	<0.005	<0.002	0.082	0.2	0.006	0.005			
98/07/29	O500730	N.OK.Centre	1-10	<0.005	<0.002	<0.002	0.18	0.006	0.004		0.8	
98/07/29	O500730	N.OK.Centre	20	<0.005	<0.002	<0.002	0.2	0.006	0.004			
98/07/29	O500730	N.OK.Centre	45	<0.005	<0.002	0.081	0.2	0.005	0.005			
98/07/28	E223295	Rattlesnake	1-10	<0.005	<0.002	<0.002	0.15	0.008	0.003		1.1	
98/07/28	E223295	Rattlesnake	20	0.01	<0.002	0.009	0.19	0.005	0.006			
98/07/28	E223295	Rattlesnake	45	0.005	<0.002	0.091	0.21	0.005	0.003			
98/07/28	O500454	S.Prairie Cr.	1-10	0.005	<0.002	<0.002	0.17	0.005	0.003		1.4	
98/07/28	O500454	S.Prairie Cr.	20	<0.005	<0.002	0.019	0.21	0.005	0.003			
98/07/28	O500454	S.Prairie Cr.	45	0.006	<0.002	0.094	0.22	0.005	0.004			
							0.196	0.006				
Date	Station	Location	Depth	Nitrogen				Phosphorus		Silica	Chlorophyll A	
	No.		(m)	ammonia	nitrite	nitrite+nitrate	total	total	total dissolved	reactive		
				(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)	
98/08/26	O500847	Kala.D.B.	1-10	<0.005	<0.002	<0.002	0.26	0.008	0.004		2.6	
98/08/26	O500847	Kala.D.B.	20	<0.005	<0.002	0.089	0.31	0.01	0.004			
98/08/26	O500847	Kala.D.B.	45	<0.005	<0.002	0.174	0.35	0.008	0.007			
							0.307	0.009				
98/08/23	O500239	Arm.Arm	1-10	<0.005	<0.002	<0.002	0.19	0.011	0.006		13.4	
98/08/23	O500239	Arm.Arm	20	<0.005	<0.002	0.088	0.3	0.007	0.007			
98/08/23	O500239	Arm.Arm	45	<0.005	<0.002	0.288	0.46	0.066	0.059			
							0.317	0.028				
98/08/23	E206611	Vern.Out.	1-10	<0.005	<0.002	<0.002	0.19	0.007	0.004		10.7	
98/08/23	E206611	Vern.Out.	20	<0.005	<0.002	0.013	0.2	0.008	0.005			
98/08/23	E206611	Vern.Out.	45	<0.005	<0.002	0.084	0.23	0.007	0.005			
98/08/23	O500730	N.OK.Centre	1-10	<0.005	<0.002	<0.002	0.2	0.006	0.004		13.7	
98/08/23	O500730	N.OK.Centre	20	<0.005	<0.002	0.002	0.21	0.008	<0.002			
98/08/23	O500730	N.OK.Centre	45	<0.005	<0.002	0.076	0.31	0.007	<0.002			
98/08/24	O500236	DNS Kel.STP	1-10	<0.005	<0.002	<0.002	0.2	0.007	0.005		8.6	
98/08/24	O500236	DNS Kel.STP	20	<0.005	<0.002	0.021	0.2	0.007	0.004			
98/08/24	O500236	DNS Kel.STP	45	<0.005	<0.002	0.094	0.23	0.007	0.006			
98/08/24	E223295	Rattlesnake	1-10	<0.005	<0.002	<0.002	0.19	0.007	0.005		13.1	
98/08/24	E223295	Rattlesnake	20	<0.005	<0.002	<0.002	0.23	0.007	0.005			
98/08/24	E223295	Rattlesnake	45	<0.005	<0.002	0.087	0.26	0.007	0.004			
98/08/25	O500454	S.Prairie Cr.	1-10	<0.005	<0.002	<0.002	0.18	0.007	0.006		1.9	
98/08/25	O500454	S.Prairie Cr.	20	<0.005	<0.002	0.046	0.22	0.009	0.005			
98/08/25	O500454	S.Prairie Cr.	45	0.007	<0.002	0.095	0.2	0.008	0.006			
							0.217	0.007				
Date	Station	Location	Depth	Nitrogen				Phosphorus		Silica	Chlorophyll A	
	No.		(m)	ammonia	nitrite	nitrite+nitrate	total	total	total dissolved	reactive		
				(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)	
98/09/24	O500847	Kala.D.B.	1-10	<0.005	<0.002	<0.002	0.22	0.004	<0.002		1.3	
98/09/24	O500847	Kala.D.B.	20	<0.005	<0.002	0.068	0.27	0.004	<0.002	7.1		
98/09/24	O500847	Kala.D.B.	45	<0.005	<0.002	0.169	0.31	0.003	<0.002	7.9		
98/10/01	O500239	Arm.Arm	1-10	<0.005	<0.002	<0.002	0.25	0.008	<0.002		4.8	
98/10/01	O500239	Arm.Arm	20	<0.005	<0.002	0.071	0.3	0.017	0.011			
98/10/01	O500239	Arm.Arm	45	<0.005	<0.002	0.313	0.5	0.075	0.064			
98/10/04	E206611	Vern.Out.	1-10	<0.005	<0.002	<0.002	0.19	0.008	<0.002		3.8	

98/10/04	E206611	Vern.Out.	20	<0.005	<0.002	0.012	0.18	0.009	0.002			
98/10/04	E206611	Vern.Out.	45	<0.005	<0.002	0.088	0.22	0.006	0.003			
98/10/04	O500730	N.OK.Centre	1-10	<0.005	<0.002	<0.002	0.17	0.006	<0.002		6.7	
98/10/04	O500730	N.OK.Centre	20	<0.005	<0.002	<0.002	0.17	0.007	<0.002			
98/10/04	O500730	N.OK.Centre	45	<0.005	<0.002	0.075	0.2	0.006	<0.002			
98/10/06	E223295	Rattlesnake	1-10	<0.005	<0.002	<0.002	0.17	0.006	<0.002		3.2	
98/10/06	E223295	Rattlesnake	20	<0.005	<0.002	0.004	0.16	0.007	0.002			
98/10/06	E223295	Rattlesnake	45	<0.005	<0.002	0.085	0.21	0.006	0.002			
98/10/06	O500454	S.Prairie Cr.	1-10	<0.005	<0.002	<0.002	0.15	0.006	<0.002		3.5	
98/10/06	O500454	S.Prairie Cr.	20	<0.005	<0.002	0.024	0.17	0.007	0.002			
98/10/06	O500454	S.Prairie Cr.	45	<0.005	<0.002	0.094	0.21	0.005	<0.002			
Date	Station	Location	Depth	Nitrogen				Phosphorus		Silica	Chlorophyll A	
	No.		(m)	ammonia	nitrite	nitrite+nitrate	total	total	total dissolved	reactive		
				(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)	
98/10/26	O500847	Kala.D.B.	1-10	<0.005	<0.002	0.005	0.24	0.01	0.003	6.2	0.8	
98/10/26	O500847	Kala.D.B.	20	0.007	<0.002	0.039	0.24	0.007	0.004			
98/10/26	O500847	Kala.D.B.	45	<0.005	<0.002	0.183	0.35	0.006	0.004			
98/10/21	O500239	Arm.Arm	1-10	<0.005	<0.002	<0.002	0.25	0.015	0.002	6.6	7.3	
98/10/21	O500239	Arm.Arm	20	<0.005	<0.002	0.088	0.29	0.042	0.028			
98/10/21	O500239	Arm.Arm	45	<0.005	<0.002	0.328	0.51	0.097	0.074			
98/10/21	E206611	Vern.Out.	1-10	<0.005	<0.002	<0.002	0.2	0.008	<0.002		3.5	
98/10/21	E206611	Vern.Out.	20	<0.005	<0.002	0.026	0.2	0.009	0.003			
98/10/21	E206611	Vern.Out.	45	<0.005	<0.002	0.079	0.23	0.007	0.003			
98/10/20	O500730	N.OK.Centre	1-10	<0.005	<0.002	<0.002	0.22	0.007	0.003	6.2	4	
98/10/20	O500730	N.OK.Centre	20	<0.005	<0.002	<0.002	0.24	0.009	0.004			
98/10/20	O500730	N.OK.Centre	45	<0.005	<0.002	0.08	0.25	0.007	0.004			
98/10/27	E223295	Rattlesnake	1-10	<0.005	<0.002	<0.002	0.17	0.008	0.002		4.6	
98/10/27	E223295	Rattlesnake	20	<0.005	<0.002	0.008	0.15	0.008	0.002			
98/10/27	E223295	Rattlesnake	45	<0.005	<0.002	0.083	0.18	0.009	0.004			
98/10/27	O500454	S.Prairie Cr.	1-10	<0.005	<0.002	<0.002	0.15	0.008	<0.002	6.3	2.2	
98/10/27	O500454	S.Prairie Cr.	20	<0.005	<0.002	<0.002	0.15	0.007	0.003			
98/10/27	O500454	S.Prairie Cr.	45	<0.005	<0.002	0.081	0.2	0.007	0.002			
							0.195	0.008				
Date	Station	Location	Depth	Nitrogen				Phosphorus			Silica	Chlorophyll A
	No.		(m)	ammonia	nitrite	nitrite+nitrate	total	ortho-	total	total dissolved	reactive	
				(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ug/L)
98/11/30	O500239	Arm.Arm	1-10	<0.005	<0.002	0.006	0.31	0.01	0.027	0.012	7.5	2.4
98/11/30	O500239	Arm.Arm	20	<0.005	<0.002	0.008	0.37	0.011	0.025	0.012		
98/11/30	O500239	Arm.Arm	45	0.024	0.003	0.319	0.55	0.074	0.09	0.087		
98/11/30	E206611	Vern.Out.	1-10	<0.005	<0.002	0.013	0.21	<0.001	0.008	0.002		<0.4
98/11/30	E206611	Vern.Out.	20	<0.005	<0.002	0.01	0.26	<0.001	0.008	0.003		
98/11/30	E206611	Vern.Out.	45	<0.005	<0.002	0.083	0.26	0.002	0.008	0.005		
98/11/30	O500730	N.OK.Centre	1-10	<0.005	<0.002	0.018	0.25	<0.001	0.007	0.003		0.8
98/11/30	O500730	N.OK.Centre	20	<0.005	<0.002	0.017	0.24	<0.001	0.007	0.003		
98/11/30	O500730	N.OK.Centre	45	<0.005	<0.002	0.069	0.25	<0.001	0.006	0.003		
98/12/02	O500236	DNS Kel.STP	1-10	<0.005	<0.002	0.033	0.25	<0.001	0.004	<0.002	6.5	<0.4
98/12/02	O500236	DNS Kel.STP	20	<0.005	<0.002	0.034	0.25	<0.001	0.004	<0.002		
98/12/02	O500236	DNS Kel.STP	45	<0.005	<0.002	0.091	0.29	<0.001	0.004	0.003		
98/12/08	O500454	S.Prairie Cr.	1-10	<0.005	<0.002	0.089	0.26	<0.001	0.007	0.004	6.9	<0.4
98/12/08	O500454	S.Prairie Cr.	20	<0.005	<0.002	0.089	0.27	<0.001	0.007	0.005		
98/12/08	O500454	S.Prairie Cr.	45	<0.005	<0.002	0.093	0.27	<0.001	0.007	0.006		

Appendix 4. Field measurements in Okanagan Lake and Kalamalka Lake, 1996 through 1998.

Date	Station No.	Location	Depth	Temp.	D.O.	Secchi		Date	Station No.	Location	Depth	Temp.	D.O.	Secchi	
			(m)	(C)	(mg/L)	Depth (m)					(m)	(C)	(mg/L)	Depth (m)	
96/07/24	0500246	Kala. S.E.	0	23.0	9.2	7.0		96/07/23	O500456	UPS Kel.STP	0	21.0	6.7	8.1	
96/07/24	0500246	Kala. S.E.	2	22.0	9.4			96/07/23	O500456	UPS Kel.STP	2	20.0	6.8		
96/07/24	0500246	Kala. S.E.	4	21.5	9.4			96/07/23	O500456	UPS Kel.STP	4	19.5	6.9		
96/07/24	0500246	Kala. S.E.	6	20.0	9.7			96/07/23	O500456	UPS Kel.STP	6	19.0	6.8		
96/07/24	0500246	Kala. S.E.	8	16.5	9.7			96/07/23	O500456	UPS Kel.STP	8	18.0	6.7		
96/07/24	0500246	Kala. S.E.	10	15.0	9.8			96/07/23	O500456	UPS Kel.STP	10	17.0	6.8		
96/07/24	0500246	Kala. S.E.	12	13.0	9.7			96/07/23	O500456	UPS Kel.STP	12	16.5	6.7		
96/07/24	0500246	Kala. S.E.	14	11.0	9.3			96/07/23	O500456	UPS Kel.STP	14	16.0	6.6		
96/07/24	0500246	Kala. S.E.	16	8.5	8.8			96/07/23	O500456	UPS Kel.STP	16	14.0	6.7		
96/07/24	0500246	Kala. S.E.	18	8.0	8.7			96/07/23	O500456	UPS Kel.STP	18	12.0	6.7		
96/07/24	0500246	Kala. S.E.	20	7.0	8.3			96/07/23	O500456	UPS Kel.STP	20	8.0	6.4		
96/07/24	0500246	Kala. S.E.	24	5.5	8.0			96/07/23	O500456	UPS Kel.STP	24	7.0	6.2		
96/07/24	0500246	Kala. S.E.	28	5.5	7.8			96/07/23	O500456	UPS Kel.STP	28	5.5	6.2		
96/07/24	0500246	Kala. S.E.	32	5.0	7.7			96/07/23	O500456	UPS Kel.STP	32	5.0	6.2		
96/07/24	0500246	Kala. S.E.	36	5.0	7.7			96/07/23	O500456	UPS Kel.STP	36	5.0	6.2		
96/07/24	0500246	Kala. S.E.	40	4.8	7.7			96/07/23	O500456	UPS Kel.STP	40	5.0	6.1		
96/07/24	0500246	Kala. S.E.	44	4.5	7.7			96/07/23	O500456	UPS Kel.STP	44	5.0	6.1		
96/07/24	0500847	Kala. D.B.	0	22.5	9.4	7.1		96/07/22	O500236	DNS Kel.STP	0	18.0	9.5	9.8	
96/07/24	0500847	Kala. D.B.	2	21.5	9.4			96/07/22	O500236	DNS Kel.STP	2	17.5	9.7		
96/07/24	0500847	Kala. D.B.	4	21.0	9.4			96/07/22	O500236	DNS Kel.STP	4	16.8	9.6		
96/07/24	0500847	Kala. D.B.	6	20.0	9.6			96/07/22	O500236	DNS Kel.STP	6	16.7	9.6		
96/07/24	0500847	Kala. D.B.	8	17.5	9.6			96/07/22	O500236	DNS Kel.STP	8	16.5	9.6		
96/07/24	0500847	Kala. D.B.	10	14.5	9.8			96/07/22	O500236	DNS Kel.STP	10	13.5	9.6		
96/07/24	0500847	Kala. D.B.	12	13.0	9.8			96/07/22	O500236	DNS Kel.STP	12	9.9	9.5		
96/07/24	0500847	Kala. D.B.	14	11.0	9.4			96/07/22	O500236	DNS Kel.STP	14	7.8	9.5		
96/07/24	0500847	Kala. D.B.	16	9.0	9.1			96/07/22	O500236	DNS Kel.STP	16	7.7	9.4		
96/07/24	0500847	Kala. D.B.	18	7.5	8.6			96/07/22	O500236	DNS Kel.STP	18	7.0	9.4		
96/07/24	0500847	Kala. D.B.	20	7.0	8.3			96/07/22	O500236	DNS Kel.STP	20	6.3	9.4		
96/07/24	0500847	Kala. D.B.	24	6.0	8.0			96/07/22	O500236	DNS Kel.STP	24	6.2	9.3		
96/07/24	0500847	Kala. D.B.	28	5.5	7.8			96/07/22	O500236	DNS Kel.STP	28	5.3	9.2		
96/07/24	0500847	Kala. D.B.	32	5.0	7.9			96/07/22	O500236	DNS Kel.STP	32	5.0	9.2		
96/07/24	0500847	Kala. D.B.	36	5.0	7.8			96/07/22	O500236	DNS Kel.STP	36	5.0	9.2		
96/07/24	0500847	Kala. D.B.	40	5.0	7.8			96/07/22	O500236	DNS Kel.STP	40	5.0	9.2		
96/07/24	0500847	Kala. D.B.	44	4.8	7.8			96/07/22	O500236	DNS Kel.STP	44	4.8	9.4		
96/07/23	0500239	Arm. Arm	0	22.0	5.8	3.2		96/07/22	E223295	Rattlesnake	0	18.8	10.8	9.5	
96/07/23	0500239	Arm. Arm	2	21.0	5.7			96/07/22	E223295	Rattlesnake	2	18.4	10.7		
96/07/23	0500239	Arm. Arm	4	20.5	5.6			96/07/22	E223295	Rattlesnake	4	18.0	10.7		
96/07/23	0500239	Arm. Arm	6	19.7	5.1			96/07/22	E223295	Rattlesnake	6	17.5	10.7		
96/07/23	0500239	Arm. Arm	8	19.5	5.3			96/07/22	E223295	Rattlesnake	8	17.0	10.7		
96/07/23	0500239	Arm. Arm	10	19.1	5.2			96/07/22	E223295	Rattlesnake	10	13.5	10.8		
96/07/23	0500239	Arm. Arm	12	16.0	4.4			96/07/22	E223295	Rattlesnake	12	9.3	10.8		
96/07/23	0500239	Arm. Arm	14	11.3	3.8			96/07/22	E223295	Rattlesnake	14	8.7	10.7		
96/07/23	0500239	Arm. Arm	16	9.3	3.6			96/07/22	E223295	Rattlesnake	16	7.1	10.6		
96/07/23	0500239	Arm. Arm	18	8.2	3.5			96/07/22	E223295	Rattlesnake	18	6.7	10.0		
96/07/23	0500239	Arm. Arm	20	6.9	3.4			96/07/22	E223295	Rattlesnake	20	6.1	10.6		
96/07/23	0500239	Arm. Arm	24	7.5	3.2			96/07/22	E223295	Rattlesnake	24	6.0	10.5		
96/07/23	0500239	Arm. Arm	28	7.0	3.2			96/07/22	E223295	Rattlesnake	28	5.8	10.4		
96/07/23	0500239	Arm. Arm	32	6.9	3.0			96/07/22	E223295	Rattlesnake	32	5.6	10.4		
96/07/23	0500239	Arm. Arm	36	6.8	2.8			96/07/22	E223295	Rattlesnake	36	5.5	10.4		
96/07/23	0500239	Arm. Arm	40	6.8	2.6			96/07/22	E223295	Rattlesnake	40	5.1	10.4		
96/07/23	0500239	Arm. Arm	44	7.0	2.2			96/07/22	E223295	Rattlesnake	44	5.1	10.4		
96/07/23	E206611	Vern.Out.	0	24.0	6.4	7.5		96/07/22	O500729	S.Squally Pt.	0	18.1	10.8	9.5	
96/07/23	E206611	Vern.Out.	2	20.0	6.1			96/07/22	O500729	S.Squally Pt.	2	17.8	10.9		
96/07/23	E206611	Vern.Out.	4	19.0	6.3			96/07/22	O500729	S.Squally Pt.	4	16.8	10.9		
96/07/23	E206611	Vern.Out.	6	17.0	6.4			96/07/22	O500729	S.Squally Pt.	6	15.5	11.0		
96/07/23	E206611	Vern.Out.	8	18.0	6.4			96/07/22	O500729	S.Squally Pt.	8	13.1	11.1		
96/07/23	E206611	Vern.Out.	10	17.5	6.3			96/07/22	O500729	S.Squally Pt.	10	10.7	11.1		
96/07/23	E206611	Vern.Out.	12	17.0	6.3			96/07/22	O500729	S.Squally Pt.	12	9.3	11.0		
96/07/23	E206611	Vern.Out.	14	16.2	6.2			96/07/22	O500729	S.Squally Pt.	14	9.0	10.9		
96/07/23	E206611	Vern.Out.	16	12.3	5.8			96/07/22	O500729	S.Squally Pt.	16	8.4	10.9		
96/07/23	E206611	Vern.Out.	18	8.8	5.9			96/07/22	O500729	S.Squally Pt.	18	7.7	11.1		
96/07/23	E206611	Vern.Out.	20	7.2	5.9			96/07/22	O500729	S.Squally Pt.	20	7.7	10.9		
96/07/23	E206611	Vern.Out.	24	6.1	6.1			96/07/22	O500729	S.Squally Pt.	24	6.3	10.8		
96/07/23	E206611	Vern.Out.	28	5.9	6.1			96/07/22	O500729	S.Squally Pt.	28	6.0	10.8		
96/07/23	E206611	Vern.Out.	32	5.5	6.0			96/07/22	O500729	S.Squally Pt.	32	5.8	10.8		
96/07/23	E206611	Vern.Out.	36	5.3	6.0			96/07/22	O500729	S.Squally Pt.	36	5.7	10.8		
96/07/23	E206611	Vern.Out.	40	5.2	5.9			96/07/22	O500729	S.Squally Pt.	40	5.5	10.7		
96/07/23	E206611	Vern.Out.	44	5.1	5.8			96/07/22	O500729	S.Squally Pt.	44	5.3	10.7		

96/07/23	O500730	N.OK.Centre	0	22.0	6.7	8.0		96/07/22	O500454	S.Prairie Cr.	0	18.8	10.8	9.0	
96/07/23	O500730	N.OK.Centre	2	21.0	6.6			96/07/22	O500454	S.Prairie Cr.	2	18.8	10.6		
96/07/23	O500730	N.OK.Centre	4	20.0	6.6			96/07/22	O500454	S.Prairie Cr.	4	18.0	10.6		
96/07/23	O500730	N.OK.Centre	6	19.0	6.6			96/07/22	O500454	S.Prairie Cr.	6	17.5	10.7		
96/07/23	O500730	N.OK.Centre	8	18.0	6.6			96/07/22	O500454	S.Prairie Cr.	8	17.5	10.7		
96/07/23	O500730	N.OK.Centre	10	17.5	6.6			96/07/22	O500454	S.Prairie Cr.	10	17.5	10.6		
96/07/23	O500730	N.OK.Centre	12	17.0	6.6			96/07/22	O500454	S.Prairie Cr.	12	17.2	10.6		
96/07/23	O500730	N.OK.Centre	14	15.0	6.4			96/07/22	O500454	S.Prairie Cr.	14	17.1	10.6		
96/07/23	O500730	N.OK.Centre	16	12.0	6.2			96/07/22	O500454	S.Prairie Cr.	16	16.8	10.6		
96/07/23	O500730	N.OK.Centre	18	9.5	6.2			96/07/22	O500454	S.Prairie Cr.	18	14.5	10.8		
96/07/23	O500730	N.OK.Centre	20	8.2	6.1			96/07/22	O500454	S.Prairie Cr.	20	11.0	11.3		
96/07/23	O500730	N.OK.Centre	24	6.8	6.2			96/07/22	O500454	S.Prairie Cr.	24	7.5	11.0		
96/07/23	O500730	N.OK.Centre	28	6.5	6.2			96/07/22	O500454	S.Prairie Cr.	28	6.0	10.8		
96/07/23	O500730	N.OK.Centre	32	5.5	6.2			96/07/22	O500454	S.Prairie Cr.	32	5.7	10.7		
96/07/23	O500730	N.OK.Centre	36	5.2	6.2			96/07/22	O500454	S.Prairie Cr.	36	5.3	10.6		
96/07/23	O500730	N.OK.Centre	40	5.0	6.2			96/07/22	O500454	S.Prairie Cr.	40	5.0	10.5		
96/07/23	O500730	N.OK.Centre	44	5.0	6.2			96/07/22	O500454	S.Prairie Cr.	44	4.9	10.5		
August 1996															
Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth		Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth	
			(m)	(C)	(mg/L)	(m)					(m)	(C)	(mg/L)	(m)	
96/08/19	0500246	Kala. S.E.	0	19.5	12.2	7.0		96/08/21	O500456	UPS Kel.STP	0	19.5	9.6	10.0	
96/08/19	0500246	Kala. S.E.	2	19.5	12.4			96/08/21	O500456	UPS Kel.STP	2	18.8	9.8		
96/08/19	0500246	Kala. S.E.	4	19.5	12.4			96/08/21	O500456	UPS Kel.STP	4	18.7	9.6		
96/08/19	0500246	Kala. S.E.	6	19.4	12.3			96/08/21	O500456	UPS Kel.STP	6	18.7	9.8		
96/08/19	0500246	Kala. S.E.	8	19.3	12.3			96/08/21	O500456	UPS Kel.STP	8	18.6	9.7		
96/08/19	0500246	Kala. S.E.	10	19.3	12.4			96/08/21	O500456	UPS Kel.STP	10	18.5	9.7		
96/08/19	0500246	Kala. S.E.	12	18.0	12.9			96/08/21	O500456	UPS Kel.STP	12	18.5	9.6		
96/08/19	0500246	Kala. S.E.	14	14.5	13.4			96/08/21	O500456	UPS Kel.STP	14	17.3	9.4		
96/08/19	0500246	Kala. S.E.	16	9.7	12.1			96/08/21	O500456	UPS Kel.STP	16	14.6	9.4		
96/08/19	0500246	Kala. S.E.	18	6.9	11.2			96/08/21	O500456	UPS Kel.STP	18	11.4	9.2		
96/08/19	0500246	Kala. S.E.	20	6.0	10.6			96/08/21	O500456	UPS Kel.STP	20	8.7	9.3		
96/08/19	0500246	Kala. S.E.	24	5.2	10.3			96/08/21	O500456	UPS Kel.STP	24	6.9	9.2		
96/08/19	0500246	Kala. S.E.	28	5.1	10.3			96/08/21	O500456	UPS Kel.STP	28	6.6	9.1		
96/08/19	0500246	Kala. S.E.	32	4.9	10.3			96/08/21	O500456	UPS Kel.STP	32	6.1	9.0		
96/08/19	0500246	Kala. S.E.	36	4.7	10.4			96/08/21	O500456	UPS Kel.STP	36	5.8	9.0		
96/08/19	0500246	Kala. S.E.	40	4.5	10.4			96/08/21	O500456	UPS Kel.STP	40	5.1	9.0		
96/08/19	0500246	Kala. S.E.	44	4.5	10.4			96/08/21	O500456	UPS Kel.STP	44	5.0	8.9		
96/08/19	0500847	Kala. D.B.	0	19.7	10.5	7.0		96/08/21	O500236	DNS Kel.STP	0	19.6	9.6	9.5	
96/08/19	0500847	Kala. D.B.	2	19.8	10.5			96/08/21	O500236	DNS Kel.STP	2	19.0	9.8		
96/08/19	0500847	Kala. D.B.	4	19.7	10.7			96/08/21	O500236	DNS Kel.STP	4	18.8	9.8		
96/08/19	0500847	Kala. D.B.	6	19.6	10.7			96/08/21	O500236	DNS Kel.STP	6	18.7	9.8		
96/08/19	0500847	Kala. D.B.	8	19.5	10.7			96/08/21	O500236	DNS Kel.STP	8	18.6	9.6		
96/08/19	0500847	Kala. D.B.	10	19.0	10.8			96/08/21	O500236	DNS Kel.STP	10	18.5	9.7		
96/08/19	0500847	Kala. D.B.	12	15.1	11.2			96/08/21	O500236	DNS Kel.STP	12	18.1	9.6		
96/08/19	0500847	Kala. D.B.	14	10.3	11.4			96/08/21	O500236	DNS Kel.STP	14	16.8	9.5		
96/08/19	0500847	Kala. D.B.	16	8.7	10.6			96/08/21	O500236	DNS Kel.STP	16	13.9	9.4		
96/08/19	0500847	Kala. D.B.	18	7.5	10.1			96/08/21	O500236	DNS Kel.STP	18	9.0	9.3		
96/08/19	0500847	Kala. D.B.	20	6.8	9.4			96/08/21	O500236	DNS Kel.STP	20	7.2	9.2		
96/08/19	0500847	Kala. D.B.	24	5.9	9.1			96/08/21	O500236	DNS Kel.STP	24	6.1	9.1		
96/08/19	0500847	Kala. D.B.	28	5.1	8.9			96/08/21	O500236	DNS Kel.STP	28	5.8	9.1		
96/08/19	0500847	Kala. D.B.	32	5.0	8.9			96/08/21	O500236	DNS Kel.STP	32	5.4	9.0		
96/08/19	0500847	Kala. D.B.	36	4.9	9.0			96/08/21	O500236	DNS Kel.STP	36	5.2	9.0		
96/08/19	0500847	Kala. D.B.	40	4.7	9.1			96/08/21	O500236	DNS Kel.STP	40	5.0	9.0		
96/08/19	0500847	Kala. D.B.	44	4.5	9.2			96/08/21	O500236	DNS Kel.STP	44	4.9	9.0		
96/08/20	0500239	Arm. Arm	0	20.5	9.2	3.8		96/08/21	E223295	Rattlesnake	0	19.0	9.7	11.6	
96/08/20	0500239	Arm. Arm	2	20.5	9.2			96/08/21	E223295	Rattlesnake	2	18.8	9.8		
96/08/20	0500239	Arm. Arm	4	20.3	9.1			96/08/21	E223295	Rattlesnake	4	18.6	9.8		
96/08/20	0500239	Arm. Arm	6	20.3	9.1			96/08/21	E223295	Rattlesnake	6	18.4	9.8		
96/08/20	0500239	Arm. Arm	8	20.0	9.0			96/08/21	E223295	Rattlesnake	8	18.4	9.8		
96/08/20	0500239	Arm. Arm	10	20.0	8.9			96/08/21	E223295	Rattlesnake	10	18.3	9.8		
96/08/20	0500239	Arm. Arm	12	17.5	7.0			96/08/21	E223295	Rattlesnake	12	18.0	9.9		
96/08/20	0500239	Arm. Arm	14	12.0	5.6			96/08/21	E223295	Rattlesnake	14	17.5	9.9		
96/08/20	0500239	Arm. Arm	16	9.8	5.0			96/08/21	E223295	Rattlesnake	16	16.0	10.0		
96/08/20	0500239	Arm. Arm	18	8.9	4.7			96/08/21	E223295	Rattlesnake	18	14.5	9.9		
96/08/20	0500239	Arm. Arm	20	8.2	4.6			96/08/21	E223295	Rattlesnake	20	9.3	9.8		
96/08/20	0500239	Arm. Arm	24	7.5	4.4			96/08/21	E223295	Rattlesnake	24	7.8	9.6		
96/08/20	0500239	Arm. Arm	28	7.0	4.2			96/08/21	E223295	Rattlesnake	28	6.3	9.3		
96/08/20	0500239	Arm. Arm	32	6.7	3.8			96/08/21	E223295	Rattlesnake	32	5.7	9.1		
96/08/20	0500239	Arm. Arm	36	6.7	3.5			96/08/21	E223295	Rattlesnake	36	5.5	9.0		
96/08/20	0500239	Arm. Arm	40	6.7	3.1			96/08/21	E223295	Rattlesnake	40	5.4	9.0		
96/08/20	0500239	Arm. Arm	44	6.7	2.9			96/08/21	E223295	Rattlesnake	44	5.3	8.9		

96/08/20	E206611	Vern.Out.	0	20.5	9.2	6.5		96/08/23	O500729	S.Squally Pt.	0	19.2	9.8	10.5	
96/08/20	E206611	Vern.Out.	2	20.0	9.4			96/08/23	O500729	S.Squally Pt.	2	19.2	9.9		
96/08/20	E206611	Vern.Out.	4	20.0	9.3			96/08/23	O500729	S.Squally Pt.	4	19.2	9.9		
96/08/20	E206611	Vern.Out.	6	19.9	9.2			96/08/23	O500729	S.Squally Pt.	6	19.1	9.8		
96/08/20	E206611	Vern.Out.	8	19.9	9.3			96/08/23	O500729	S.Squally Pt.	8	18.6	9.8		
96/08/20	E206611	Vern.Out.	10	19.7	9.2			96/08/23	O500729	S.Squally Pt.	10	18.5	9.8		
96/08/20	E206611	Vern.Out.	12	19.5	9.2			96/08/23	O500729	S.Squally Pt.	12	18.0	9.7		
96/08/20	E206611	Vern.Out.	14	17.3	8.5			96/08/23	O500729	S.Squally Pt.	14	16.3	9.7		
96/08/20	E206611	Vern.Out.	16	12.1	8.4			96/08/23	O500729	S.Squally Pt.	16	14.4	9.6		
96/08/20	E206611	Vern.Out.	18	8.9	8.3			96/08/23	O500729	S.Squally Pt.	18	11.0	9.6		
96/08/20	E206611	Vern.Out.	20	8.0	8.3			96/08/23	O500729	S.Squally Pt.	20	9.0	9.4		
96/08/20	E206611	Vern.Out.	24	6.9	8.3			96/08/23	O500729	S.Squally Pt.	24	7.3	9.3		
96/08/20	E206611	Vern.Out.	28	6.3	8.4			96/08/23	O500729	S.Squally Pt.	28	6.4	9.2		
96/08/20	E206611	Vern.Out.	32	5.8	8.5			96/08/23	O500729	S.Squally Pt.	32	6.0	9.0		
96/08/20	E206611	Vern.Out.	36	5.5	8.4			96/08/23	O500729	S.Squally Pt.	36	5.5	8.8		
96/08/20	E206611	Vern.Out.	40	5.3	8.5			96/08/23	O500729	S.Squally Pt.	40	5.3	8.8		
96/08/20	E206611	Vern.Out.	44	5.1	8.5			96/08/23	O500729	S.Squally Pt.	44	5.1	8.7		
96/08/20	O500730	N.OK.Centre	0	20.0	9.2	8.3		96/08/23	O500454	S.Prairie Cr.	0	20.1	9.2	10.5	
96/08/20	O500730	N.OK.Centre	2	19.9	9.4			96/08/23	O500454	S.Prairie Cr.	2	20.1	9.1		
96/08/20	O500730	N.OK.Centre	4	19.7	9.3			96/08/23	O500454	S.Prairie Cr.	4	20.1	9.3		
96/08/20	O500730	N.OK.Centre	6	19.5	9.4			96/08/23	O500454	S.Prairie Cr.	6	20.0	9.4		
96/08/20	O500730	N.OK.Centre	8	19.5	9.4			96/08/23	O500454	S.Prairie Cr.	8	19.7	9.3		
96/08/20	O500730	N.OK.Centre	10	19.3	9.4			96/08/23	O500454	S.Prairie Cr.	10	19.6	9.4		
96/08/20	O500730	N.OK.Centre	12	18.9	9.2			96/08/23	O500454	S.Prairie Cr.	12	18.4	9.4		
96/08/20	O500730	N.OK.Centre	14	15.7	8.8			96/08/23	O500454	S.Prairie Cr.	14	17.3	9.5		
96/08/20	O500730	N.OK.Centre	16	12.7	8.8			96/08/23	O500454	S.Prairie Cr.	16	14.2	9.6		
96/08/20	O500730	N.OK.Centre	18	11.5	8.8			96/08/23	O500454	S.Prairie Cr.	18	11.0	9.4		
96/08/20	O500730	N.OK.Centre	20	11.1	8.7			96/08/23	O500454	S.Prairie Cr.	20	9.8	9.3		
96/08/20	O500730	N.OK.Centre	24	7.8	8.5			96/08/23	O500454	S.Prairie Cr.	24	7.2	9.0		
96/08/20	O500730	N.OK.Centre	28	6.4	8.6			96/08/23	O500454	S.Prairie Cr.	28	6.5	8.8		
96/08/20	O500730	N.OK.Centre	32	6.0	8.6			96/08/23	O500454	S.Prairie Cr.	32	5.9	8.7		
96/08/20	O500730	N.OK.Centre	36	5.5	8.6			96/08/23	O500454	S.Prairie Cr.	36	5.5	8.5		
96/08/20	O500730	N.OK.Centre	40	5.2	8.6			96/08/23	O500454	S.Prairie Cr.	40	5.3	8.5		
96/08/20	O500730	N.OK.Centre	44	5.0	8.7			96/08/23	O500454	S.Prairie Cr.	44	5.1	8.4		
September 1996															
Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth		Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth	
			(m)	(C)	(mg/L)	(m)					(m)	(C)	(mg/L)	(m)	
96/09/12	0500246	Kala. S.E.	0	17.1	10.3	4.9		96/09/17	O500456	UPS Kel.STP	0	17.2	9.2	9.5	
96/09/12	0500246	Kala. S.E.	2	17.2	10.2			96/09/17	O500456	UPS Kel.STP	2	17.2	9.2		
96/09/12	0500246	Kala. S.E.	4	17.2	10.2			96/09/17	O500456	UPS Kel.STP	4	17.2	9.2		
96/09/12	0500246	Kala. S.E.	6	17.2	10.3			96/09/17	O500456	UPS Kel.STP	6				
96/09/12	0500246	Kala. S.E.	8	17.2	10.2			96/09/17	O500456	UPS Kel.STP	8	17.2	9.3		
96/09/12	0500246	Kala. S.E.	10	17.2	10.2			96/09/17	O500456	UPS Kel.STP	10				
96/09/12	0500246	Kala. S.E.	12	17.2	10.2			96/09/17	O500456	UPS Kel.STP	12				
96/09/12	0500246	Kala. S.E.	14	14.8	10.7			96/09/17	O500456	UPS Kel.STP	14				
96/09/12	0500246	Kala. S.E.	16	10.5	11.2			96/09/17	O500456	UPS Kel.STP	16				
96/09/12	0500246	Kala. S.E.	18	7.6	11.1			96/09/17	O500456	UPS Kel.STP	18				
96/09/12	0500246	Kala. S.E.	20	6.3	10.7			96/09/17	O500456	UPS Kel.STP	20	12.0	9.4		
96/09/12	0500246	Kala. S.E.	24	5.6	10.5			96/09/17	O500456	UPS Kel.STP	24	7.0	8.9		
96/09/12	0500246	Kala. S.E.	28	5.2	10.4			96/09/17	O500456	UPS Kel.STP	28	6.5	8.9		
96/09/12	0500246	Kala. S.E.	32	5.0	10.5			96/09/17	O500456	UPS Kel.STP	32	6.0	8.9		
96/09/12	0500246	Kala. S.E.	36	4.9	10.6			96/09/17	O500456	UPS Kel.STP	36	6.0	8.9		
96/09/12	0500246	Kala. S.E.	40	4.8	10.7			96/09/17	O500456	UPS Kel.STP	40	5.5	8.9		
96/09/12	0500246	Kala. S.E.	44	4.7	10.8			96/09/17	O500456	UPS Kel.STP	44	5.5	8.9		
96/09/12	0500847	Kala. D.B.	0	17.2	10.4	4.9		96/09/18	O500236	DNS Kel.STP	0	16.8	8.4	8.5	
96/09/12	0500847	Kala. D.B.	2	17.2	10.4			96/09/18	O500236	DNS Kel.STP	2	16.8	8.4		
96/09/12	0500847	Kala. D.B.	4	17.2	10.4			96/09/18	O500236	DNS Kel.STP	4	16.8	8.4		
96/09/12	0500847	Kala. D.B.	6	17.2	10.4			96/09/18	O500236	DNS Kel.STP	6	16.8	8.4		
96/09/12	0500847	Kala. D.B.	8	17.2	10.4			96/09/18	O500236	DNS Kel.STP	8	16.8	8.4		
96/09/12	0500847	Kala. D.B.	10	17.2	10.4			96/09/18	O500236	DNS Kel.STP	10	16.8	8.4		
96/09/12	0500847	Kala. D.B.	12	17.1	10.4			96/09/18	O500236	DNS Kel.STP	12	16.8	8.4		
96/09/12	0500847	Kala. D.B.	14	15.5	10.7			96/09/18	O500236	DNS Kel.STP	14	16.8	8.3		
96/09/12	0500847	Kala. D.B.	16	14.8	11.9			96/09/18	O500236	DNS Kel.STP	16	14.5	8.2		
96/09/12	0500847	Kala. D.B.	18	7.8	10.9			96/09/18	O500236	DNS Kel.STP	18	12.2	8.2		
96/09/12	0500847	Kala. D.B.	20	7.2	10.7			96/09/18	O500236	DNS Kel.STP	20	7.0	8.0		
96/09/12	0500847	Kala. D.B.	24	5.9	10.6			96/09/18	O500236	DNS Kel.STP	24	6.0	8.2		
96/09/12	0500847	Kala. D.B.	28	5.3	10.5			96/09/18	O500236	DNS Kel.STP	28	5.5	8.3		
96/09/12	0500847	Kala. D.B.	32	5.1	10.6			96/09/18	O500236	DNS Kel.STP	32	5.2	8.2		
96/09/12	0500847	Kala. D.B.	36	4.9	10.6			96/09/18	O500236	DNS Kel.STP	36	5.0	8.2		
96/09/12	0500847	Kala. D.B.	40	4.8	10.6			96/09/18	O500236	DNS Kel.STP	40	5.0	8.2		
96/09/12	0500847	Kala. D.B.	44	4.7	10.8			96/09/18	O500236	DNS Kel.STP	44	5.0	8.0		

96/09/16	0500239	Arm. Arm	0	18.5	9.6	4.5		96/09/17	E223295	Rattlesnake	0	17.0	8.2	938.0	
96/09/16	0500239	Arm. Arm	2	18.5	9.6			96/09/17	E223295	Rattlesnake	2	17.0	8.2		
96/09/16	0500239	Arm. Arm	4	18.5	9.6			96/09/17	E223295	Rattlesnake	4	17.0	8.4		
96/09/16	0500239	Arm. Arm	6	18.3	9.5			96/09/17	E223295	Rattlesnake	6	17.0	8.2		
96/09/16	0500239	Arm. Arm	8	18.3	9.0			96/09/17	E223295	Rattlesnake	8	17.0	8.2		
96/09/16	0500239	Arm. Arm	10	18.3	9.0			96/09/17	E223295	Rattlesnake	10	17.0	8.2		
96/09/16	0500239	Arm. Arm	12	16.2	7.3			96/09/17	E223295	Rattlesnake	12	17.0	8.0		
96/09/16	0500239	Arm. Arm	14	11.9	5.3			96/09/17	E223295	Rattlesnake	14	17.0	8.2		
96/09/16	0500239	Arm. Arm	16	10.5	4.6			96/09/17	E223295	Rattlesnake	16	17.0			
96/09/16	0500239	Arm. Arm	18	9.8	4.2			96/09/17	E223295	Rattlesnake	18	12.0	8.2		
96/09/16	0500239	Arm. Arm	20	8.8	3.8			96/09/17	E223295	Rattlesnake	20	9.5	8.0		
96/09/16	0500239	Arm. Arm	24	8.0	3.6			96/09/17	E223295	Rattlesnake	24	8.0	8.0		
96/09/16	0500239	Arm. Arm	28	7.4	3.5			96/09/17	E223295	Rattlesnake	28	6.5	7.8		
96/09/16	0500239	Arm. Arm	32	7.0	2.9			96/09/17	E223295	Rattlesnake	32	6.0	7.8		
96/09/16	0500239	Arm. Arm	36	7.0	2.7			96/09/17	E223295	Rattlesnake	36	5.5	7.8		
96/09/16	0500239	Arm. Arm	40	6.9	2.3			96/09/17	E223295	Rattlesnake	40	5.2	7.9		
96/09/16	0500239	Arm. Arm	44	6.8	1.8			96/09/17	E223295	Rattlesnake	44	5.2	8.0		
96/09/16	E206611	Vern.Out.	0	18.5	9.3	6.0		96/09/18	O500729	S.Squally Pt.	0	17.2	8.2	10.0	
96/09/16	E206611	Vern.Out.	2	18.5	9.4			96/09/18	O500729	S.Squally Pt.	2	17.0	8.1		
96/09/16	E206611	Vern.Out.	4	18.1	9.4			96/09/18	O500729	S.Squally Pt.	4	17.0	8.0		
96/09/16	E206611	Vern.Out.	6	18.0	9.3			96/09/18	O500729	S.Squally Pt.	6	17.0	8.0		
96/09/16	E206611	Vern.Out.	8	18.0	9.3			96/09/18	O500729	S.Squally Pt.	8	17.0	8.0		
96/09/16	E206611	Vern.Out.	10	18.0	9.3			96/09/18	O500729	S.Squally Pt.	10	17.0	8.0		
96/09/16	E206611	Vern.Out.	12	18.0	9.3			96/09/18	O500729	S.Squally Pt.	12	17.0	8.0		
96/09/16	E206611	Vern.Out.	14	17.8	9.2			96/09/18	O500729	S.Squally Pt.	14	17.0	8.0		
96/09/16	E206611	Vern.Out.	16	17.2	9.2			96/09/18	O500729	S.Squally Pt.	16	16.8	8.0		
96/09/16	E206611	Vern.Out.	18	15.5	8.9			96/09/18	O500729	S.Squally Pt.	18	15.0	7.7		
96/09/16	E206611	Vern.Out.	20	14.0	8.6			96/09/18	O500729	S.Squally Pt.	20	10.8	8.0		
96/09/16	E206611	Vern.Out.	24	9.1	8.5			96/09/18	O500729	S.Squally Pt.	24	7.5	8.0		
96/09/16	E206611	Vern.Out.	28	7.6	8.6			96/09/18	O500729	S.Squally Pt.	28	6.5	8.0		
96/09/16	E206611	Vern.Out.	32	6.5	8.6			96/09/18	O500729	S.Squally Pt.	32	6.0	7.9		
96/09/16	E206611	Vern.Out.	36	6.0	8.7			96/09/18	O500729	S.Squally Pt.	36	5.8	8.0		
96/09/16	E206611	Vern.Out.	40	5.8	8.8			96/09/18	O500729	S.Squally Pt.	40	5.4	7.9		
96/09/16	E206611	Vern.Out.	44	5.5	8.8			96/09/18	O500729	S.Squally Pt.	44	5.0	7.9		
96/09/17	O500730	N.OK.Centre	0	18.0	9.2	8.0		96/09/18	O500454	S.Prairie Cr.	0	17.2	8.6	9.3	
96/09/17	O500730	N.OK.Centre	2	17.5	9.1			96/09/18	O500454	S.Prairie Cr.	2	17.2	8.3		
96/09/17	O500730	N.OK.Centre	4	17.5	9.1			96/09/18	O500454	S.Prairie Cr.	4	17.2	8.2		
96/09/17	O500730	N.OK.Centre	6	17.2	9.1			96/09/18	O500454	S.Prairie Cr.	6	17.2	8.1		
96/09/17	O500730	N.OK.Centre	8	17.2	9.1			96/09/18	O500454	S.Prairie Cr.	8	17.2	8.1		
96/09/17	O500730	N.OK.Centre	10	17.2	9.1			96/09/18	O500454	S.Prairie Cr.	10	17.2	8.0		
96/09/17	O500730	N.OK.Centre	12					96/09/18	O500454	S.Prairie Cr.	12	17.0	8.0		
96/09/17	O500730	N.OK.Centre	14	16.8	8.9			96/09/18	O500454	S.Prairie Cr.	14	17.0	8.0		
96/09/17	O500730	N.OK.Centre	16	13.8	8.4			96/09/18	O500454	S.Prairie Cr.	16	16.0	7.8		
96/09/17	O500730	N.OK.Centre	18	10.5	8.1			96/09/18	O500454	S.Prairie Cr.	18	14.0	7.8		
96/09/17	O500730	N.OK.Centre	20	9.5	8.2			96/09/18	O500454	S.Prairie Cr.	20	9.0	7.8		
96/09/17	O500730	N.OK.Centre	24	8.0	8.4			96/09/18	O500454	S.Prairie Cr.	24	6.8	7.9		
96/09/17	O500730	N.OK.Centre	28	7.0	8.5			96/09/18	O500454	S.Prairie Cr.	28	6.2	8.0		
96/09/17	O500730	N.OK.Centre	32	6.0	8.6			96/09/18	O500454	S.Prairie Cr.	32	5.8	8.0		
96/09/17	O500730	N.OK.Centre	36	6.0	8.6			96/09/18	O500454	S.Prairie Cr.	36	5.4	8.0		
96/09/17	O500730	N.OK.Centre	40	5.2	8.8			96/09/18	O500454	S.Prairie Cr.	40	5.2	7.9		
96/09/17	O500730	N.OK.Centre	44	5.0	8.8			96/09/18	O500454	S.Prairie Cr.	44	5.0	8.0		
October 1996															
Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth		Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth	
			(m)	(C)	(mg/L)	(m)					(m)	(C)	(mg/L)	(m)	
96/10/15	0500847	Kala. D.B.	0	14.2	8.9	4.5		96/10/17	O500236	DNS Kel.STP	0	13.9	8.8	7.3	
96/10/15	0500847	Kala. D.B.	2	14.2	8.9			96/10/17	O500236	DNS Kel.STP	2	13.9	8.8		
96/10/15	0500847	Kala. D.B.	4	14.2	8.6			96/10/17	O500236	DNS Kel.STP	4	13.9	8.7		
96/10/15	0500847	Kala. D.B.	6	14.2	8.8			96/10/17	O500236	DNS Kel.STP	6	13.9	8.7		
96/10/15	0500847	Kala. D.B.	8	14.2	8.8			96/10/17	O500236	DNS Kel.STP	8	13.9	8.7		
96/10/15	0500847	Kala. D.B.	10	14.0	8.0			96/10/17	O500236	DNS Kel.STP	10	13.9	8.6		
96/10/15	0500847	Kala. D.B.	12	14.0	8.7			96/10/17	O500236	DNS Kel.STP	12	13.8	8.6		
96/10/15	0500847	Kala. D.B.	14	14.0	8.6			96/10/17	O500236	DNS Kel.STP	14	12.8	8.5		
96/10/15	0500847	Kala. D.B.	16	14.0	8.6			96/10/17	O500236	DNS Kel.STP	16	11.0	8.4		
96/10/15	0500847	Kala. D.B.	18	8.0	7.5			96/10/17	O500236	DNS Kel.STP	18	10.2	8.3		
96/10/15	0500847	Kala. D.B.	20	7.8	7.0			96/10/17	O500236	DNS Kel.STP	20	9.7	8.3		
96/10/15	0500847	Kala. D.B.	24	7.2	7.1			96/10/17	O500236	DNS Kel.STP	24	8.9	8.3		
96/10/15	0500847	Kala. D.B.	28	6.0	7.0			96/10/17	O500236	DNS Kel.STP	28	8.0	8.2		
96/10/15	0500847	Kala. D.B.	32	5.5	7.0			96/10/17	O500236	DNS Kel.STP	32	7.3	8.2		
96/10/15	0500847	Kala. D.B.	36	5.5	7.0			96/10/17	O500236	DNS Kel.STP	36	6.8	8.2		
96/10/15	0500847	Kala. D.B.	40	5.0	7.1			96/10/17	O500236	DNS Kel.STP	40	6.3	8.0		
96/10/15	0500847	Kala. D.B.	44	5.0	7.1			96/10/17	O500236	DNS Kel.STP	44	6.1	8.1		

96/10/23	0500239	Arm. Arm	0	11.7	3.8	5.3		96/10/17	E223295	Rattlesnake	0	13.4	8.2	6.8	
96/10/23	0500239	Arm. Arm	2	11.7	3.8			96/10/17	E223295	Rattlesnake	2	13.4	8.2		
96/10/23	0500239	Arm. Arm	4	11.7	3.8			96/10/17	E223295	Rattlesnake	4	13.4	8.2		
96/10/23	0500239	Arm. Arm	6	11.7	3.8			96/10/17	E223295	Rattlesnake	6	13.4	8.1		
96/10/23	0500239	Arm. Arm	8	11.5	3.8			96/10/17	E223295	Rattlesnake	8	13.3	8.1		
96/10/23	0500239	Arm. Arm	10	11.5	3.8			96/10/17	E223295	Rattlesnake	10	13.0	8.1		
96/10/23	0500239	Arm. Arm	12	11.5	3.8			96/10/17	E223295	Rattlesnake	12	11.5	8.0		
96/10/23	0500239	Arm. Arm	14	11.5	3.7			96/10/17	E223295	Rattlesnake	14	11.0	8.0		
96/10/23	0500239	Arm. Arm	16	11.3	3.5			96/10/17	E223295	Rattlesnake	16	10.2	8.0		
96/10/23	0500239	Arm. Arm	18	11.0	3.3			96/10/17	E223295	Rattlesnake	18	10.0	8.0		
96/10/23	0500239	Arm. Arm	20	10.1	1.8			96/10/17	E223295	Rattlesnake	20	9.5	8.0		
96/10/23	0500239	Arm. Arm	24	9.0	1.4			96/10/17	E223295	Rattlesnake	24	8.5	8.0		
96/10/23	0500239	Arm. Arm	28	8.0	1.2			96/10/17	E223295	Rattlesnake	28	7.3	7.9		
96/10/23	0500239	Arm. Arm	32	7.1	0.8			96/10/17	E223295	Rattlesnake	32	7.1	7.9		
96/10/23	0500239	Arm. Arm	36	7.0	0.6			96/10/17	E223295	Rattlesnake	36	6.9	7.8		
96/10/23	0500239	Arm. Arm	40	7.0	0.4			96/10/17	E223295	Rattlesnake	40	6.8	7.8		
96/10/23	0500239	Arm. Arm	44	6.9	0.5			96/10/17	E223295	Rattlesnake	44	6.2	7.8		
96/10/17	E206611	Vern.Out.	0	13.8	8.2	9.5		96/10/16	O500729	S.Squally Pt.	0	9.8	10.0	7.5	
96/10/17	E206611	Vern.Out.	2	14.0	8.2			96/10/16	O500729	S.Squally Pt.	2	9.2	10.0		
96/10/17	E206611	Vern.Out.	4	14.0	8.1			96/10/16	O500729	S.Squally Pt.	4	9.0	9.9		
96/10/17	E206611	Vern.Out.	6	14.0	8.1			96/10/16	O500729	S.Squally Pt.	6	9.0	9.9		
96/10/17	E206611	Vern.Out.	8	14.0	8.1			96/10/16	O500729	S.Squally Pt.	8	9.0	9.9		
96/10/17	E206611	Vern.Out.	10	14.0	8.0			96/10/16	O500729	S.Squally Pt.	10	8.9	9.9		
96/10/17	E206611	Vern.Out.	12	14.0	8.0			96/10/16	O500729	S.Squally Pt.	12	8.8	9.8		
96/10/17	E206611	Vern.Out.	14	14.0	8.0			96/10/16	O500729	S.Squally Pt.	14	8.8	9.8		
96/10/17	E206611	Vern.Out.	16	14.0	8.1			96/10/16	O500729	S.Squally Pt.	16	8.5	9.8		
96/10/17	E206611	Vern.Out.	18	14.0	8.0			96/10/16	O500729	S.Squally Pt.	18	7.5	9.7		
96/10/17	E206611	Vern.Out.	20	14.0	8.0			96/10/16	O500729	S.Squally Pt.	20	7.2	9.7		
96/10/17	E206611	Vern.Out.	24	8.5	7.1			96/10/16	O500729	S.Squally Pt.	24	7.0	9.7		
96/10/17	E206611	Vern.Out.	28	6.8	7.3			96/10/16	O500729	S.Squally Pt.	28	6.9	9.6		
96/10/17	E206611	Vern.Out.	32	6.0	7.3			96/10/16	O500729	S.Squally Pt.	32	6.5	9.6		
96/10/17	E206611	Vern.Out.	36	5.8	7.4			96/10/16	O500729	S.Squally Pt.	36	6.2	9.6		
96/10/17	E206611	Vern.Out.	40	5.5	7.4			96/10/16	O500729	S.Squally Pt.	40	6.1	9.6		
96/10/17	E206611	Vern.Out.	44	5.3	7.6			96/10/16	O500729	S.Squally Pt.	44	6.0	9.5		
96/10/17	O500730	N.OK.Centre	0	13.9	8.2	9.5		96/10/16	O500454	S.Prairie Cr.	0	11.8	10.2	6.3	
96/10/17	O500730	N.OK.Centre	2	13.9	8.2			96/10/16	O500454	S.Prairie Cr.	2	11.8			
96/10/17	O500730	N.OK.Centre	4	13.9	8.2			96/10/16	O500454	S.Prairie Cr.	4	11.0			
96/10/17	O500730	N.OK.Centre	6	14.0	8.2			96/10/16	O500454	S.Prairie Cr.	6	11.0			
96/10/17	O500730	N.OK.Centre	8	14.0	8.1			96/10/16	O500454	S.Prairie Cr.	8	10.9			
96/10/17	O500730	N.OK.Centre	10	14.0	8.2			96/10/16	O500454	S.Prairie Cr.	10	10.9			
96/10/17	O500730	N.OK.Centre	12	14.0	8.2			96/10/16	O500454	S.Prairie Cr.	12	10.8			
96/10/17	O500730	N.OK.Centre	14	14.0	8.2			96/10/16	O500454	S.Prairie Cr.	14	10.4			
96/10/17	O500730	N.OK.Centre	16	14.0	8.0			96/10/16	O500454	S.Prairie Cr.	16	10.0			
96/10/17	O500730	N.OK.Centre	18	14.0	8.2			96/10/16	O500454	S.Prairie Cr.	18	9.9			
96/10/17	O500730	N.OK.Centre	20	14.0	8.1			96/10/16	O500454	S.Prairie Cr.	20	9.7			
96/10/17	O500730	N.OK.Centre	24	11.1	7.5			96/10/16	O500454	S.Prairie Cr.	24	9.0			
96/10/17	O500730	N.OK.Centre	28	7.7	7.4			96/10/16	O500454	S.Prairie Cr.	28	8.2			
96/10/17	O500730	N.OK.Centre	32	6.7	7.4			96/10/16	O500454	S.Prairie Cr.	32	7.7			
96/10/17	O500730	N.OK.Centre	36	6.1	7.4			96/10/16	O500454	S.Prairie Cr.	36	7.0			
96/10/17	O500730	N.OK.Centre	40	5.8	7.4			96/10/16	O500454	S.Prairie Cr.	40	6.5			
96/10/17	O500730	N.OK.Centre	44	5.7	7.4			96/10/16	O500454	S.Prairie Cr.	44	6.2			
96/10/17	O500456	UPS Kel.STP	0	13.0	8.2	8.5									
96/10/17	O500456	UPS Kel.STP	2	13.0	8.2										
96/10/17	O500456	UPS Kel.STP	4	13.0	8.2										
96/10/17	O500456	UPS Kel.STP	6	13.0	8.2										
96/10/17	O500456	UPS Kel.STP	8	13.1	8.1										
96/10/17	O500456	UPS Kel.STP	10	13.1	8.1										
96/10/17	O500456	UPS Kel.STP	12	13.1	8.1										
96/10/17	O500456	UPS Kel.STP	14	13.1	8.1										
96/10/17	O500456	UPS Kel.STP	16	13.1	8.1										
96/10/17	O500456	UPS Kel.STP	18	13.1	8.1										
96/10/17	O500456	UPS Kel.STP	20	13.1	8.1										
96/10/17	O500456	UPS Kel.STP	24	12.5	8.0										
96/10/17	O500456	UPS Kel.STP	28	9.1	7.3										
96/10/17	O500456	UPS Kel.STP	32	8.2	7.4										
96/10/17	O500456	UPS Kel.STP	36	6.9	7.4										
96/10/17	O500456	UPS Kel.STP	40	6.1	7.4										
96/10/17	O500456	UPS Kel.STP	44	5.9	7.6										

November 1996													
Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth	Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth
			(m)	(C)	(mg/L)	(m)				(m)	(C)	(mg/L)	(m)
96/11/25	E206611	Vern.Out.	0	6.5	11.0	8.5	96/11/25	O500456	UPS Kel.STP	0	7.0	11.2	10.1
96/11/25	E206611	Vern.Out.	2	6.5	10.8		96/11/25	O500456	UPS Kel.STP	2	7.0	11.2	
96/11/25	E206611	Vern.Out.	4	6.5	10.7		96/11/25	O500456	UPS Kel.STP	4	7.0	11.2	
96/11/25	E206611	Vern.Out.	6	6.5	10.6		96/11/25	O500456	UPS Kel.STP	6	7.0	11.2	
96/11/25	E206611	Vern.Out.	8	6.5	10.6		96/11/25	O500456	UPS Kel.STP	8	7.0	11.3	
96/11/25	E206611	Vern.Out.	10	6.5	10.7		96/11/25	O500456	UPS Kel.STP	10	7.0	11.3	
96/11/25	E206611	Vern.Out.	12	6.5	10.6		96/11/25	O500456	UPS Kel.STP	12	7.0	11.3	
96/11/25	E206611	Vern.Out.	14	6.5	10.6		96/11/25	O500456	UPS Kel.STP	14	7.0	11.3	
96/11/25	E206611	Vern.Out.	16	6.3	10.6		96/11/25	O500456	UPS Kel.STP	16	7.0	11.3	
96/11/25	E206611	Vern.Out.	18	6.3	10.6		96/11/25	O500456	UPS Kel.STP	18	7.0	11.3	
96/11/25	E206611	Vern.Out.	20	6.2	10.5		96/11/25	O500456	UPS Kel.STP	20	7.0	11.2	
96/11/25	E206611	Vern.Out.	24	6.2	10.5		96/11/25	O500456	UPS Kel.STP	24	7.0	11.2	
96/11/25	E206611	Vern.Out.	28	6.2	10.3		96/11/25	O500456	UPS Kel.STP	28	7.0	11.0	
96/11/25	E206611	Vern.Out.	32	6.2	10.3		96/11/25	O500456	UPS Kel.STP	32	6.8	10.9	
96/11/25	E206611	Vern.Out.	36	6.2	10.3		96/11/25	O500456	UPS Kel.STP	36	6.3	10.8	
96/11/25	E206611	Vern.Out.	40	6.2	10.3		96/11/25	O500456	UPS Kel.STP	40	6.2	10.8	
96/11/25	E206611	Vern.Out.	44	6.2	10.2		96/11/25	O500456	UPS Kel.STP	44	8.0	10.7	
96/11/25	O500730	N.OK.Centre	0	6.9	10.9	8.2							
96/11/25	O500730	N.OK.Centre	2	6.9	10.9								
96/11/25	O500730	N.OK.Centre	4	6.9	10.9								
96/11/25	O500730	N.OK.Centre	6	6.9	10.9								
96/11/25	O500730	N.OK.Centre	8	6.9	10.9								
96/11/25	O500730	N.OK.Centre	10	6.9	10.9								
96/11/25	O500730	N.OK.Centre	12	6.9	10.9								
96/11/25	O500730	N.OK.Centre	14	6.9	10.9								
96/11/25	O500730	N.OK.Centre	16	6.9	10.9								
96/11/25	O500730	N.OK.Centre	18	6.9	10.9								
96/11/25	O500730	N.OK.Centre	20	6.9	10.9								
96/11/25	O500730	N.OK.Centre	24	6.9	10.9								
96/11/25	O500730	N.OK.Centre	28	6.9	10.9								
96/11/25	O500730	N.OK.Centre	32	6.9	10.9								
96/11/25	O500730	N.OK.Centre	36	6.9	10.8								
96/11/25	O500730	N.OK.Centre	40	6.9	10.9								
96/11/25	O500730	N.OK.Centre	44	6.9	10.9								
February 1997													
Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth	Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth
			(m)	(C)	(mg/L)	(m)				(m)	(C)	(mg/L)	(m)
97/02/10	E206611	Vern.Out.	0	2.0	12.2	10.6	97/02/11	E223295	Rattlesnake	0	1.5	10.2	10.8
97/02/10	E206611	Vern.Out.	2	2.0	12.2		97/02/11	E223295	Rattlesnake	2	1.5	10.3	
97/02/10	E206611	Vern.Out.	4	2.0	12.2		97/02/11	E223295	Rattlesnake	4	1.7	10.3	
97/02/10	E206611	Vern.Out.	6	2.0	12.3		97/02/11	E223295	Rattlesnake	6	1.8	10.3	
97/02/10	E206611	Vern.Out.	8	2.0	12.2		97/02/11	E223295	Rattlesnake	8	1.8	10.3	
97/02/10	E206611	Vern.Out.	10	2.1	12.2		97/02/11	E223295	Rattlesnake	10	1.8	10.3	
97/02/10	E206611	Vern.Out.	12	2.2	12.1		97/02/11	E223295	Rattlesnake	12	1.9	10.2	
97/02/10	E206611	Vern.Out.	14	2.5	12.1		97/02/11	E223295	Rattlesnake	14	1.9	10.2	
97/02/10	E206611	Vern.Out.	16	2.8	12.0		97/02/11	E223295	Rattlesnake	16	2.0	10.2	
97/02/10	E206611	Vern.Out.	18	2.9	12.0		97/02/11	E223295	Rattlesnake	18	2.0	10.2	
97/02/10	E206611	Vern.Out.	20	3.0	11.9		97/02/11	E223295	Rattlesnake	20	2.0	10.2	
97/02/10	E206611	Vern.Out.	24	3.0	11.9		97/02/11	E223295	Rattlesnake	24	2.3	10.1	
97/02/10	E206611	Vern.Out.	28	3.0	11.8		97/02/11	E223295	Rattlesnake	28	2.5	10.0	
97/02/10	E206611	Vern.Out.	32	3.1	11.8		97/02/11	E223295	Rattlesnake	32	2.5	10.0	
97/02/10	E206611	Vern.Out.	36	3.1	11.8		97/02/11	E223295	Rattlesnake	36	2.7	9.9	
97/02/10	E206611	Vern.Out.	40	3.1	11.8		97/02/11	E223295	Rattlesnake	40	2.8	9.8	
97/02/10	E206611	Vern.Out.	44	3.1	11.8		97/02/11	E223295	Rattlesnake	44	2.9	9.8	
97/02/10	O500730	N.OK.Centre	0	2.0	12.4	12.0	97/02/11	O500729	S.Squally Pt.	0	1.8	9.9	10.3
97/02/10	O500730	N.OK.Centre	2	2.0	12.4		97/02/11	O500729	S.Squally Pt.	2	2.0	10.2	
97/02/10	O500730	N.OK.Centre	4	2.0	12.4		97/02/11	O500729	S.Squally Pt.	4	2.0	10.2	
97/02/10	O500730	N.OK.Centre	6	2.0	12.4		97/02/11	O500729	S.Squally Pt.	6	2.0	10.2	
97/02/10	O500730	N.OK.Centre	8	2.0	12.4		97/02/11	O500729	S.Squally Pt.	8	2.0	10.2	
97/02/10	O500730	N.OK.Centre	10	2.0	12.4		97/02/11	O500729	S.Squally Pt.	10	2.0	10.1	
97/02/10	O500730	N.OK.Centre	12	2.2	12.3		97/02/11	O500729	S.Squally Pt.	12	2.1	10.1	
97/02/10	O500730	N.OK.Centre	14	2.5	12.2		97/02/11	O500729	S.Squally Pt.	14	2.1	10.0	
97/02/10	O500730	N.OK.Centre	16	2.5	12.2		97/02/11	O500729	S.Squally Pt.	16	2.1	9.9	
97/02/10	O500730	N.OK.Centre	18	2.6	12.1		97/02/11	O500729	S.Squally Pt.	18	2.1	10.0	
97/02/10	O500730	N.OK.Centre	20	2.7	12.1		97/02/11	O500729	S.Squally Pt.	20	2.1	9.9	
97/02/10	O500730	N.OK.Centre	24	2.9	12.0		97/02/11	O500729	S.Squally Pt.	24	2.1	10.0	
97/02/10	O500730	N.OK.Centre	28	3.0	11.9		97/02/11	O500729	S.Squally Pt.	28	2.3	9.6	
97/02/10	O500730	N.OK.Centre	32	3.0	11.8		97/02/11	O500729	S.Squally Pt.	32	2.4	9.0	
97/02/10	O500730	N.OK.Centre	36	3.0	11.8		97/02/11	O500729	S.Squally Pt.	36	2.8	9.0	
97/02/10	O500730	N.OK.Centre	40	3.1	11.8		97/02/11	O500729	S.Squally Pt.	40	2.8	9.0	
97/02/10	O500730	N.OK.Centre	44	3.1	11.8		97/02/11	O500729	S.Squally Pt.	44	2.9	8.2	

97/02/17	O500456	UPS Kel.STP	0	2.6	8.6	12.0	97/02/11	O500454	S.Prairie Cr.	0	1.2	10.0	11.0
97/02/17	O500456	UPS Kel.STP	2	2.6	8.6		97/02/11	O500454	S.Prairie Cr.	2	1.5	10.2	
97/02/17	O500456	UPS Kel.STP	4	2.9	8.6		97/02/11	O500454	S.Prairie Cr.	4	1.8	10.0	
97/02/17	O500456	UPS Kel.STP	6	2.9	8.6		97/02/11	O500454	S.Prairie Cr.	6	1.9	9.9	
97/02/17	O500456	UPS Kel.STP	8	2.3	8.6		97/02/11	O500454	S.Prairie Cr.	8	2.0	9.9	
97/02/17	O500456	UPS Kel.STP	10	2.9	8.6		97/02/11	O500454	S.Prairie Cr.	10	2.0	9.9	
97/02/17	O500456	UPS Kel.STP	12	2.9	8.6		97/02/11	O500454	S.Prairie Cr.	12	2.0	9.8	
97/02/17	O500456	UPS Kel.STP	14	3.0	8.6		97/02/11	O500454	S.Prairie Cr.	14	2.0	9.8	
97/02/17	O500456	UPS Kel.STP	16	3.0	8.6		97/02/11	O500454	S.Prairie Cr.	16	2.1	9.8	
97/02/17	O500456	UPS Kel.STP	18	3.0	8.5		97/02/11	O500454	S.Prairie Cr.	18	2.1	9.9	
97/02/17	O500456	UPS Kel.STP	20	3.0	8.4		97/02/11	O500454	S.Prairie Cr.	20	2.2	9.9	
97/02/17	O500456	UPS Kel.STP	24	3.0	8.4		97/02/11	O500454	S.Prairie Cr.	24	2.5	9.8	
97/02/17	O500456	UPS Kel.STP	28	3.0	8.4		97/02/11	O500454	S.Prairie Cr.	28	2.5	9.8	
97/02/17	O500456	UPS Kel.STP	32	3.2	8.4		97/02/11	O500454	S.Prairie Cr.	32	2.5	9.4	
97/02/17	O500456	UPS Kel.STP	36	3.3	8.3		97/02/11	O500454	S.Prairie Cr.	36	2.5	9.7	
97/02/17	O500456	UPS Kel.STP	40	3.5	8.2		97/02/11	O500454	S.Prairie Cr.	40	2.6	9.7	
97/02/17	O500456	UPS Kel.STP	44	3.5	8.2		97/02/11	O500454	S.Prairie Cr.	44	2.6	9.7	
97/02/17	O500236	DNS Kel.STP	0	2.1	8.9	12.3							
97/02/17	O500236	DNS Kel.STP	2	2.1	9.0								
97/02/17	O500236	DNS Kel.STP	4	2.1	9.0								
97/02/17	O500236	DNS Kel.STP	6	2.1	8.9								
97/02/17	O500236	DNS Kel.STP	8	2.1	8.8								
97/02/17	O500236	DNS Kel.STP	10	2.1	8.8								
97/02/17	O500236	DNS Kel.STP	12	2.1	8.8								
97/02/17	O500236	DNS Kel.STP	14	2.1	8.8								
97/02/17	O500236	DNS Kel.STP	16	2.1	8.8								
97/02/17	O500236	DNS Kel.STP	18	2.1	8.8								
97/02/17	O500236	DNS Kel.STP	20	2.1	8.8								
97/02/17	O500236	DNS Kel.STP	24	2.1	8.7								
97/02/17	O500236	DNS Kel.STP	28	2.1	8.7								
97/02/17	O500236	DNS Kel.STP	32	2.1	8.7								
97/02/17	O500236	DNS Kel.STP	36	2.1	8.7								
97/02/17	O500236	DNS Kel.STP	40	2.1	8.7								
97/02/17	O500236	DNS Kel.STP	44	2.1	8.7								
March 1997													
Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth	Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth
			(m)	(C)	(mg/L)	(m)				(m)	(C)	(mg/L)	(m)
97/03/13	0500847	Kala. D.B.	0	3.0	8.4	8.4	97/03/17	O500236	DNS Kel.STP	0	3.0	10.2	11.5
97/03/13	0500847	Kala. D.B.	2	3.0	8.4		97/03/17	O500236	DNS Kel.STP	2	2.5	10.2	
97/03/13	0500847	Kala. D.B.	4	3.0	8.4		97/03/17	O500236	DNS Kel.STP	4	2.6	11.6	
97/03/13	0500847	Kala. D.B.	6	3.0	8.4		97/03/17	O500236	DNS Kel.STP	6	2.8	11.7	
97/03/13	0500847	Kala. D.B.	8	3.0	8.4		97/03/17	O500236	DNS Kel.STP	8	3.0	11.6	
97/03/13	0500847	Kala. D.B.	10	3.0	8.4		97/03/17	O500236	DNS Kel.STP	10	3.0	11.7	
97/03/13	0500847	Kala. D.B.	12	3.0	8.4		97/03/17	O500236	DNS Kel.STP	12	2.8	11.6	
97/03/13	0500847	Kala. D.B.	14	3.0	8.4		97/03/17	O500236	DNS Kel.STP	14	2.8	11.7	
97/03/13	0500847	Kala. D.B.	16	3.0	8.4		97/03/17	O500236	DNS Kel.STP	16	2.8	11.5	
97/03/13	0500847	Kala. D.B.	18	3.0	8.4		97/03/17	O500236	DNS Kel.STP	18	3.0	11.5	
97/03/13	0500847	Kala. D.B.	20	3.0	8.3		97/03/17	O500236	DNS Kel.STP	20	3.0	11.5	
97/03/13	0500847	Kala. D.B.	24	3.0	8.3		97/03/17	O500236	DNS Kel.STP	24	2.8	11.4	
97/03/13	0500847	Kala. D.B.	28	3.0	8.2		97/03/17	O500236	DNS Kel.STP	28	2.8	11.4	
97/03/13	0500847	Kala. D.B.	32	3.0	8.2		97/03/17	O500236	DNS Kel.STP	32	3.0	11.4	
97/03/13	0500847	Kala. D.B.	36	3.0	8.2		97/03/17	O500236	DNS Kel.STP	36	2.8	11.4	
97/03/13	0500847	Kala. D.B.	40	3.0	8.2		97/03/17	O500236	DNS Kel.STP	40	2.8	11.3	
97/03/13	0500847	Kala. D.B.	44	3.0	8.2		97/03/17	O500236	DNS Kel.STP	44	2.8	11.4	
97/03/16	E206611	Vern.Out.	0	3.0	14.0	12.8	97/03/12	E223295	Rattlesnake	0	3.0	11.4	13.0
97/03/16	E206611	Vern.Out.	2	3.0	14.2		97/03/12	E223295	Rattlesnake	2	3.0	11.5	
97/03/16	E206611	Vern.Out.	4	3.0	14.3		97/03/12	E223295	Rattlesnake	4	2.8	11.5	
97/03/16	E206611	Vern.Out.	6	3.0	14.3		97/03/12	E223295	Rattlesnake	6	3.0	11.5	
97/03/16	E206611	Vern.Out.	8	3.0	14.3		97/03/12	E223295	Rattlesnake	8	2.9	11.4	
97/03/16	E206611	Vern.Out.	10	3.0	14.2		97/03/12	E223295	Rattlesnake	10	3.0	11.4	
97/03/16	E206611	Vern.Out.	12	3.0	14.2		97/03/12	E223295	Rattlesnake	12	2.8	11.4	
97/03/16	E206611	Vern.Out.	14	3.0	14.2		97/03/12	E223295	Rattlesnake	14	3.0	11.4	
97/03/16	E206611	Vern.Out.	16	3.0	14.2		97/03/12	E223295	Rattlesnake	16	3.0	11.4	
97/03/16	E206611	Vern.Out.	18	3.0	14.2		97/03/12	E223295	Rattlesnake	18	3.0	11.4	
97/03/16	E206611	Vern.Out.	20	3.0	14.1		97/03/12	E223295	Rattlesnake	20	3.0	11.4	
97/03/16	E206611	Vern.Out.	24	3.0	14.0		97/03/12	E223295	Rattlesnake	24	3.0	11.4	
97/03/16	E206611	Vern.Out.	28	3.0	14.0		97/03/12	E223295	Rattlesnake	28	3.0	11.4	
97/03/16	E206611	Vern.Out.	32	3.0	14.0		97/03/12	E223295	Rattlesnake	32	3.0	11.3	
97/03/16	E206611	Vern.Out.	36	3.0	13.9		97/03/12	E223295	Rattlesnake	36	3.0	11.3	
97/03/16	E206611	Vern.Out.	40	3.0	13.9		97/03/12	E223295	Rattlesnake	40	3.0	11.3	
97/03/16	E206611	Vern.Out.	44		13.8		97/03/12	E223295	Rattlesnake	44	3.0	11.3	

97/03/16	O500730	N.OK.Centre	0	3.0	13.0	12.8		97/03/20	O500729	S.Squally Pt.	0	3.0	11.4	13.0	
97/03/16	O500730	N.OK.Centre	2		13.0			97/03/20	O500729	S.Squally Pt.	2	3.0	11.5		
97/03/16	O500730	N.OK.Centre	4		13.0			97/03/20	O500729	S.Squally Pt.	4	2.8	11.5		
97/03/16	O500730	N.OK.Centre	6		13.0			97/03/20	O500729	S.Squally Pt.	6	3.0	11.5		
97/03/16	O500730	N.OK.Centre	8		13.0			97/03/20	O500729	S.Squally Pt.	8	2.9	11.4		
97/03/16	O500730	N.OK.Centre	10		13.0			97/03/20	O500729	S.Squally Pt.	10	3.0	11.4		
97/03/16	O500730	N.OK.Centre	12		12.9			97/03/20	O500729	S.Squally Pt.	12	2.8	11.4		
97/03/16	O500730	N.OK.Centre	14		12.8			97/03/20	O500729	S.Squally Pt.	14	3.0	11.4		
97/03/16	O500730	N.OK.Centre	16		12.8			97/03/20	O500729	S.Squally Pt.	16	3.0	11.4		
97/03/16	O500730	N.OK.Centre	18		12.8			97/03/20	O500729	S.Squally Pt.	18	3.0	11.4		
97/03/16	O500730	N.OK.Centre	20		12.8			97/03/20	O500729	S.Squally Pt.	20	3.0	11.4		
97/03/16	O500730	N.OK.Centre	24		12.8			97/03/20	O500729	S.Squally Pt.	24	3.0	11.4		
97/03/16	O500730	N.OK.Centre	28		12.8			97/03/20	O500729	S.Squally Pt.	28	3.0	11.4		
97/03/16	O500730	N.OK.Centre	32		12.8			97/03/20	O500729	S.Squally Pt.	32	3.0	11.3		
97/03/16	O500730	N.OK.Centre	36		12.7			97/03/20	O500729	S.Squally Pt.	36	3.0	11.3		
97/03/16	O500730	N.OK.Centre	40		12.6			97/03/20	O500729	S.Squally Pt.	40	3.0	11.3		
97/03/16	O500730	N.OK.Centre	44		12.6			97/03/20	O500729	S.Squally Pt.	44	3.0	11.3		
97/03/17	O500456	UPS Kel.STP	0	3.0	10.8	13.0		97/03/20	O500454	S.Prairie Cr.	0	3.0	13.2	9.8	
97/03/17	O500456	UPS Kel.STP	2		10.7			97/03/20	O500454	S.Prairie Cr.	2		13.1		
97/03/17	O500456	UPS Kel.STP	4		10.7			97/03/20	O500454	S.Prairie Cr.	4		13.1		
97/03/17	O500456	UPS Kel.STP	6		11.0			97/03/20	O500454	S.Prairie Cr.	6		13.0		
97/03/17	O500456	UPS Kel.STP	8		11.0			97/03/20	O500454	S.Prairie Cr.	8		13.0		
97/03/17	O500456	UPS Kel.STP	10		11.0			97/03/20	O500454	S.Prairie Cr.	10		13.1		
97/03/17	O500456	UPS Kel.STP	12		11.0			97/03/20	O500454	S.Prairie Cr.	12		13.1		
97/03/17	O500456	UPS Kel.STP	14		10.9			97/03/20	O500454	S.Prairie Cr.	14		13.1		
97/03/17	O500456	UPS Kel.STP	16		10.9			97/03/20	O500454	S.Prairie Cr.	16		13.2		
97/03/17	O500456	UPS Kel.STP	18		10.9			97/03/20	O500454	S.Prairie Cr.	18		13.1		
97/03/17	O500456	UPS Kel.STP	20		10.8			97/03/20	O500454	S.Prairie Cr.	20		13.1		
97/03/17	O500456	UPS Kel.STP	24		10.8			97/03/20	O500454	S.Prairie Cr.	24		13.0		
97/03/17	O500456	UPS Kel.STP	28		10.8			97/03/20	O500454	S.Prairie Cr.	28		13.0		
97/03/17	O500456	UPS Kel.STP	32		10.7			97/03/20	O500454	S.Prairie Cr.	32		13.0		
97/03/17	O500456	UPS Kel.STP	36		10.7			97/03/20	O500454	S.Prairie Cr.	36		1.0		
97/03/17	O500456	UPS Kel.STP	40		10.6			97/03/20	O500454	S.Prairie Cr.	40		13.0		
97/03/17	O500456	UPS Kel.STP	44		10.6			97/03/20	O500454	S.Prairie Cr.	44		12.8		
April 1997															
Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth		Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth	
			(m)	(C)	(mg/L)	(m)					(m)	(C)	(mg/L)	(m)	
97/04/21	0500246	Kala. S.E.	0	4.3	12.2	8.0		97/04/15	O500456	UPS Kel.STP	0	4.0	12.6		
97/04/21	0500246	Kala. S.E.	2	4.0	12.2			97/04/15	O500456	UPS Kel.STP	2	4.0	12.6	12.5	
97/04/21	0500246	Kala. S.E.	4	4.0	12.2			97/04/15	O500456	UPS Kel.STP	4	4.0	12.6		
97/04/21	0500246	Kala. S.E.	6	4.0	12.0			97/04/15	O500456	UPS Kel.STP	6	4.0	12.6		
97/04/21	0500246	Kala. S.E.	8	4.0	12.0			97/04/15	O500456	UPS Kel.STP	8	4.0	12.6		
97/04/21	0500246	Kala. S.E.	10	4.0	12.0			97/04/15	O500456	UPS Kel.STP	10	4.0	12.5		
97/04/21	0500246	Kala. S.E.	12	4.0	12.0			97/04/15	O500456	UPS Kel.STP	12	4.0	12.5		
97/04/21	0500246	Kala. S.E.	14	4.0	11.9			97/04/15	O500456	UPS Kel.STP	14	4.0	12.5		
97/04/21	0500246	Kala. S.E.	16	4.0	11.9			97/04/15	O500456	UPS Kel.STP	16	4.0	12.5		
97/04/21	0500246	Kala. S.E.	18	4.0	11.9			97/04/15	O500456	UPS Kel.STP	18	4.0	12.5		
97/04/21	0500246	Kala. S.E.	20	4.0	11.9			97/04/15	O500456	UPS Kel.STP	20	4.0	12.4		
97/04/21	0500246	Kala. S.E.	24	4.0	11.9			97/04/15	O500456	UPS Kel.STP	24	4.0	12.4		
97/04/21	0500246	Kala. S.E.	28	4.0	11.9			97/04/15	O500456	UPS Kel.STP	28	4.0	12.4		
97/04/21	0500246	Kala. S.E.	32	4.0	11.8			97/04/15	O500456	UPS Kel.STP	32	4.0	12.4		
97/04/21	0500246	Kala. S.E.	36	4.0	11.8			97/04/15	O500456	UPS Kel.STP	36	4.0	12.4		
97/04/21	0500246	Kala. S.E.	40	4.0	11.8			97/04/15	O500456	UPS Kel.STP	40	4.0	12.3		
97/04/21	0500246	Kala. S.E.	44	4.0	11.8			97/04/15	O500456	UPS Kel.STP	44	4.0	12.4		
97/04/21	0500847	Kala. D.B.	0	4.5	12.2	9.5		97/04/16	O500236	DNS Kel.STP	0	4.0	12.4	10.3	
97/04/21	0500847	Kala. D.B.	2	4.0	12.1			97/04/16	O500236	DNS Kel.STP	2	4.0	12.6		
97/04/21	0500847	Kala. D.B.	4	4.0	12.2			97/04/16	O500236	DNS Kel.STP	4	4.0	12.6		
97/04/21	0500847	Kala. D.B.	6	4.0	12.0			97/04/16	O500236	DNS Kel.STP	6	4.0	12.6		
97/04/21	0500847	Kala. D.B.	8	4.0	12.0			97/04/16	O500236	DNS Kel.STP	8	4.0	12.6		
97/04/21	0500847	Kala. D.B.	10	4.0	12.0			97/04/16	O500236	DNS Kel.STP	10	4.0	12.6		
97/04/21	0500847	Kala. D.B.	12	4.0	12.0			97/04/16	O500236	DNS Kel.STP	12	4.0	12.6		
97/04/21	0500847	Kala. D.B.	14	4.0	12.0			97/04/16	O500236	DNS Kel.STP	14	4.0	12.6		
97/04/21	0500847	Kala. D.B.	16	3.9	12.0			97/04/16	O500236	DNS Kel.STP	16	4.0	12.5		
97/04/21	0500847	Kala. D.B.	18	3.9	12.0			97/04/16	O500236	DNS Kel.STP	18	4.0	12.6		
97/04/21	0500847	Kala. D.B.	20	3.9	12.0			97/04/16	O500236	DNS Kel.STP	20	4.0	12.6		
97/04/21	0500847	Kala. D.B.	24	3.9	12.0			97/04/16	O500236	DNS Kel.STP	24	4.0	12.6		
97/04/21	0500847	Kala. D.B.	28	3.9	11.9			97/04/16	O500236	DNS Kel.STP	28	4.0	12.6		
97/04/21	0500847	Kala. D.B.	32	3.9	11.9			97/04/16	O500236	DNS Kel.STP	32	4.0	12.6		
97/04/21	0500847	Kala. D.B.	36	3.9	11.9			97/04/16	O500236	DNS Kel.STP	36	4.0	12.5		
97/04/21	0500847	Kala. D.B.	40	3.9	11.8			97/04/16	O500236	DNS Kel.STP	40	4.0	12.5		
97/04/21	0500847	Kala. D.B.	44	3.9	11.8			97/04/16	O500236	DNS Kel.STP	44	4.0	12.5		

97/04/15	0500239	Arm. Arm	0	6.5	11.8	3.0		97/04/10	E223295	Rattlesnake	0	3.5	12.8	11.8
97/04/15	0500239	Arm. Arm	2	6.0	11.8			97/04/10	E223295	Rattlesnake	2	3.3	12.8	
97/04/15	0500239	Arm. Arm	4	5.3	11.8			97/04/10	E223295	Rattlesnake	4	3.3	12.8	
97/04/15	0500239	Arm. Arm	6	5.1	11.6			97/04/10	E223295	Rattlesnake	6	3.3	12.8	
97/04/15	0500239	Arm. Arm	8	5.1	11.6			97/04/10	E223295	Rattlesnake	8	3.3	12.8	
97/04/15	0500239	Arm. Arm	10	5.1	11.5			97/04/10	E223295	Rattlesnake	10	3.3	12.8	
97/04/15	0500239	Arm. Arm	12	5.0	11.4			97/04/10	E223295	Rattlesnake	12	3.3	12.8	
97/04/15	0500239	Arm. Arm	14	5.0	11.2			97/04/10	E223295	Rattlesnake	14	3.3	12.7	
97/04/15	0500239	Arm. Arm	16	4.5	11.0			97/04/10	E223295	Rattlesnake	16	3.3	12.7	
97/04/15	0500239	Arm. Arm	18	4.3	10.7			97/04/10	E223295	Rattlesnake	18	3.3	12.7	
97/04/15	0500239	Arm. Arm	20	4.0	10.4			97/04/10	E223295	Rattlesnake	20	3.3	12.7	
97/04/15	0500239	Arm. Arm	24	3.8	9.8			97/04/10	E223295	Rattlesnake	24	3.3	12.7	
97/04/15	0500239	Arm. Arm	28	3.5	9.4			97/04/10	E223295	Rattlesnake	28	3.3	12.7	
97/04/15	0500239	Arm. Arm	32	3.5	9.0			97/04/10	E223295	Rattlesnake	32	3.3	12.6	
97/04/15	0500239	Arm. Arm	36	3.5	8.7			97/04/10	E223295	Rattlesnake	36	3.3	12.6	
97/04/15	0500239	Arm. Arm	40	3.3	8.4			97/04/10	E223295	Rattlesnake	40	3.3	12.6	
97/04/15	0500239	Arm. Arm	44	3.3	8.3			97/04/10	E223295	Rattlesnake	44	3.3	12.6	
97/04/15	E206611	Vern.Out.	0	4.3	12.2	8.0		97/04/10	O500729	S.Squally Pt.	0	3.9	12.9	11.7
97/04/15	E206611	Vern.Out.	2	4.2	12.2			97/04/10	O500729	S.Squally Pt.	2	3.7	13.1	
97/04/15	E206611	Vern.Out.	4	4.1	12.3			97/04/10	O500729	S.Squally Pt.	4	3.7	13.1	
97/04/15	E206611	Vern.Out.	6	4.0	12.3			97/04/10	O500729	S.Squally Pt.	6	3.7	13.1	
97/04/15	E206611	Vern.Out.	8	4.0	12.3			97/04/10	O500729	S.Squally Pt.	8	3.7	13.1	
97/04/15	E206611	Vern.Out.	10	4.0	12.3			97/04/10	O500729	S.Squally Pt.	10	3.7	13.1	
97/04/15	E206611	Vern.Out.	12	4.0	12.3			97/04/10	O500729	S.Squally Pt.	12	3.7	13.0	
97/04/15	E206611	Vern.Out.	14	4.0	12.3			97/04/10	O500729	S.Squally Pt.	14	3.7	13.0	
97/04/15	E206611	Vern.Out.	16	4.0	12.2			97/04/10	O500729	S.Squally Pt.	16	3.7	13.0	
97/04/15	E206611	Vern.Out.	18	4.0	12.2			97/04/10	O500729	S.Squally Pt.	18	3.7	13.0	
97/04/15	E206611	Vern.Out.	20	4.0	12.2			97/04/10	O500729	S.Squally Pt.	20	3.7	13.0	
97/04/15	E206611	Vern.Out.	24	4.0	12.2			97/04/10	O500729	S.Squally Pt.	24	3.7	13.0	
97/04/15	E206611	Vern.Out.	28	4.0	12.2			97/04/10	O500729	S.Squally Pt.	28	3.7	13.0	
97/04/15	E206611	Vern.Out.	32	4.0	12.2			97/04/10	O500729	S.Squally Pt.	32	3.7	13.0	
97/04/15	E206611	Vern.Out.	36	4.0	12.2			97/04/10	O500729	S.Squally Pt.	36	3.7	12.9	
97/04/15	E206611	Vern.Out.	40	4.0	12.0			97/04/10	O500729	S.Squally Pt.	40	3.7	12.9	
97/04/15	E206611	Vern.Out.	44	4.0	12.0			97/04/10	O500729	S.Squally Pt.	44	3.7	12.9	
97/04/15	O500730	N.OK.Centre	0	3.8	12.6	13.3		97/04/17	O500454	S.Prairie Cr.	0	4.7	12.2	
97/04/15	O500730	N.OK.Centre	2	3.8	12.6			97/04/17	O500454	S.Prairie Cr.	2	4.0	12.2	
97/04/15	O500730	N.OK.Centre	4	3.8	12.6			97/04/17	O500454	S.Prairie Cr.	4	4.0	12.2	
97/04/15	O500730	N.OK.Centre	6	3.8	12.6			97/04/17	O500454	S.Prairie Cr.	6	4.0	12.2	
97/04/15	O500730	N.OK.Centre	8	3.8	12.6			97/04/17	O500454	S.Prairie Cr.	8	4.0	12.2	
97/04/15	O500730	N.OK.Centre	10	3.8	12.6			97/04/17	O500454	S.Prairie Cr.	10	4.0	12.2	
97/04/15	O500730	N.OK.Centre	12	3.5	12.6			97/04/17	O500454	S.Prairie Cr.	12	4.0	12.2	
97/04/15	O500730	N.OK.Centre	14	3.5	12.6			97/04/17	O500454	S.Prairie Cr.	14	4.0	12.2	
97/04/15	O500730	N.OK.Centre	16	3.5	12.6			97/04/17	O500454	S.Prairie Cr.	16	4.0	12.2	
97/04/15	O500730	N.OK.Centre	18	3.5	12.6			97/04/17	O500454	S.Prairie Cr.	18	4.0	12.1	
97/04/15	O500730	N.OK.Centre	20	3.5	12.5			97/04/17	O500454	S.Prairie Cr.	20	4.0	12.1	
97/04/15	O500730	N.OK.Centre	24	3.5	12.5			97/04/17	O500454	S.Prairie Cr.	24	4.0	12.0	
97/04/15	O500730	N.OK.Centre	28	3.5	12.4			97/04/17	O500454	S.Prairie Cr.	28	4.0	12.0	
97/04/15	O500730	N.OK.Centre	32	3.5	12.4			97/04/17	O500454	S.Prairie Cr.	32	4.0	12.0	
97/04/15	O500730	N.OK.Centre	36	3.5	12.4			97/04/17	O500454	S.Prairie Cr.	36	4.0	11.9	
97/04/15	O500730	N.OK.Centre	40	3.5	12.4			97/04/17	O500454	S.Prairie Cr.	40	4.0	11.9	
97/04/15	O500730	N.OK.Centre	44	3.5	12.4			97/04/17	O500454	S.Prairie Cr.	44	4.0	11.9	
May 1997														
Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth		Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth
			(m)	(C)	(mg/L)	(m)					(m)	(C)	(mg/L)	(m)
97/05/07	0500246	Kala. S.E.	0	9.0	10.8	3.8		97/05/12	O500456	UPS Kel.STP	0	13.0	10.0	5.3
97/05/07	0500246	Kala. S.E.	2	6.2	11.5			97/05/12	O500456	UPS Kel.STP	2	10.1	10.8	
97/05/07	0500246	Kala. S.E.	4	5.8	11.5			97/05/12	O500456	UPS Kel.STP	4	9.5	10.8	
97/05/07	0500246	Kala. S.E.	6	5.7	11.4			97/05/12	O500456	UPS Kel.STP	6	8.6	10.8	
97/05/07	0500246	Kala. S.E.	8	5.0	11.6			97/05/12	O500456	UPS Kel.STP	8	7.8	10.8	
97/05/07	0500246	Kala. S.E.	10	5.0	11.4			97/05/12	O500456	UPS Kel.STP	10	7.3	10.8	
97/05/07	0500246	Kala. S.E.	12	5.0	11.2			97/05/12	O500456	UPS Kel.STP	12	7.2	10.8	
97/05/07	0500246	Kala. S.E.	14	5.0	11.1			97/05/12	O500456	UPS Kel.STP	14	7.0	10.8	
97/05/07	0500246	Kala. S.E.	16	4.8	10.9			97/05/12	O500456	UPS Kel.STP	16	6.4	11.0	
97/05/07	0500246	Kala. S.E.	18	4.5	10.8			97/05/12	O500456	UPS Kel.STP	18	5.9	11.0	
97/05/07	0500246	Kala. S.E.	20	4.5	10.7			97/05/12	O500456	UPS Kel.STP	20	4.8	10.9	
97/05/07	0500246	Kala. S.E.	24	4.5	10.6			97/05/12	O500456	UPS Kel.STP	24	4.5	10.8	
97/05/07	0500246	Kala. S.E.	28	4.5	10.6			97/05/12	O500456	UPS Kel.STP	28	4.5	10.6	
97/05/07	0500246	Kala. S.E.	32	4.5	10.6			97/05/12	O500456	UPS Kel.STP	32	4.3	10.6	
97/05/07	0500246	Kala. S.E.	36	4.5	10.5			97/05/12	O500456	UPS Kel.STP	36	4.3	10.6	
97/05/07	0500246	Kala. S.E.	40	4.5	10.5			97/05/12	O500456	UPS Kel.STP	40	4.2	10.6	
97/05/07	0500246	Kala. S.E.	44	4.5	10.5			97/05/12	O500456	UPS Kel.STP	44	4.2	10.6	

97/05/07	0500847	Kala. D.B.	0	9.0	11.1	3.8		97/05/06	O500236	DNS Kel.STP	0	9.0	10.8	5.0	
97/05/07	0500847	Kala. D.B.	2	6.9	11.5			97/05/06	O500236	DNS Kel.STP	2	8.2	10.9		
97/05/07	0500847	Kala. D.B.	4	6.1	11.3			97/05/06	O500236	DNS Kel.STP	4	8.0	11.0		
97/05/07	0500847	Kala. D.B.	6	5.8	11.1			97/05/06	O500236	DNS Kel.STP	6	7.9	11.0		
97/05/07	0500847	Kala. D.B.	8	5.3	11.2			97/05/06	O500236	DNS Kel.STP	8	6.0	11.2		
97/05/07	0500847	Kala. D.B.	10	5.0	11.0			97/05/06	O500236	DNS Kel.STP	10	6.0	11.4		
97/05/07	0500847	Kala. D.B.	12	4.8	10.9			97/05/06	O500236	DNS Kel.STP	12	6.0	11.4		
97/05/07	0500847	Kala. D.B.	14	4.5	10.9			97/05/06	O500236	DNS Kel.STP	14	5.5	11.4		
97/05/07	0500847	Kala. D.B.	16	4.5	10.8			97/05/06	O500236	DNS Kel.STP	16	5.5	11.4		
97/05/07	0500847	Kala. D.B.	18	4.5	10.8			97/05/06	O500236	DNS Kel.STP	18	5.2	11.4		
97/05/07	0500847	Kala. D.B.	20	4.3	10.7			97/05/06	O500236	DNS Kel.STP	20	5.0	11.2		
97/05/07	0500847	Kala. D.B.	24	4.2	10.5			97/05/06	O500236	DNS Kel.STP	24	5.0	11.2		
97/05/07	0500847	Kala. D.B.	28	4.1	10.5			97/05/06	O500236	DNS Kel.STP	28	5.0	11.0		
97/05/07	0500847	Kala. D.B.	32	4.1	10.5			97/05/06	O500236	DNS Kel.STP	32	5.0	11.0		
97/05/07	0500847	Kala. D.B.	36	4.0	10.4			97/05/06	O500236	DNS Kel.STP	36	5.0	11.0		
97/05/07	0500847	Kala. D.B.	40	4.0	10.4			97/05/06	O500236	DNS Kel.STP	40	4.9	11.0		
97/05/07	0500847	Kala. D.B.	44	4.0	10.4			97/05/06	O500236	DNS Kel.STP	44	5.0	11.0		
97/05/06	0500239	Arm. Arm	0	12.2	10.8	2.3		97/05/12	E223295	Rattlesnake	0	9.6	10.8	6.5	
97/05/06	0500239	Arm. Arm	2	12.2	10.6			97/05/12	E223295	Rattlesnake	2	7.0	11.4		
97/05/06	0500239	Arm. Arm	4	10.0	10.6			97/05/12	E223295	Rattlesnake	4	6.8	11.3		
97/05/06	0500239	Arm. Arm	6	9.0	10.6			97/05/12	E223295	Rattlesnake	6	6.5	11.4		
97/05/06	0500239	Arm. Arm	8	8.0	10.6			97/05/12	E223295	Rattlesnake	8	6.1	11.3		
97/05/06	0500239	Arm. Arm	10	7.2	10.2			97/05/12	E223295	Rattlesnake	10	6.0	11.4		
97/05/06	0500239	Arm. Arm	12	6.5	9.9			97/05/12	E223295	Rattlesnake	12	5.7	11.3		
97/05/06	0500239	Arm. Arm	14	5.8	9.7			97/05/12	E223295	Rattlesnake	14	5.7	11.3		
97/05/06	0500239	Arm. Arm	16	5.6	9.5			97/05/12	E223295	Rattlesnake	16	5.5	11.2		
97/05/06	0500239	Arm. Arm	18	5.5	9.4			97/05/12	E223295	Rattlesnake	18	5.1	11.3		
97/05/06	0500239	Arm. Arm	20	5.5	9.3			97/05/12	E223295	Rattlesnake	20	5.0	11.3		
97/05/06	0500239	Arm. Arm	24	5.2	9.1			97/05/12	E223295	Rattlesnake	24	5.0	11.2		
97/05/06	0500239	Arm. Arm	28	5.0	9.0			97/05/12	E223295	Rattlesnake	28	4.7	11.2		
97/05/06	0500239	Arm. Arm	32	4.7	8.8			97/05/12	E223295	Rattlesnake	32	4.5	11.2		
97/05/06	0500239	Arm. Arm	36	4.7	8.6			97/05/12	E223295	Rattlesnake	36	4.5	11.1		
97/05/06	0500239	Arm. Arm	40	4.5	8.4			97/05/12	E223295	Rattlesnake	40	4.3	11.1		
97/05/06	0500239	Arm. Arm	44	4.5	8.2			97/05/12	E223295	Rattlesnake	44	4.2	11.0		
97/05/06	E206611	Vern.Out.	0	7.9	11.1	7.3		97/05/12	O500729	S.Squally Pt.	0	10.3	10.6	8.5	
97/05/06	E206611	Vern.Out.	2	6.9	11.1			97/05/12	O500729	S.Squally Pt.	2	7.2	11.2		
97/05/06	E206611	Vern.Out.	4	6.0	11.2			97/05/12	O500729	S.Squally Pt.	4	5.9	11.1		
97/05/06	E206611	Vern.Out.	6	6.0	11.1			97/05/12	O500729	S.Squally Pt.	6	5.5	11.5		
97/05/06	E206611	Vern.Out.	8	5.5	11.1			97/05/12	O500729	S.Squally Pt.	8	5.1	11.5		
97/05/06	E206611	Vern.Out.	10	5.2	11.1			97/05/12	O500729	S.Squally Pt.	10	5.1	11.5		
97/05/06	E206611	Vern.Out.	12	5.0	11.1			97/05/12	O500729	S.Squally Pt.	12	5.1	11.4		
97/05/06	E206611	Vern.Out.	14	5.0	11.0			97/05/12	O500729	S.Squally Pt.	14	5.0	11.4		
97/05/06	E206611	Vern.Out.	16	5.0	10.9			97/05/12	O500729	S.Squally Pt.	16	5.0	11.4		
97/05/06	E206611	Vern.Out.	18	5.0	11.1			97/05/12	O500729	S.Squally Pt.	18	5.0	11.5		
97/05/06	E206611	Vern.Out.	20	5.0	10.9			97/05/12	O500729	S.Squally Pt.	20	5.0	11.4		
97/05/06	E206611	Vern.Out.	24	5.0	10.8			97/05/12	O500729	S.Squally Pt.	24	5.0	11.5		
97/05/06	E206611	Vern.Out.	28	5.0	10.8			97/05/12	O500729	S.Squally Pt.	28	5.0	11.4		
97/05/06	E206611	Vern.Out.	32	5.0	10.8			97/05/12	O500729	S.Squally Pt.	32	5.0	11.4		
97/05/06	E206611	Vern.Out.	36	4.9	10.6			97/05/12	O500729	S.Squally Pt.	36	5.0	11.4		
97/05/06	E206611	Vern.Out.	40	4.9	10.6			97/05/12	O500729	S.Squally Pt.	40	4.8	11.3		
97/05/06	E206611	Vern.Out.	44	4.9	10.6			97/05/12	O500729	S.Squally Pt.	44	4.5	11.4		
97/05/12	O500730	N.OK.Centre	0	12.2	10.1	6.2		97/05/12	O500454	S.Prairie Cr.	0	9.9	10.9	7.3	
97/05/12	O500730	N.OK.Centre	2	10.5	10.6			97/05/12	O500454	S.Prairie Cr.	2	8.4	11.2		
97/05/12	O500730	N.OK.Centre	4	9.3	10.9			97/05/12	O500454	S.Prairie Cr.	4	7.5	11.4		
97/05/12	O500730	N.OK.Centre	6	8.1	11.4			97/05/12	O500454	S.Prairie Cr.	6	7.1	11.4		
97/05/12	O500730	N.OK.Centre	8	7.8	11.2			97/05/12	O500454	S.Prairie Cr.	8	7.1	11.4		
97/05/12	O500730	N.OK.Centre	10	6.8	11.2			97/05/12	O500454	S.Prairie Cr.	10	7.0	11.4		
97/05/12	O500730	N.OK.Centre	12	6.2	11.1			97/05/12	O500454	S.Prairie Cr.	12	7.0	11.4		
97/05/12	O500730	N.OK.Centre	14	6.0	11.1			97/05/12	O500454	S.Prairie Cr.	14	7.0	11.4		
97/05/12	O500730	N.OK.Centre	16	5.5	11.2			97/05/12	O500454	S.Prairie Cr.	16	6.8	11.4		
97/05/12	O500730	N.OK.Centre	18	5.2	11.2			97/05/12	O500454	S.Prairie Cr.	18	6.5	11.5		
97/05/12	O500730	N.OK.Centre	20	5.0	11.1			97/05/12	O500454	S.Prairie Cr.	20	6.3	11.4		
97/05/12	O500730	N.OK.Centre	24	4.6	10.8			97/05/12	O500454	S.Prairie Cr.	24	6.1	11.4		
97/05/12	O500730	N.OK.Centre	28	4.5	10.7			97/05/12	O500454	S.Prairie Cr.	28	6.0	11.4		
97/05/12	O500730	N.OK.Centre	32	4.3	10.5			97/05/12	O500454	S.Prairie Cr.	32	6.0	11.3		
97/05/12	O500730	N.OK.Centre	36	4.3	10.4			97/05/12	O500454	S.Prairie Cr.	36	5.7	11.4		
97/05/12	O500730	N.OK.Centre	40	4.3	10.4			97/05/12	O500454	S.Prairie Cr.	40	5.2	11.4		
97/05/12	O500730	N.OK.Centre	44	4.2	10.3			97/05/12	O500454	S.Prairie Cr.	44	4.9	11.4		

June 1997													
Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth	Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth
			(m)	(C)	(mg/L)	(m)				(m)	(C)	(mg/L)	(m)
97/06/09	0500246	Kala. S.E.	0	19.5	9.1	3.5	97/06/12	O500456	UPS Kel.STP	0	17.5	9.2	4.0
97/06/09	0500246	Kala. S.E.	2	17.5	9.0		97/06/12	O500456	UPS Kel.STP	2	17.2	9.4	
97/06/09	0500246	Kala. S.E.	4	17.3	9.3		97/06/12	O500456	UPS Kel.STP	4	16.5	9.8	
97/06/09	0500246	Kala. S.E.	6	14.0	10.7		97/06/12	O500456	UPS Kel.STP	6	16.0	9.8	
97/06/09	0500246	Kala. S.E.	8	11.0	11.0		97/06/12	O500456	UPS Kel.STP	8	15.6	9.7	
97/06/09	0500246	Kala. S.E.	10	9.0	10.9		97/06/12	O500456	UPS Kel.STP	10	14.8	9.8	
97/06/09	0500246	Kala. S.E.	12	8.0	10.4		97/06/12	O500456	UPS Kel.STP	12	11.8	10.2	
97/06/09	0500246	Kala. S.E.	14	7.0	10.3		97/06/12	O500456	UPS Kel.STP	14	9.7	10.6	
97/06/09	0500246	Kala. S.E.	16	6.5	10.2		97/06/12	O500456	UPS Kel.STP	16	8.1	10.9	
97/06/09	0500246	Kala. S.E.	18	6.0	10.1		97/06/12	O500456	UPS Kel.STP	18	7.2	11.0	
97/06/09	0500246	Kala. S.E.	20	5.8	10.2		97/06/12	O500456	UPS Kel.STP	20	6.2	11.2	
97/06/09	0500246	Kala. S.E.	24	5.0	10.2		97/06/12	O500456	UPS Kel.STP	24	5.3	11.1	
97/06/09	0500246	Kala. S.E.	28	4.8	10.2		97/06/12	O500456	UPS Kel.STP	28	5.0	11.2	
97/06/09	0500246	Kala. S.E.	32	4.5	10.2		97/06/12	O500456	UPS Kel.STP	32	4.8	11.3	
97/06/09	0500246	Kala. S.E.	36	4.2	10.2		97/06/12	O500456	UPS Kel.STP	36	4.6	11.2	
97/06/09	0500246	Kala. S.E.	40	4.1	10.1		97/06/12	O500456	UPS Kel.STP	40	4.2	11.2	
97/06/09	0500246	Kala. S.E.	44	4.0	10.2		97/06/12	O500456	UPS Kel.STP	44	4.1	11.1	
97/06/09	0500847	Kala. D.B.	0	18.5	9.3	3.3	97/06/12	O500236	DNS Kel.STP	0	17.3	9.2	3.5
97/06/09	0500847	Kala. D.B.	2	17.1	9.4		97/06/12	O500236	DNS Kel.STP	2	17.0	9.6	
97/06/09	0500847	Kala. D.B.	4	15.7	10.0		97/06/12	O500236	DNS Kel.STP	4	16.2	9.7	
97/06/09	0500847	Kala. D.B.	6	14.0	10.6		97/06/12	O500236	DNS Kel.STP	6	15.1	9.9	
97/06/09	0500847	Kala. D.B.	8	11.0	11.1		97/06/12	O500236	DNS Kel.STP	8	14.2	10.1	
97/06/09	0500847	Kala. D.B.	10	9.5	10.9		97/06/12	O500236	DNS Kel.STP	10	11.8	10.5	
97/06/09	0500847	Kala. D.B.	12	8.0	10.6		97/06/12	O500236	DNS Kel.STP	12	11.3	10.7	
97/06/09	0500847	Kala. D.B.	14	7.0	10.5		97/06/12	O500236	DNS Kel.STP	14	10.0	10.6	
97/06/09	0500847	Kala. D.B.	16	6.6	10.2		97/06/12	O500236	DNS Kel.STP	16	9.5	11.0	
97/06/09	0500847	Kala. D.B.	18	5.9	10.1		97/06/12	O500236	DNS Kel.STP	18	8.0	11.4	
97/06/09	0500847	Kala. D.B.	20	5.5	10.2		97/06/12	O500236	DNS Kel.STP	20	7.3	11.5	
97/06/09	0500847	Kala. D.B.	24	5.0	9.9		97/06/12	O500236	DNS Kel.STP	24	6.3	11.6	
97/06/09	0500847	Kala. D.B.	28	4.7	10.1		97/06/12	O500236	DNS Kel.STP	28	6.0	11.6	
97/06/09	0500847	Kala. D.B.	32	4.2	10.2		97/06/12	O500236	DNS Kel.STP	32	5.5	11.7	
97/06/09	0500847	Kala. D.B.	36	4.1	10.1		97/06/12	O500236	DNS Kel.STP	36	5.2	11.6	
97/06/09	0500847	Kala. D.B.	40	4.0	10.1		97/06/12	O500236	DNS Kel.STP	40	5.0	11.6	
97/06/09	0500847	Kala. D.B.	44	4.0	10.2		97/06/12	O500236	DNS Kel.STP	44	4.9	11.7	
97/06/16	0500239	Arm. Arm	0	21.3	9.2	2.5	97/06/11	E223295	Rattlesnake	0	17.3	9.2	4.8
97/06/16	0500239	Arm. Arm	2	20.0	9.6		97/06/11	E223295	Rattlesnake	2	16.5	9.6	
97/06/16	0500239	Arm. Arm	4	19.1	9.8		97/06/11	E223295	Rattlesnake	4	14.5	10.0	
97/06/16	0500239	Arm. Arm	6	18.0	9.8		97/06/11	E223295	Rattlesnake	6	13.5	10.2	
97/06/16	0500239	Arm. Arm	8	16.8	10.0		97/06/11	E223295	Rattlesnake	8	12.0	10.4	
97/06/16	0500239	Arm. Arm	10	11.8	9.6		97/06/11	E223295	Rattlesnake	10	10.8	10.5	
97/06/16	0500239	Arm. Arm	12	10.5	9.6		97/06/11	E223295	Rattlesnake	12	9.7	10.7	
97/06/16	0500239	Arm. Arm	14	7.1	9.4		97/06/11	E223295	Rattlesnake	14	8.0	11.0	
97/06/16	0500239	Arm. Arm	16	6.6	9.1		97/06/11	E223295	Rattlesnake	16	6.7	11.3	
97/06/16	0500239	Arm. Arm	18	6.5	9.0		97/06/11	E223295	Rattlesnake	18	6.0	11.5	
97/06/16	0500239	Arm. Arm	20	6.5	8.9		97/06/11	E223295	Rattlesnake	20	5.8	11.6	
97/06/16	0500239	Arm. Arm	24	6.3	8.8		97/06/11	E223295	Rattlesnake	24	5.1	11.6	
97/06/16	0500239	Arm. Arm	28	6.0	8.9		97/06/11	E223295	Rattlesnake	28	5.0	11.6	
97/06/16	0500239	Arm. Arm	32	6.0	8.6		97/06/11	E223295	Rattlesnake	32	4.9	11.5	
97/06/16	0500239	Arm. Arm	36	6.0	8.4		97/06/11	E223295	Rattlesnake	36	4.9	11.4	
97/06/16	0500239	Arm. Arm	40	6.0	8.4		97/06/11	E223295	Rattlesnake	40	4.7	11.5	
97/06/16	0500239	Arm. Arm	44	6.0	8.2		97/06/11	E223295	Rattlesnake	44	4.5	11.5	
97/06/16	E206611	Vern.Out.	0	19.0	10.7	4.5	97/06/11	O500729	S.Squally Pt.	0	16.0	9.6	4.8
97/06/16	E206611	Vern.Out.	2	18.8	11.0		97/06/11	O500729	S.Squally Pt.	2	15.6	9.8	
97/06/16	E206611	Vern.Out.	4	18.2	11.1		97/06/11	O500729	S.Squally Pt.	4	15.3	10.0	
97/06/16	E206611	Vern.Out.	6	17.7	11.2		97/06/11	O500729	S.Squally Pt.	6	14.0	10.2	
97/06/16	E206611	Vern.Out.	8	17.3	11.2		97/06/11	O500729	S.Squally Pt.	8	13.0	10.5	
97/06/16	E206611	Vern.Out.	10	17.0	11.2		97/06/11	O500729	S.Squally Pt.	10	11.5	10.8	
97/06/16	E206611	Vern.Out.	12	16.5	11.6		97/06/11	O500729	S.Squally Pt.	12	10.5	10.7	
97/06/16	E206611	Vern.Out.	14	13.0	11.8		97/06/11	O500729	S.Squally Pt.	14	9.3	11.0	
97/06/16	E206611	Vern.Out.	16	11.8	12.0		97/06/11	O500729	S.Squally Pt.	16	8.0	11.3	
97/06/16	E206611	Vern.Out.	18	10.5	12.3		97/06/11	O500729	S.Squally Pt.	18	7.5	11.3	
97/06/16	E206611	Vern.Out.	20	8.8	12.8		97/06/11	O500729	S.Squally Pt.	20	6.8	11.4	
97/06/16	E206611	Vern.Out.	24	8.5	12.6		97/06/11	O500729	S.Squally Pt.	24	6.0	11.6	
97/06/16	E206611	Vern.Out.	28	7.5	12.2		97/06/11	O500729	S.Squally Pt.	28	5.3	11.7	
97/06/16	E206611	Vern.Out.	32	5.6	12.1		97/06/11	O500729	S.Squally Pt.	32	5.1	11.7	
97/06/16	E206611	Vern.Out.	36	5.0	12.5		97/06/11	O500729	S.Squally Pt.	36	5.0	11.7	
97/06/16	E206611	Vern.Out.	40	4.8	12.8		97/06/11	O500729	S.Squally Pt.	40	4.8	11.8	
97/06/16	E206611	Vern.Out.	44	4.3	12.8		97/06/11	O500729	S.Squally Pt.	44	4.8	11.8	

97/06/15	O500730	N.OK.Centre	0	20.0	8.7	4.8	97/06/11	O500454	S.Prairie Cr.	0	17.7	9.9	4.8
97/06/15	O500730	N.OK.Centre	2	18.9	9.0		97/06/11	O500454	S.Prairie Cr.	2	17.0	10.0	
97/06/15	O500730	N.OK.Centre	4	17.6	9.3		97/06/11	O500454	S.Prairie Cr.	4	15.5	10.4	
97/06/15	O500730	N.OK.Centre	6	15.7	9.6		97/06/11	O500454	S.Prairie Cr.	6	14.4	10.4	
97/06/15	O500730	N.OK.Centre	8	15.0	9.6		97/06/11	O500454	S.Prairie Cr.	8	14.0	10.5	
97/06/15	O500730	N.OK.Centre	10	13.5	9.7		97/06/11	O500454	S.Prairie Cr.	10	11.8	11.2	
97/06/15	O500730	N.OK.Centre	12	11.1	9.9		97/06/11	O500454	S.Prairie Cr.	12	9.5	11.5	
97/06/15	O500730	N.OK.Centre	14	9.3	10.2		97/06/11	O500454	S.Prairie Cr.	14	8.0	11.9	
97/06/15	O500730	N.OK.Centre	16	8.3	10.2		97/06/11	O500454	S.Prairie Cr.	16	7.2	12.1	
97/06/15	O500730	N.OK.Centre	18	7.2	10.4		97/06/11	O500454	S.Prairie Cr.	18	6.6	12.1	
97/06/15	O500730	N.OK.Centre	20	6.6	10.4		97/06/11	O500454	S.Prairie Cr.	20	6.2	12.2	
97/06/15	O500730	N.OK.Centre	24	5.7	10.6		97/06/11	O500454	S.Prairie Cr.	24	5.5	12.2	
97/06/15	O500730	N.OK.Centre	28	5.0	10.6		97/06/11	O500454	S.Prairie Cr.	28	5.2	12.2	
97/06/15	O500730	N.OK.Centre	32	4.9	10.4		97/06/11	O500454	S.Prairie Cr.	32	5.0	12.3	
97/06/15	O500730	N.OK.Centre	36	4.5	10.5		97/06/11	O500454	S.Prairie Cr.	36	4.9	12.2	
97/06/15	O500730	N.OK.Centre	40	4.5	10.5		97/06/11	O500454	S.Prairie Cr.	40	4.8	12.2	
97/06/15	O500730	N.OK.Centre	44	4.2	10.5		97/06/11	O500454	S.Prairie Cr.	44	4.8	12.2	
July 1997													
Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth	Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth
			(m)	(C)	(mg/L)	(m)				(m)	(C)	(mg/L)	(m)
97/07/06	0500246	Kala. S.E.	0	19.1	9.2	5.8	97/07/14	O500456	UPS Kel.STP	0	18.0	9.7	6.5
97/07/06	0500246	Kala. S.E.	2	18.8	9.2		97/07/14	O500456	UPS Kel.STP	2	18.0	9.7	
97/07/06	0500246	Kala. S.E.	4	18.5	9.4		97/07/14	O500456	UPS Kel.STP	4	17.4	9.9	
97/07/06	0500246	Kala. S.E.	6	18.5	9.4		97/07/14	O500456	UPS Kel.STP	6	17.3	9.9	
97/07/06	0500246	Kala. S.E.	8	16.0	10.1		97/07/14	O500456	UPS Kel.STP	8	16.0	10.0	
97/07/06	0500246	Kala. S.E.	10	15.0	10.4		97/07/14	O500456	UPS Kel.STP	10	15.6	10.0	
97/07/06	0500246	Kala. S.E.	12	13.5	10.8		97/07/14	O500456	UPS Kel.STP	12	14.5	10.2	
97/07/06	0500246	Kala. S.E.	14	11.7	11.1		97/07/14	O500456	UPS Kel.STP	14	12.8	10.5	
97/07/06	0500246	Kala. S.E.	16	11.2	11.3		97/07/14	O500456	UPS Kel.STP	16	12.0	10.6	
97/07/06	0500246	Kala. S.E.	18	9.2	11.4		97/07/14	O500456	UPS Kel.STP	18	9.3	11.0	
97/07/06	0500246	Kala. S.E.	20	8.0	11.0		97/07/14	O500456	UPS Kel.STP	20	8.6	11.4	
97/07/06	0500246	Kala. S.E.	24	6.3	10.8		97/07/14	O500456	UPS Kel.STP	24	7.8	11.8	
97/07/06	0500246	Kala. S.E.	28	5.2	10.8		97/07/14	O500456	UPS Kel.STP	28	6.1	12.0	
97/07/06	0500246	Kala. S.E.	32	4.8	10.8		97/07/14	O500456	UPS Kel.STP	32	5.6	12.2	
97/07/06	0500246	Kala. S.E.	36	4.7	10.6		97/07/14	O500456	UPS Kel.STP	36	4.9	12.6	
97/07/06	0500246	Kala. S.E.	40	4.7	10.6		97/07/14	O500456	UPS Kel.STP	40	4.8	12.6	
97/07/06	0500246	Kala. S.E.	44	4.5	10.6		97/07/14	O500456	UPS Kel.STP	44	4.7	12.4	
97/07/07	0500847	Kala. D.B.	0	18.5	9.6	4.5	97/07/15	O500236	DNS Kel.STP	0	18.3	9.6	1.8
97/07/07	0500847	Kala. D.B.	2	18.5	9.6		97/07/15	O500236	DNS Kel.STP	2	17.5	9.9	
97/07/07	0500847	Kala. D.B.	4	18.5	9.6		97/07/15	O500236	DNS Kel.STP	4	17.0	9.9	
97/07/07	0500847	Kala. D.B.	6	18.2	9.7		97/07/15	O500236	DNS Kel.STP	6	16.0	10.1	
97/07/07	0500847	Kala. D.B.	8	18.0	9.8		97/07/15	O500236	DNS Kel.STP	8	15.3	10.1	
97/07/07	0500847	Kala. D.B.	10	13.8	11.2		97/07/15	O500236	DNS Kel.STP	10	13.2	10.5	
97/07/07	0500847	Kala. D.B.	12	12.0	11.4		97/07/15	O500236	DNS Kel.STP	12	10.0	11.2	
97/07/07	0500847	Kala. D.B.	14	9.4	11.6		97/07/15	O500236	DNS Kel.STP	14	6.8	12.0	
97/07/07	0500847	Kala. D.B.	16	7.8	11.4		97/07/15	O500236	DNS Kel.STP	16	6.3	12.2	
97/07/07	0500847	Kala. D.B.	18	6.8	11.0		97/07/15	O500236	DNS Kel.STP	18	5.9	12.4	
97/07/07	0500847	Kala. D.B.	20	6.2	11.0		97/07/15	O500236	DNS Kel.STP	20	5.7	12.3	
97/07/07	0500847	Kala. D.B.	24	5.3	10.9		97/07/15	O500236	DNS Kel.STP	24	5.3	12.3	
97/07/07	0500847	Kala. D.B.	28	5.0	11.0		97/07/15	O500236	DNS Kel.STP	28	5.0	12.4	
97/07/07	0500847	Kala. D.B.	32	4.7	11.0		97/07/15	O500236	DNS Kel.STP	32	4.9	12.4	
97/07/07	0500847	Kala. D.B.	36	4.5	11.0		97/07/15	O500236	DNS Kel.STP	36	4.9	12.4	
97/07/07	0500847	Kala. D.B.	40	4.3	11.0		97/07/15	O500236	DNS Kel.STP	40	4.6	12.8	
97/07/07	0500847	Kala. D.B.	44	4.3	11.0		97/07/15	O500236	DNS Kel.STP	44	4.5	12.9	
97/07/09	0500239	Arm. Arm	0	21.8	8.9	2.5	97/07/10	E223295	Rattlesnake	0	17.8	9.2	7.0
97/07/09	0500239	Arm. Arm	2	21.2	9.0		97/07/10	E223295	Rattlesnake	2	17.8	9.2	
97/07/09	0500239	Arm. Arm	4	21.0	9.0		97/07/10	E223295	Rattlesnake	4	17.5	9.3	
97/07/09	0500239	Arm. Arm	6	19.3	8.6		97/07/10	E223295	Rattlesnake	6	16.8	9.4	
97/07/09	0500239	Arm. Arm	8	15.5	8.2		97/07/10	E223295	Rattlesnake	8	15.8	9.6	
97/07/09	0500239	Arm. Arm	10	13.5	8.0		97/07/10	E223295	Rattlesnake	10	14.7	9.8	
97/07/09	0500239	Arm. Arm	12	11.6	7.8		97/07/10	E223295	Rattlesnake	12	13.0	10.0	
97/07/09	0500239	Arm. Arm	14	8.8	7.7		97/07/10	E223295	Rattlesnake	14	11.5	10.3	
97/07/09	0500239	Arm. Arm	16	8.0	7.7		97/07/10	E223295	Rattlesnake	16	9.0	10.9	
97/07/09	0500239	Arm. Arm	18	7.7	7.7		97/07/10	E223295	Rattlesnake	18	7.9	11.2	
97/07/09	0500239	Arm. Arm	20	7.3	7.5		97/07/10	E223295	Rattlesnake	20	6.8	11.6	
97/07/09	0500239	Arm. Arm	24	7.0	7.4		97/07/10	E223295	Rattlesnake	24	5.8	12.0	
97/07/09	0500239	Arm. Arm	28	6.7	7.3		97/07/10	E223295	Rattlesnake	28	5.5	12.0	
97/07/09	0500239	Arm. Arm	32	6.3	7.1		97/07/10	E223295	Rattlesnake	32	5.2	12.1	
97/07/09	0500239	Arm. Arm	36	6.3	6.9		97/07/10	E223295	Rattlesnake	36	5.0	12.2	
97/07/09	0500239	Arm. Arm	40	6.3	6.8		97/07/10	E223295	Rattlesnake	40	4.8	12.3	
97/07/09	0500239	Arm. Arm	44	6.3	6.6		97/07/10	E223295	Rattlesnake	44	4.8	12.3	

97/07/09	E206611	Vern.Out.	0	19.7	9.0	5.2		97/07/10	O500729	S.Squally Pt.	0	17.2	9.1	6.9	
97/07/09	E206611	Vern.Out.	2	19.0	9.2			97/07/10	O500729	S.Squally Pt.	2	17.2	9.2		
97/07/09	E206611	Vern.Out.	4	18.6	9.4			97/07/10	O500729	S.Squally Pt.	4	17.2	9.2		
97/07/09	E206611	Vern.Out.	6	18.6	9.4			97/07/10	O500729	S.Squally Pt.	6	17.2	9.2		
97/07/09	E206611	Vern.Out.	8	18.5	9.4			97/07/10	O500729	S.Squally Pt.	8	16.3	9.4		
97/07/09	E206611	Vern.Out.	10	17.5	9.1			97/07/10	O500729	S.Squally Pt.	10	15.8	9.6		
97/07/09	E206611	Vern.Out.	12	13.7	9.5			97/07/10	O500729	S.Squally Pt.	12	13.7	9.9		
97/07/09	E206611	Vern.Out.	14	10.8	10.2			97/07/10	O500729	S.Squally Pt.	14	11.0	10.3		
97/07/09	E206611	Vern.Out.	16	8.5	10.3			97/07/10	O500729	S.Squally Pt.	16	9.1	10.7		
97/07/09	E206611	Vern.Out.	18	7.3	10.8			97/07/10	O500729	S.Squally Pt.	18	7.3	11.1		
97/07/09	E206611	Vern.Out.	20	6.7	11.2			97/07/10	O500729	S.Squally Pt.	20	6.7	11.4		
97/07/09	E206611	Vern.Out.	24	6.0	11.6			97/07/10	O500729	S.Squally Pt.	24	6.0	11.7		
97/07/09	E206611	Vern.Out.	28	5.5	11.7			97/07/10	O500729	S.Squally Pt.	28	5.5	11.8		
97/07/09	E206611	Vern.Out.	32	5.3	11.6			97/07/10	O500729	S.Squally Pt.	32	5.2	11.9		
97/07/09	E206611	Vern.Out.	36	5.0	11.7			97/07/10	O500729	S.Squally Pt.	36	5.0	12.0		
97/07/09	E206611	Vern.Out.	40	4.9	11.7			97/07/10	O500729	S.Squally Pt.	40	4.9	12.1		
97/07/09	E206611	Vern.Out.	44	4.9	11.7			97/07/10	O500729	S.Squally Pt.	44	4.8	12.1		
97/07/14	O500730	N.OK.Centre	0	19.4	9.1	7.5		97/07/10	O500454	S.Prairie Cr.	0	19.0	8.4	6.2	
97/07/14	O500730	N.OK.Centre	2	17.4	9.6			97/07/10	O500454	S.Prairie Cr.	2	18.3	8.6		
97/07/14	O500730	N.OK.Centre	4	17.0	9.8			97/07/10	O500454	S.Prairie Cr.	4	18.0	8.6		
97/07/14	O500730	N.OK.Centre	6	16.4	9.8			97/07/10	O500454	S.Prairie Cr.	6	17.8	8.7		
97/07/14	O500730	N.OK.Centre	8	16.2	9.8			97/07/10	O500454	S.Prairie Cr.	8	17.0	8.8		
97/07/14	O500730	N.OK.Centre	10	16.0	9.8			97/07/10	O500454	S.Prairie Cr.	10	16.0	9.2		
97/07/14	O500730	N.OK.Centre	12	15.4	10.0			97/07/10	O500454	S.Prairie Cr.	12	14.0	9.4		
97/07/14	O500730	N.OK.Centre	14	14.6	10.1			97/07/10	O500454	S.Prairie Cr.	14	12.8	9.6		
97/07/14	O500730	N.OK.Centre	16	13.8	10.2			97/07/10	O500454	S.Prairie Cr.	16	10.3	10.0		
97/07/14	O500730	N.OK.Centre	18	12.9	10.3			97/07/10	O500454	S.Prairie Cr.	18	8.0	10.8		
97/07/14	O500730	N.OK.Centre	20	9.9	10.9			97/07/10	O500454	S.Prairie Cr.	20	7.0	10.9		
97/07/14	O500730	N.OK.Centre	24	7.0	11.8			97/07/10	O500454	S.Prairie Cr.	24	5.6	11.4		
97/07/14	O500730	N.OK.Centre	28	6.0	12.3			97/07/10	O500454	S.Prairie Cr.	28	5.2	11.5		
97/07/14	O500730	N.OK.Centre	32	5.5	12.4			97/07/10	O500454	S.Prairie Cr.	32	5.0	11.6		
97/07/14	O500730	N.OK.Centre	36	5.0	12.6			97/07/10	O500454	S.Prairie Cr.	36	5.0	11.6		
97/07/14	O500730	N.OK.Centre	40	4.8	12.8			97/07/10	O500454	S.Prairie Cr.	40	4.8	11.6		
97/07/14	O500730	N.OK.Centre	44	4.7	12.7			97/07/10	O500454	S.Prairie Cr.	44	4.7	11.8		
August 1997															
Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth		Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth	
			(m)	(C)	(mg/L)	(m)					(m)	(C)	(mg/L)	(m)	
97/08/04	0500246	Kala. S.E.	0	22.5	8.8	6.8		97/08/13	O500456	UPS Kel.STP	0	21.7	8.9	6.0	
97/08/04	0500246	Kala. S.E.	2	22.3	8.8			97/08/13	O500456	UPS Kel.STP	2	21.5	9.0		
97/08/04	0500246	Kala. S.E.	4	22.0	8.8			97/08/13	O500456	UPS Kel.STP	4	21.0	9.1		
97/08/04	0500246	Kala. S.E.	6	22.0	8.8			97/08/13	O500456	UPS Kel.STP	6	21.0	9.1		
97/08/04	0500246	Kala. S.E.	8	19.5	9.8			97/08/13	O500456	UPS Kel.STP	8	20.1	9.2		
97/08/04	0500246	Kala. S.E.	10	15.7	10.6			97/08/13	O500456	UPS Kel.STP	10	19.7	9.3		
97/08/04	0500246	Kala. S.E.	12	14.3	10.7			97/08/13	O500456	UPS Kel.STP	12	17.3	9.3		
97/08/04	0500246	Kala. S.E.	14	10.4	11.2			97/08/13	O500456	UPS Kel.STP	14	14.8	9.7		
97/08/04	0500246	Kala. S.E.	16	8.0	10.9			97/08/13	O500456	UPS Kel.STP	16	11.0	10.4		
97/08/04	0500246	Kala. S.E.	18	7.0	10.8			97/08/13	O500456	UPS Kel.STP	18	8.6	11.0		
97/08/04	0500246	Kala. S.E.	20	5.9	10.6			97/08/13	O500456	UPS Kel.STP	20	7.2	11.4		
97/08/04	0500246	Kala. S.E.	24	5.0	10.7			97/08/13	O500456	UPS Kel.STP	24	5.9	11.8		
97/08/04	0500246	Kala. S.E.	28	4.6	10.6			97/08/13	O500456	UPS Kel.STP	28	5.3	12.0		
97/08/04	0500246	Kala. S.E.	32	4.5	10.8			97/08/13	O500456	UPS Kel.STP	32	4.9	12.4		
97/08/04	0500246	Kala. S.E.	36	4.3	10.9			97/08/13	O500456	UPS Kel.STP	36	4.9	12.4		
97/08/04	0500246	Kala. S.E.	40	4.3	10.9			97/08/13	O500456	UPS Kel.STP	40	4.8	12.4		
97/08/04	0500246	Kala. S.E.	44	4.3	10.9			97/08/13	O500456	UPS Kel.STP	44	4.8	12.4		
97/08/04	0500847	Kala. D.B.	0	23.1	8.6	6.0		97/08/13	O500236	DNS Kel.STP	0	22.4	9.0	6.9	
97/08/04	0500847	Kala. D.B.	2	22.0	8.6			97/08/13	O500236	DNS Kel.STP	2	22.0	9.1		
97/08/04	0500847	Kala. D.B.	4	21.5	9.0			97/08/13	O500236	DNS Kel.STP	4	21.2	9.4		
97/08/04	0500847	Kala. D.B.	6	21.5	9.0			97/08/13	O500236	DNS Kel.STP	6	20.5	9.4		
97/08/04	0500847	Kala. D.B.	8	20.3	9.2			97/08/13	O500236	DNS Kel.STP	8	19.9	9.3		
97/08/04	0500847	Kala. D.B.	10	16.2	10.5			97/08/13	O500236	DNS Kel.STP	10	18.3	9.3		
97/08/04	0500847	Kala. D.B.	12	12.4	11.2			97/08/13	O500236	DNS Kel.STP	12	17.5	9.3		
97/08/04	0500847	Kala. D.B.	14	9.0	11.2			97/08/13	O500236	DNS Kel.STP	14	16.5	9.4		
97/08/04	0500847	Kala. D.B.	16	7.5	11.0			97/08/13	O500236	DNS Kel.STP	16	14.0	9.8		
97/08/04	0500847	Kala. D.B.	18	6.2	11.0			97/08/13	O500236	DNS Kel.STP	18	11.1	10.3		
97/08/04	0500847	Kala. D.B.	20	6.0	10.8			97/08/13	O500236	DNS Kel.STP	20	8.8	10.9		
97/08/04	0500847	Kala. D.B.	24	5.2	10.6			97/08/13	O500236	DNS Kel.STP	24	6.3	11.8		
97/08/04	0500847	Kala. D.B.	28	4.9	10.8			97/08/13	O500236	DNS Kel.STP	28	5.4	12.2		
97/08/04	0500847	Kala. D.B.	32	4.5	10.9			97/08/13	O500236	DNS Kel.STP	32	5.0	12.4		
97/08/04	0500847	Kala. D.B.	36	4.2	11.0			97/08/13	O500236	DNS Kel.STP	36	5.0	12.4		
97/08/04	0500847	Kala. D.B.	40	4.2	11.0			97/08/13	O500236	DNS Kel.STP	40	4.8	12.5		
97/08/04	0500847	Kala. D.B.	44	4.2	11.0			97/08/13	O500236	DNS Kel.STP	44	4.8	12.5		

97/08/10	0500239	Arm. Arm	0	21.0	9.3	3.1	97/08/07	E223295	Rattlesnake	0	21.8	8.8	7.8
97/08/10	0500239	Arm. Arm	2	20.5	9.4		97/08/07	E223295	Rattlesnake	2	21.8	8.8	
97/08/10	0500239	Arm. Arm	4	20.2	9.4		97/08/07	E223295	Rattlesnake	4	21.5	8.9	
97/08/10	0500239	Arm. Arm	6	19.0	9.2		97/08/07	E223295	Rattlesnake	6	21.5	8.9	
97/08/10	0500239	Arm. Arm	8	16.0	9.1		97/08/07	E223295	Rattlesnake	8	20.5	9.0	
97/08/10	0500239	Arm. Arm	10	14.9	9.1		97/08/07	E223295	Rattlesnake	10	18.5	9.0	
97/08/10	0500239	Arm. Arm	12	13.2	8.0		97/08/07	E223295	Rattlesnake	12	17.0	9.3	
97/08/10	0500239	Arm. Arm	14	10.8	6.9		97/08/07	E223295	Rattlesnake	14	12.9	10.0	
97/08/10	0500239	Arm. Arm	16	8.9	6.5		97/08/07	E223295	Rattlesnake	16	11.8	10.3	
97/08/10	0500239	Arm. Arm	18	8.2	6.2		97/08/07	E223295	Rattlesnake	18	10.5	10.6	
97/08/10	0500239	Arm. Arm	20	7.9	6.3		97/08/07	E223295	Rattlesnake	20	8.2	11.2	
97/08/10	0500239	Arm. Arm	24	7.5	6.0		97/08/07	E223295	Rattlesnake	24	6.4	11.8	
97/08/10	0500239	Arm. Arm	28	7.0	5.7		97/08/07	E223295	Rattlesnake	28	5.5	12.2	
97/08/10	0500239	Arm. Arm	32	6.8	5.4		97/08/07	E223295	Rattlesnake	32	5.0	12.5	
97/08/10	0500239	Arm. Arm	36	6.8	5.1		97/08/07	E223295	Rattlesnake	36	4.9	12.6	
97/08/10	0500239	Arm. Arm	40	6.5	4.9		97/08/07	E223295	Rattlesnake	40	4.7	12.6	
97/08/10	0500239	Arm. Arm	44	6.5	4.8		97/08/07	E223295	Rattlesnake	44	4.7	12.6	
97/08/10	E206611	Vern.Out.	0	20.2	9.5	5.5	97/08/07	O500729	S.Squally Pt.	0	21.2	8.6	8.0
97/08/10	E206611	Vern.Out.	2	20.0	9.6		97/08/07	O500729	S.Squally Pt.	2	21.2	8.7	
97/08/10	E206611	Vern.Out.	4	19.8	9.8		97/08/07	O500729	S.Squally Pt.	4	20.9	8.7	
97/08/10	E206611	Vern.Out.	6	18.1	9.9		97/08/07	O500729	S.Squally Pt.	6	20.7	8.7	
97/08/10	E206611	Vern.Out.	8	13.0	9.6		97/08/07	O500729	S.Squally Pt.	8	20.5	8.7	
97/08/10	E206611	Vern.Out.	10	12.0	9.7		97/08/07	O500729	S.Squally Pt.	10	19.6	8.8	
97/08/10	E206611	Vern.Out.	12	9.9	10.0		97/08/07	O500729	S.Squally Pt.	12	14.0	9.5	
97/08/10	E206611	Vern.Out.	14	8.9	10.5		97/08/07	O500729	S.Squally Pt.	14	11.8	10.0	
97/08/10	E206611	Vern.Out.	16	7.9	10.8		97/08/07	O500729	S.Squally Pt.	16	9.0	10.7	
97/08/10	E206611	Vern.Out.	18	6.8	11.2		97/08/07	O500729	S.Squally Pt.	18	7.6	11.0	
97/08/10	E206611	Vern.Out.	20	6.0	11.8		97/08/07	O500729	S.Squally Pt.	20	6.9	11.4	
97/08/10	E206611	Vern.Out.	24	5.5	12.2		97/08/07	O500729	S.Squally Pt.	24	6.0	11.6	
97/08/10	E206611	Vern.Out.	28	5.0	12.4		97/08/07	O500729	S.Squally Pt.	28	5.2	12.0	
97/08/10	E206611	Vern.Out.	32	5.0	12.3		97/08/07	O500729	S.Squally Pt.	32	5.0	12.0	
97/08/10	E206611	Vern.Out.	36	4.9	12.2		97/08/07	O500729	S.Squally Pt.	36	4.8	12.2	
97/08/10	E206611	Vern.Out.	40	4.8	12.3		97/08/07	O500729	S.Squally Pt.	40	4.6	12.3	
97/08/10	E206611	Vern.Out.	44	4.5	12.4		97/08/07	O500729	S.Squally Pt.	44	4.5	12.4	
97/08/11	O500730	N.OK.Centre	0	21.5	9.0	5.8	97/08/07	O500454	S.Prairie Cr.	0	22.5	8.3	8.0
97/08/11	O500730	N.OK.Centre	2	20.0	9.4		97/08/07	O500454	S.Prairie Cr.	2	22.5	8.5	
97/08/11	O500730	N.OK.Centre	4	19.9	9.3		97/08/07	O500454	S.Prairie Cr.	4	22.0	8.5	
97/08/11	O500730	N.OK.Centre	6	19.7	9.6		97/08/07	O500454	S.Prairie Cr.	6	21.8	8.6	
97/08/11	O500730	N.OK.Centre	8	19.2	9.4		97/08/07	O500454	S.Prairie Cr.	8	21.8	8.6	
97/08/11	O500730	N.OK.Centre	10	16.0	9.8		97/08/07	O500454	S.Prairie Cr.	10	21.2	8.5	
97/08/11	O500730	N.OK.Centre	12	14.3	10.0		97/08/07	O500454	S.Prairie Cr.	12	20.5	8.6	
97/08/11	O500730	N.OK.Centre	14	12.1	10.3		97/08/07	O500454	S.Prairie Cr.	14	10.7	10.5	
97/08/11	O500730	N.OK.Centre	16	11.0	10.4		97/08/07	O500454	S.Prairie Cr.	16	8.6	10.8	
97/08/11	O500730	N.OK.Centre	18	9.8	10.6		97/08/07	O500454	S.Prairie Cr.	18	8.0	11.1	
97/08/11	O500730	N.OK.Centre	20	8.0	11.0		97/08/07	O500454	S.Prairie Cr.	20	7.5	11.2	
97/08/11	O500730	N.OK.Centre	24	6.3	11.6		97/08/07	O500454	S.Prairie Cr.	24	6.0	11.6	
97/08/11	O500730	N.OK.Centre	28	5.5	12.0		97/08/07	O500454	S.Prairie Cr.	28	5.5	12.0	
97/08/11	O500730	N.OK.Centre	32	5.1	12.2		97/08/07	O500454	S.Prairie Cr.	32	5.0	12.2	
97/08/11	O500730	N.OK.Centre	36	4.9	12.4		97/08/07	O500454	S.Prairie Cr.	36	4.7	12.4	
97/08/11	O500730	N.OK.Centre	40	4.9	12.4		97/08/07	O500454	S.Prairie Cr.	40	4.5	12.4	
97/08/11	O500730	N.OK.Centre	44	4.7	12.5		97/08/07	O500454	S.Prairie Cr.	44	4.5	12.4	
September 1997													
Date	Station No.	Location	Depth (m)	Temp. (C)	D.O. (mg/L)	Secchi Depth (m)	Date	Station No.	Location	Depth (m)	Temp. (C)	D.O. (mg/L)	Secchi Depth (m)
97/08/27	0500246	Kala. S.E.	0	21.0	8.4	3.8	97/09/04	O500456	UPS Kel.STP	0	20.4	8.8	7.3
97/08/27	0500246	Kala. S.E.	2	21.0	8.5		97/09/04	O500456	UPS Kel.STP	2	20.4	8.9	
97/08/27	0500246	Kala. S.E.	4	20.9	8.4		97/09/04	O500456	UPS Kel.STP	4	20.4	8.9	
97/08/27	0500246	Kala. S.E.	6	20.8	8.6		97/09/04	O500456	UPS Kel.STP	6	20.4	9.0	
97/08/27	0500246	Kala. S.E.	8	20.5	8.6		97/09/04	O500456	UPS Kel.STP	8	20.0	9.0	
97/08/27	0500246	Kala. S.E.	10	17.7	9.8		97/09/04	O500456	UPS Kel.STP	10	17.5	9.2	
97/08/27	0500246	Kala. S.E.	12	15.5	10.2		97/09/04	O500456	UPS Kel.STP	12	14.8	9.7	
97/08/27	0500246	Kala. S.E.	14	13.1	10.4		97/09/04	O500456	UPS Kel.STP	14	10.1	10.6	
97/08/27	0500246	Kala. S.E.	16	9.6	10.6		97/09/04	O500456	UPS Kel.STP	16	7.3	11.3	
97/08/27	0500246	Kala. S.E.	18	9.0	10.3		97/09/04	O500456	UPS Kel.STP	18	6.5	11.6	
97/08/27	0500246	Kala. S.E.	20	7.3	10.2		97/09/04	O500456	UPS Kel.STP	20	6.2	11.6	
97/08/27	0500246	Kala. S.E.	24	6.0	10.2		97/09/04	O500456	UPS Kel.STP	24	5.4	12.0	
97/08/27	0500246	Kala. S.E.	28	5.0	10.3		97/09/04	O500456	UPS Kel.STP	28	5.0	12.2	
97/08/27	0500246	Kala. S.E.	32	4.8	10.4		97/09/04	O500456	UPS Kel.STP	32	4.8	12.3	
97/08/27	0500246	Kala. S.E.	36	4.7	10.4		97/09/04	O500456	UPS Kel.STP	36	4.7	12.3	
97/08/27	0500246	Kala. S.E.	40	4.5	10.5		97/09/04	O500456	UPS Kel.STP	40	4.7	12.3	
97/08/27	0500246	Kala. S.E.	44	4.3	10.7		97/09/04	O500456	UPS Kel.STP	44	4.3	12.4	

97/08/27	0500847	Kala. D.B.	0	21.0	8.4	3.5		97/09/11	O500236	DNS Kel.STP	0	19.5	10.4	7.0	
97/08/27	0500847	Kala. D.B.	2	21.0	8.5			97/09/11	O500236	DNS Kel.STP	2	19.5	10.4		
97/08/27	0500847	Kala. D.B.	4	20.8	8.6			97/09/11	O500236	DNS Kel.STP	4	19.5	10.4		
97/08/27	0500847	Kala. D.B.	6	20.8	8.6			97/09/11	O500236	DNS Kel.STP	6	19.5	10.4		
97/08/27	0500847	Kala. D.B.	8	20.5	8.6			97/09/11	O500236	DNS Kel.STP	8	19.0	10.2		
97/08/27	0500847	Kala. D.B.	10	19.0	9.0			97/09/11	O500236	DNS Kel.STP	10	17.5	10.1		
97/08/27	0500847	Kala. D.B.	12	14.1	10.2			97/09/11	O500236	DNS Kel.STP	12	16.2	10.0		
97/08/27	0500847	Kala. D.B.	14	12.0	10.5			97/09/11	O500236	DNS Kel.STP	14	16.0	10.0		
97/08/27	0500847	Kala. D.B.	16	8.7	10.4			97/09/11	O500236	DNS Kel.STP	16	15.0	9.8		
97/08/27	0500847	Kala. D.B.	18	7.6	10.2			97/09/11	O500236	DNS Kel.STP	18	12.0	9.8		
97/08/27	0500847	Kala. D.B.	20	6.3	10.2			97/09/11	O500236	DNS Kel.STP	20	9.5	9.6		
97/08/27	0500847	Kala. D.B.	24	5.0	10.5			97/09/11	O500236	DNS Kel.STP	24	9.5	9.6		
97/08/27	0500847	Kala. D.B.	28	4.8	10.6			97/09/11	O500236	DNS Kel.STP	28	6.0	9.8		
97/08/27	0500847	Kala. D.B.	32	4.6	10.6			97/09/11	O500236	DNS Kel.STP	32	5.5	9.8		
97/08/27	0500847	Kala. D.B.	36	4.5	10.7			97/09/11	O500236	DNS Kel.STP	36	5.2	10.0		
97/08/27	0500847	Kala. D.B.	40	4.2	10.8			97/09/11	O500236	DNS Kel.STP	40	5.0	10.0		
97/08/27	0500847	Kala. D.B.	44	4.2	10.9			97/09/11	O500236	DNS Kel.STP	44	5.0	10.0		
97/09/03	0500239	Arm. Arm	0	20.5	9.4	3.0		97/09/09	E223295	Rattlesnake	0	19.0	8.8	7.5	
97/09/03	0500239	Arm. Arm	2	20.2	9.4			97/09/09	E223295	Rattlesnake	2	19.0	8.8		
97/09/03	0500239	Arm. Arm	4	20.0	9.2			97/09/09	E223295	Rattlesnake	4	19.0	8.8		
97/09/03	0500239	Arm. Arm	6	20.0	9.3			97/09/09	E223295	Rattlesnake	6	19.0	8.7		
97/09/03	0500239	Arm. Arm	8	19.9	8.9			97/09/09	E223295	Rattlesnake	8	19.0	8.7		
97/09/03	0500239	Arm. Arm	10	17.5	7.9			97/09/09	E223295	Rattlesnake	10	18.5	8.7		
97/09/03	0500239	Arm. Arm	12	13.0	7.0			97/09/09	E223295	Rattlesnake	12	18.5	8.8		
97/09/03	0500239	Arm. Arm	14	10.1	5.6			97/09/09	E223295	Rattlesnake	14	18.0	8.8		
97/09/03	0500239	Arm. Arm	16	9.0	5.4			97/09/09	E223295	Rattlesnake	16	14.5	8.5		
97/09/03	0500239	Arm. Arm	18	8.0	5.6			97/09/09	E223295	Rattlesnake	18	12.0	8.2		
97/09/03	0500239	Arm. Arm	20	8.0	5.6			97/09/09	E223295	Rattlesnake	20	9.0	8.0		
97/09/03	0500239	Arm. Arm	24	7.5	5.2			97/09/09	E223295	Rattlesnake	24	6.8	8.0		
97/09/03	0500239	Arm. Arm	28	7.0	4.9			97/09/09	E223295	Rattlesnake	28	6.0	8.2		
97/09/03	0500239	Arm. Arm	32	7.0	4.4			97/09/09	E223295	Rattlesnake	32	5.5	8.4		
97/09/03	0500239	Arm. Arm	36	6.9	4.0			97/09/09	E223295	Rattlesnake	36	5.2	8.5		
97/09/03	0500239	Arm. Arm	40	6.5	3.4			97/09/09	E223295	Rattlesnake	40	5.0	8.6		
97/09/03	0500239	Arm. Arm	44	6.5	2.8			97/09/09	E223295	Rattlesnake	44	5.0	8.6		
97/09/03	E206611	Vern.Out.	0	20.0	9.1	5.0		97/09/09	O500729	S.Squally Pt.	0	18.6	8.6	8.0	
97/09/03	E206611	Vern.Out.	2	20.0	9.3			97/09/09	O500729	S.Squally Pt.	2	18.6	8.8		
97/09/03	E206611	Vern.Out.	4	19.8	9.4			97/09/09	O500729	S.Squally Pt.	4	18.6	8.7		
97/09/03	E206611	Vern.Out.	6	19.6	9.4			97/09/09	O500729	S.Squally Pt.	6	18.6	8.7		
97/09/03	E206611	Vern.Out.	8	19.0	9.2			97/09/09	O500729	S.Squally Pt.	8	18.6	8.7		
97/09/03	E206611	Vern.Out.	10	16.5	9.1			97/09/09	O500729	S.Squally Pt.	10	18.6	8.8		
97/09/03	E206611	Vern.Out.	12	15.0	9.2			97/09/09	O500729	S.Squally Pt.	12	18.6	8.7		
97/09/03	E206611	Vern.Out.	14	12.8	9.6			97/09/09	O500729	S.Squally Pt.	14	18.5	8.7		
97/09/03	E206611	Vern.Out.	16	10.8	9.4			97/09/09	O500729	S.Squally Pt.	16	18.2	8.6		
97/09/03	E206611	Vern.Out.	18	8.9	9.6			97/09/09	O500729	S.Squally Pt.	18	11.0	8.2		
97/09/03	E206611	Vern.Out.	20	7.6	10.1			97/09/09	O500729	S.Squally Pt.	20	9.5	8.3		
97/09/03	E206611	Vern.Out.	24	6.0	10.8			97/09/09	O500729	S.Squally Pt.	24	7.0	8.2		
97/09/03	E206611	Vern.Out.	28	5.3	11.4			97/09/09	O500729	S.Squally Pt.	28	6.0	8.4		
97/09/03	E206611	Vern.Out.	32	4.9	11.8			97/09/09	O500729	S.Squally Pt.	32	5.5	8.4		
97/09/03	E206611	Vern.Out.	36	4.7	12.0			97/09/09	O500729	S.Squally Pt.	36	5.0	8.6		
97/09/03	E206611	Vern.Out.	40	4.5	12.0			97/09/09	O500729	S.Squally Pt.	40	5.0	8.6		
97/09/03	E206611	Vern.Out.	44	4.3	12.2			97/09/09	O500729	S.Squally Pt.	44	5.0	8.6		
97/09/03	O500730	N.OK.Centre	0	20.2	9.0	6.5		97/09/01	O500454	S.Prairie Cr.	0	20.7	8.5	7.5	
97/09/03	O500730	N.OK.Centre	2	20.2	9.2			97/09/01	O500454	S.Prairie Cr.	2	20.7	8.5		
97/09/03	O500730	N.OK.Centre	4	20.0	9.3			97/09/01	O500454	S.Prairie Cr.	4	20.4	8.5		
97/09/03	O500730	N.OK.Centre	6	19.7	9.2			97/09/01	O500454	S.Prairie Cr.	6	20.4	8.5		
97/09/03	O500730	N.OK.Centre	8	19.3	9.2			97/09/01	O500454	S.Prairie Cr.	8	20.1	8.6		
97/09/03	O500730	N.OK.Centre	10	18.8	9.0			97/09/01	O500454	S.Prairie Cr.	10	20.1	8.6		
97/09/03	O500730	N.OK.Centre	12	15.5	9.2			97/09/01	O500454	S.Prairie Cr.	12	19.7	8.6		
97/09/03	O500730	N.OK.Centre	14	12.6	9.8			97/09/01	O500454	S.Prairie Cr.	14	19.2	8.6		
97/09/03	O500730	N.OK.Centre	16	8.8	10.4			97/09/01	O500454	S.Prairie Cr.	16	14.6	9.2		
97/09/03	O500730	N.OK.Centre	18	7.5	10.5			97/09/01	O500454	S.Prairie Cr.	18	12.0	9.6		
97/09/03	O500730	N.OK.Centre	20	6.5	10.9			97/09/01	O500454	S.Prairie Cr.	20	9.8	10.0		
97/09/03	O500730	N.OK.Centre	24	5.8	11.4			97/09/01	O500454	S.Prairie Cr.	24	7.0	10.8		
97/09/03	O500730	N.OK.Centre	28	5.1	11.7			97/09/01	O500454	S.Prairie Cr.	28	5.9	11.2		
97/09/03	O500730	N.OK.Centre	32	4.9	11.9			97/09/01	O500454	S.Prairie Cr.	32	5.2	11.6		
97/09/03	O500730	N.OK.Centre	36	4.7	12.2			97/09/01	O500454	S.Prairie Cr.	36	4.9	11.8		
97/09/03	O500730	N.OK.Centre	40	4.5	12.4			97/09/01	O500454	S.Prairie Cr.	40	4.9	11.9		
97/09/03	O500730	N.OK.Centre	44	4.2	12.4			97/09/01	O500454	S.Prairie Cr.	44	4.8	12.0		

October 1997															
Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth		Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth	
			(m)	(C)	(mg/L)	(m)					(m)	(C)	(mg/L)	(m)	
97/10/14	0500246	Kala. S.E.	0	12.3	10.1	5.5		97/10/15	O500730	N.OK.Centre	0	13.3	8.8	7.0	
97/10/14	0500246	Kala. S.E.	2	12.3	10.0			97/10/15	O500730	N.OK.Centre	2	13.3	9.0		
97/10/14	0500246	Kala. S.E.	4	12.3	10.0			97/10/15	O500730	N.OK.Centre	4	13.3	9.0		
97/10/14	0500246	Kala. S.E.	6	12.3	10.0			97/10/15	O500730	N.OK.Centre	6	13.3	9.0		
97/10/14	0500246	Kala. S.E.	8	12.3	9.9			97/10/15	O500730	N.OK.Centre	8	13.3	9.0		
97/10/14	0500246	Kala. S.E.	10	12.1	10.0			97/10/15	O500730	N.OK.Centre	10	13.3	9.0		
97/10/14	0500246	Kala. S.E.	12	12.0	10.0			97/10/15	O500730	N.OK.Centre	12	13.0	9.0		
97/10/14	0500246	Kala. S.E.	14	12.0	10.0			97/10/15	O500730	N.OK.Centre	14	13.0	9.1		
97/10/14	0500246	Kala. S.E.	16	12.0	10.0			97/10/15	O500730	N.OK.Centre	16	13.0	9.1		
97/10/14	0500246	Kala. S.E.	18	11.6	9.8			97/10/15	O500730	N.OK.Centre	18	12.6	9.0		
97/10/14	0500246	Kala. S.E.	20	10.0	9.6			97/10/15	O500730	N.OK.Centre	20	9.7	9.0		
97/10/14	0500246	Kala. S.E.	24	6.1	9.8			97/10/15	O500730	N.OK.Centre	24	7.0	9.4		
97/10/14	0500246	Kala. S.E.	28	4.9	10.2			97/10/15	O500730	N.OK.Centre	28	6.2	9.8		
97/10/14	0500246	Kala. S.E.	32	4.5	10.2			97/10/15	O500730	N.OK.Centre	32	5.8	10.3		
97/10/14	0500246	Kala. S.E.	36	4.0	10.4			97/10/15	O500730	N.OK.Centre	36	5.2	10.4		
97/10/14	0500246	Kala. S.E.	40	4.0	10.4			97/10/15	O500730	N.OK.Centre	40	5.0	10.6		
97/10/14	0500246	Kala. S.E.	44	4.0	10.4			97/10/15	O500730	N.OK.Centre	44	4.8	10.7		
97/10/14	0500847	Kala. D.B.	0	12.3	9.7	5.5		97/10/15	O500456	UPS Kel.STP	0	13.0	9.2	7.8	
97/10/14	0500847	Kala. D.B.	2	12.3	9.9			97/10/15	O500456	UPS Kel.STP	2	13.0	9.2		
97/10/14	0500847	Kala. D.B.	4	12.3	10.0			97/10/15	O500456	UPS Kel.STP	4	13.0	9.2		
97/10/14	0500847	Kala. D.B.	6	12.3	10.0			97/10/15	O500456	UPS Kel.STP	6	13.0	9.2		
97/10/14	0500847	Kala. D.B.	8	12.3	10.0			97/10/15	O500456	UPS Kel.STP	8	12.9	9.2		
97/10/14	0500847	Kala. D.B.	10	12.3	10.0			97/10/15	O500456	UPS Kel.STP	10	12.9	9.2		
97/10/14	0500847	Kala. D.B.	12	12.3	10.0			97/10/15	O500456	UPS Kel.STP	12	12.8	9.1		
97/10/14	0500847	Kala. D.B.	14	12.3	10.0			97/10/15	O500456	UPS Kel.STP	14	12.8	9.1		
97/10/14	0500847	Kala. D.B.	16	12.1	10.0			97/10/15	O500456	UPS Kel.STP	16	12.3	9.1		
97/10/14	0500847	Kala. D.B.	18	11.0	9.7			97/10/15	O500456	UPS Kel.STP	18	11.8	9.2		
97/10/14	0500847	Kala. D.B.	20	8.5	9.6			97/10/15	O500456	UPS Kel.STP	20	8.9	9.4		
97/10/14	0500847	Kala. D.B.	24	5.5	10.0			97/10/15	O500456	UPS Kel.STP	24	7.0	10.1		
97/10/14	0500847	Kala. D.B.	28	4.9	10.0			97/10/15	O500456	UPS Kel.STP	28	6.4	10.4		
97/10/14	0500847	Kala. D.B.	32	4.5	10.0			97/10/15	O500456	UPS Kel.STP	32	6.0	10.5		
97/10/14	0500847	Kala. D.B.	36	4.0	10.4			97/10/15	O500456	UPS Kel.STP	36	5.7	10.6		
97/10/14	0500847	Kala. D.B.	40	4.0	10.5			97/10/15	O500456	UPS Kel.STP	40	5.5	10.6		
97/10/14	0500847	Kala. D.B.	44	4.0	10.6			97/10/15	O500456	UPS Kel.STP	44	5.1	10.7		
97/10/15	0500239	Arm. Arm	0	12.5	9.4	5.3		97/10/16	O500236	DNS Kel.STP	0	12.5		7.5	
97/10/15	0500239	Arm. Arm	2	12.5	9.3			97/10/16	O500236	DNS Kel.STP	2	12.5			
97/10/15	0500239	Arm. Arm	4	12.5	9.2			97/10/16	O500236	DNS Kel.STP	4	12.5			
97/10/15	0500239	Arm. Arm	6	12.5	9.2			97/10/16	O500236	DNS Kel.STP	6	12.5			
97/10/15	0500239	Arm. Arm	8	12.5	9.2			97/10/16	O500236	DNS Kel.STP	8	12.5			
97/10/15	0500239	Arm. Arm	10	12.5	9.0			97/10/16	O500236	DNS Kel.STP	10	12.5			
97/10/15	0500239	Arm. Arm	12	12.5	9.0			97/10/16	O500236	DNS Kel.STP	12	12.2			
97/10/15	0500239	Arm. Arm	14	12.5	9.0			97/10/16	O500236	DNS Kel.STP	14	12.1			
97/10/15	0500239	Arm. Arm	16	12.0	7.3			97/10/16	O500236	DNS Kel.STP	16	12.1			
97/10/15	0500239	Arm. Arm	18	9.2	3.8			97/10/16	O500236	DNS Kel.STP	18	10.5			
97/10/15	0500239	Arm. Arm	20	8.5	3.4			97/10/16	O500236	DNS Kel.STP	20	6.6			
97/10/15	0500239	Arm. Arm	24	7.7	3.2			97/10/16	O500236	DNS Kel.STP	24	5.9			
97/10/15	0500239	Arm. Arm	28	7.0	3.0			97/10/16	O500236	DNS Kel.STP	28	5.5			
97/10/15	0500239	Arm. Arm	32	6.8	2.2			97/10/16	O500236	DNS Kel.STP	32	5.1			
97/10/15	0500239	Arm. Arm	36	6.6	1.6			97/10/16	O500236	DNS Kel.STP	36	5.0			
97/10/15	0500239	Arm. Arm	40	6.5	1.2			97/10/16	O500236	DNS Kel.STP	40	5.0			
97/10/15	0500239	Arm. Arm	44	6.5	0.8			97/10/16	O500236	DNS Kel.STP	44	4.8			
97/10/15	0500239	Arm. Arm	48	6.5	0.4										
								97/10/16	E223295	Rattlesnake	0	12.6	9.8	8.5	
97/10/15	E206611	Vern.Out.	0	13.3	8.6	7.5		97/10/16	E223295	Rattlesnake	2	12.6	9.8		
97/10/15	E206611	Vern.Out.	2	13.3	8.6			97/10/16	E223295	Rattlesnake	4	12.6	9.8		
97/10/15	E206611	Vern.Out.	4	13.3	8.6			97/10/16	E223295	Rattlesnake	6	12.6	9.8		
97/10/15	E206611	Vern.Out.	6	13.3	8.6			97/10/16	E223295	Rattlesnake	8	12.6	9.8		
97/10/15	E206611	Vern.Out.	8	13.0	8.6			97/10/16	E223295	Rattlesnake	10	12.6	9.8		
97/10/15	E206611	Vern.Out.	10	13.3	8.6			97/10/16	E223295	Rattlesnake	12	12.2	9.8		
97/10/15	E206611	Vern.Out.	12	13.3	8.6			97/10/16	E223295	Rattlesnake	14	11.9	9.7		
97/10/15	E206611	Vern.Out.	14	13.0	8.7			97/10/16	E223295	Rattlesnake	16	10.1	10.0		
97/10/15	E206611	Vern.Out.	16	12.0	8.4			97/10/16	E223295	Rattlesnake	18	10.2	10.0		
97/10/15	E206611	Vern.Out.	18	9.7	8.2			97/10/16	E223295	Rattlesnake	20	9.5	10.1		
97/10/15	E206611	Vern.Out.	20	8.5	8.3			97/10/16	E223295	Rattlesnake	24	8.6	10.3		
97/10/15	E206611	Vern.Out.	24	6.0	9.2			97/10/16	E223295	Rattlesnake	28	7.2	10.5		
97/10/15	E206611	Vern.Out.	28	5.5	9.6			97/10/16	E223295	Rattlesnake	32	6.5	10.6		
97/10/15	E206611	Vern.Out.	32	5.1	9.8			97/10/16	E223295	Rattlesnake	36	6.0	10.6		
97/10/15	E206611	Vern.Out.	36	4.9	9.8			97/10/16	E223295	Rattlesnake	40	5.3	10.8		
97/10/15	E206611	Vern.Out.	40	4.9	9.8			97/10/16	E223295	Rattlesnake	44	5.1	10.8		
97/10/15	E206611	Vern.Out.	44	4.8	10.0										

November 1997															
Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth		Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth	
			(m)	(C)	(mg/L)	(m)					(m)	(C)	(mg/L)	(m)	
97/11/04	0500246	Kala. S.E.	0	9.9	10.0	4.3		97/11/12	O500456	UPS Kel.STP	0	9.5	10.0	8.8	
97/11/04	0500246	Kala. S.E.	2	9.9	10.0			97/11/12	O500456	UPS Kel.STP	2	9.5	10.0		
97/11/04	0500246	Kala. S.E.	4	9.7	10.0			97/11/12	O500456	UPS Kel.STP	4	9.5	10.0		
97/11/04	0500246	Kala. S.E.	6	9.7	10.0			97/11/12	O500456	UPS Kel.STP	6	9.5	10.0		
97/11/04	0500246	Kala. S.E.	8	9.7	10.0			97/11/12	O500456	UPS Kel.STP	8	9.5	10.0		
97/11/04	0500246	Kala. S.E.	10	9.7	10.0			97/11/12	O500456	UPS Kel.STP	10	9.5	10.0		
97/11/04	0500246	Kala. S.E.	12	9.7	9.9			97/11/12	O500456	UPS Kel.STP	12	9.5	10.0		
97/11/04	0500246	Kala. S.E.	14	9.7	9.9			97/11/12	O500456	UPS Kel.STP	14	9.5	10.0		
97/11/04	0500246	Kala. S.E.	16	9.7	9.9			97/11/12	O500456	UPS Kel.STP	16	9.5	10.0		
97/11/04	0500246	Kala. S.E.	18	9.7	10.0			97/11/12	O500456	UPS Kel.STP	18	9.5	10.0		
97/11/04	0500246	Kala. S.E.	20	9.0	9.0			97/11/12	O500456	UPS Kel.STP	20	9.4	9.9		
97/11/04	0500246	Kala. S.E.	24	5.5	9.7			97/11/12	O500456	UPS Kel.STP	24	9.4	10.0		
97/11/04	0500246	Kala. S.E.	28	5.0	9.6			97/11/12	O500456	UPS Kel.STP	28	9.3	9.8		
97/11/04	0500246	Kala. S.E.	32	4.8	9.6			97/11/12	O500456	UPS Kel.STP	32	7.3	10.2		
97/11/04	0500246	Kala. S.E.	36	4.5	9.7			97/11/12	O500456	UPS Kel.STP	36	6.7	10.2		
97/11/04	0500246	Kala. S.E.	40	4.4	9.6			97/11/12	O500456	UPS Kel.STP	40	6.2	10.2		
97/11/04	0500246	Kala. S.E.	44	4.1	9.7			97/11/12	O500456	UPS Kel.STP	44	5.8	10.4		
97/11/04	0500847	Kala. D.B.	0	10.0	9.6	4.3		97/11/12	O500236	DNS Kel.STP	0	8.0	10.5	8.9	
97/11/04	0500847	Kala. D.B.	2	10.0	9.8			97/11/12	O500236	DNS Kel.STP	2	8.0	10.4		
97/11/04	0500847	Kala. D.B.	4	9.8	9.8			97/11/12	O500236	DNS Kel.STP	4	8.0	10.4		
97/11/04	0500847	Kala. D.B.	6	9.8	9.8			97/11/12	O500236	DNS Kel.STP	6	8.0	10.3		
97/11/04	0500847	Kala. D.B.	8	9.8	9.8			97/11/12	O500236	DNS Kel.STP	8	8.0	10.3		
97/11/04	0500847	Kala. D.B.	10	9.8	9.8			97/11/12	O500236	DNS Kel.STP	10	7.0	10.3		
97/11/04	0500847	Kala. D.B.	12	9.8	9.8			97/11/12	O500236	DNS Kel.STP	12	6.6	10.4		
97/11/04	0500847	Kala. D.B.	14	9.8	9.7			97/11/12	O500236	DNS Kel.STP	14	6.5	10.4		
97/11/04	0500847	Kala. D.B.	16	9.6	9.7			97/11/12	O500236	DNS Kel.STP	16	6.5	10.3		
97/11/04	0500847	Kala. D.B.	18	8.1	9.6			97/11/12	O500236	DNS Kel.STP	18	6.5	10.3		
97/11/04	0500847	Kala. D.B.	20	6.5	9.6			97/11/12	O500236	DNS Kel.STP	20	6.5	10.3		
97/11/04	0500847	Kala. D.B.	24	6.0	9.5			97/11/12	O500236	DNS Kel.STP	24	6.2	10.4		
97/11/04	0500847	Kala. D.B.	28	4.9	9.4			97/11/12	O500236	DNS Kel.STP	28	6.0	10.6		
97/11/04	0500847	Kala. D.B.	32	4.7	9.4			97/11/12	O500236	DNS Kel.STP	32	6.0	10.5		
97/11/04	0500847	Kala. D.B.	36	4.3	9.6			97/11/12	O500236	DNS Kel.STP	36	6.0	10.4		
97/11/04	0500847	Kala. D.B.	40	4.3	9.6			97/11/12	O500236	DNS Kel.STP	40	5.8	10.6		
97/11/04	0500847	Kala. D.B.	44	4.0	9.8			97/11/12	O500236	DNS Kel.STP	44	5.8	10.5		
97/11/11	0500239	Arm. Arm	0	9.0	10.0	4.8		97/11/12	E223295	Rattlesnake	0	7.9	10.7	10.0	
97/11/11	0500239	Arm. Arm	2	9.0	9.8			97/11/12	E223295	Rattlesnake	2	7.9	10.6		
97/11/11	0500239	Arm. Arm	4	9.0	9.8			97/11/12	E223295	Rattlesnake	4	7.9	10.6		
97/11/11	0500239	Arm. Arm	6	9.0	9.8			97/11/12	E223295	Rattlesnake	6	7.9	10.6		
97/11/11	0500239	Arm. Arm	8	9.0	9.8			97/11/12	E223295	Rattlesnake	8	7.9	10.6		
97/11/11	0500239	Arm. Arm	10	9.0	9.8			97/11/12	E223295	Rattlesnake	10	7.9	10.6		
97/11/11	0500239	Arm. Arm	12	9.0	9.8			97/11/12	E223295	Rattlesnake	12	7.9	10.5		
97/11/11	0500239	Arm. Arm	14	9.0	9.8			97/11/12	E223295	Rattlesnake	14	7.9	10.5		
97/11/11	0500239	Arm. Arm	16	9.0	9.7			97/11/12	E223295	Rattlesnake	16	7.9	10.5		
97/11/11	0500239	Arm. Arm	18	9.0	9.7			97/11/12	E223295	Rattlesnake	18	7.7	10.6		
97/11/11	0500239	Arm. Arm	20	9.0	9.6			97/11/12	E223295	Rattlesnake	20	7.7	10.6		
97/11/11	0500239	Arm. Arm	24	8.7	9.0			97/11/12	E223295	Rattlesnake	24	7.5	10.6		
97/11/11	0500239	Arm. Arm	28	7.5	1.8			97/11/12	E223295	Rattlesnake	28	7.5	10.6		
97/11/11	0500239	Arm. Arm	32	7.0	1.0			97/11/12	E223295	Rattlesnake	32	7.3	10.6		
97/11/11	0500239	Arm. Arm	36	7.0	0.6			97/11/12	E223295	Rattlesnake	36	7.0	10.5		
97/11/11	0500239	Arm. Arm	40	7.0	0.4			97/11/12	E223295	Rattlesnake	40	6.9	10.4		
97/11/11	0500239	Arm. Arm	44	7.0	0.2			97/11/12	E223295	Rattlesnake	44	6.0	10.5		
97/11/13	E206611	Vern.Out.	0	8.6	10.3	8.0		97/11/12	O500729	S.Squally Pt.	0	8.0	11.0	10.0	
97/11/13	E206611	Vern.Out.	2	8.6	10.3			97/11/12	O500729	S.Squally Pt.	2	8.0	10.6		
97/11/13	E206611	Vern.Out.	4	8.6	10.3			97/11/12	O500729	S.Squally Pt.	4	8.0	10.5		
97/11/13	E206611	Vern.Out.	6	8.7	10.2			97/11/12	O500729	S.Squally Pt.	6	8.0	10.5		
97/11/13	E206611	Vern.Out.	8	8.7	10.2			97/11/12	O500729	S.Squally Pt.	8	8.0	10.4		
97/11/13	E206611	Vern.Out.	10	8.6	10.2			97/11/12	O500729	S.Squally Pt.	10	8.0	10.4		
97/11/13	E206611	Vern.Out.	12	8.6	10.1			97/11/12	O500729	S.Squally Pt.	12	8.0	10.4		
97/11/13	E206611	Vern.Out.	14	8.6	10.1			97/11/12	O500729	S.Squally Pt.	14	8.0	10.4		
97/11/13	E206611	Vern.Out.	16	8.6	10.1			97/11/12	O500729	S.Squally Pt.	16	8.0	10.4		
97/11/13	E206611	Vern.Out.	18	8.6	10.1			97/11/12	O500729	S.Squally Pt.	18	8.0	10.3		
97/11/13	E206611	Vern.Out.	20	8.0	9.9			97/11/12	O500729	S.Squally Pt.	20	8.0	10.3		
97/11/13	E206611	Vern.Out.	24	7.2	9.9			97/11/12	O500729	S.Squally Pt.	24	8.0	10.4		
97/11/13	E206611	Vern.Out.	28	6.4	10.1			97/11/12	O500729	S.Squally Pt.	28	8.0	10.4		
97/11/13	E206611	Vern.Out.	32	6.1	10.0			97/11/12	O500729	S.Squally Pt.	32	7.8	10.3		
97/11/13	E206611	Vern.Out.	36	5.6	10.1			97/11/12	O500729	S.Squally Pt.	36	7.5	10.4		
97/11/13	E206611	Vern.Out.	40	5.6	10.1			97/11/12	O500729	S.Squally Pt.	40	6.8	10.4		
97/11/13	E206611	Vern.Out.	44	5.4	10.2			97/11/12	O500729	S.Squally Pt.	44	6.2	10.4		

97/11/11	O500730	N.OK.Centre	0	9.3	11.2	8.0		97/11/06	O500454	S.Prairie Cr.	0	7.8	11.2	9.5	
97/11/11	O500730	N.OK.Centre	2	9.5	11.0			97/11/06	O500454	S.Prairie Cr.	2	7.8	11.2		
97/11/11	O500730	N.OK.Centre	4	9.5	10.9			97/11/06	O500454	S.Prairie Cr.	4	7.8	11.2		
97/11/11	O500730	N.OK.Centre	6	9.5	10.8			97/11/06	O500454	S.Prairie Cr.	6	7.5	11.2		
97/11/11	O500730	N.OK.Centre	8	9.5	10.8			97/11/06	O500454	S.Prairie Cr.	8	7.5	11.2		
97/11/11	O500730	N.OK.Centre	10	9.5	10.8			97/11/06	O500454	S.Prairie Cr.	10	7.5	11.2		
97/11/11	O500730	N.OK.Centre	12	9.5	10.8			97/11/06	O500454	S.Prairie Cr.	12	7.5	11.1		
97/11/11	O500730	N.OK.Centre	14	9.5	10.8			97/11/06	O500454	S.Prairie Cr.	14	7.5	11.1		
97/11/11	O500730	N.OK.Centre	16	9.5	10.8			97/11/06	O500454	S.Prairie Cr.	16	7.5	11.2		
97/11/11	O500730	N.OK.Centre	18	9.5	10.8			97/11/06	O500454	S.Prairie Cr.	18	7.5	11.1		
97/11/11	O500730	N.OK.Centre	20	9.3	10.8			97/11/06	O500454	S.Prairie Cr.	20	7.5	11.1		
97/11/11	O500730	N.OK.Centre	24	8.7	10.7			97/11/06	O500454	S.Prairie Cr.	24	7.1	11.0		
97/11/11	O500730	N.OK.Centre	28	6.8	10.7			97/11/06	O500454	S.Prairie Cr.	28	7.0	11.0		
97/11/11	O500730	N.OK.Centre	32	6.1	10.7			97/11/06	O500454	S.Prairie Cr.	32	6.3	11.3		
97/11/11	O500730	N.OK.Centre	36	5.8	10.8			97/11/06	O500454	S.Prairie Cr.	36	6.1	11.2		
97/11/11	O500730	N.OK.Centre	40	5.2	10.8			97/11/06	O500454	S.Prairie Cr.	40	5.9	11.2		
97/11/11	O500730	N.OK.Centre	44	5.0	11.1			97/11/06	O500454	S.Prairie Cr.	44	5.8	11.2		
December 1997															
Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth		Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth	
			(m)	(C)	(mg/L)	(m)					(m)	(C)	(mg/L)	(m)	
97/12/07	0500246	Kala. S.E.	0	5.9	11.2	8.0		97/12/06	O500456	UPS Kel.STP	0	7.0	11.0	11.5	
97/12/07	0500246	Kala. S.E.	2	5.9	11.0			97/12/06	O500456	UPS Kel.STP	2	7.0	11.0		
97/12/07	0500246	Kala. S.E.	4	6.0	11.0			97/12/06	O500456	UPS Kel.STP	4	7.0	11.0		
97/12/07	0500246	Kala. S.E.	6	6.0	11.0			97/12/06	O500456	UPS Kel.STP	6	7.0	11.0		
97/12/07	0500246	Kala. S.E.	8	6.0	11.0			97/12/06	O500456	UPS Kel.STP	8	7.0	11.0		
97/12/07	0500246	Kala. S.E.	10	6.0	11.0			97/12/06	O500456	UPS Kel.STP	10	7.0	11.0		
97/12/07	0500246	Kala. S.E.	12	6.0	10.8			97/12/06	O500456	UPS Kel.STP	12	7.0	11.0		
97/12/07	0500246	Kala. S.E.	14	6.0	10.8			97/12/06	O500456	UPS Kel.STP	14	7.0	11.0		
97/12/07	0500246	Kala. S.E.	16	6.0	10.8			97/12/06	O500456	UPS Kel.STP	16	7.0	11.0		
97/12/07	0500246	Kala. S.E.	18	6.0	10.8			97/12/06	O500456	UPS Kel.STP	18	7.0	11.0		
97/12/07	0500246	Kala. S.E.	20	6.0	10.8			97/12/06	O500456	UPS Kel.STP	20	7.0	11.0		
97/12/07	0500246	Kala. S.E.	24	6.0	10.8			97/12/06	O500456	UPS Kel.STP	24	7.0	11.0		
97/12/07	0500246	Kala. S.E.	28	6.0	10.8			97/12/06	O500456	UPS Kel.STP	28	7.0	11.0		
97/12/07	0500246	Kala. S.E.	32	6.0	10.8			97/12/06	O500456	UPS Kel.STP	32	7.0	11.0		
97/12/07	0500246	Kala. S.E.	36	6.0	10.7			97/12/06	O500456	UPS Kel.STP	36	7.0	11.0		
97/12/07	0500246	Kala. S.E.	40	5.9	10.6			97/12/06	O500456	UPS Kel.STP	40	7.0	11.0		
97/12/07	0500246	Kala. S.E.	44	4.9	9.8			97/12/06	O500456	UPS Kel.STP	44	7.0	10.8		
97/12/07	0500847	Kala. D.B.	0	6.0	11.0	7.5		97/12/04	O500236	DNS Kel.STP	0	6.8	11.8	10.5	
97/12/07	0500847	Kala. D.B.	2	6.0	10.8			97/12/04	O500236	DNS Kel.STP	2	6.8	11.8		
97/12/07	0500847	Kala. D.B.	4	6.0	10.8			97/12/04	O500236	DNS Kel.STP	4	6.8	11.8		
97/12/07	0500847	Kala. D.B.	6	6.0	10.8			97/12/04	O500236	DNS Kel.STP	6	6.8	11.8		
97/12/07	0500847	Kala. D.B.	8	6.0	10.8			97/12/04	O500236	DNS Kel.STP	8	6.8	11.8		
97/12/07	0500847	Kala. D.B.	10	6.0	10.7			97/12/04	O500236	DNS Kel.STP	10	6.8	11.8		
97/12/07	0500847	Kala. D.B.	12	6.0	10.7			97/12/04	O500236	DNS Kel.STP	12	6.8	11.7		
97/12/07	0500847	Kala. D.B.	14	6.0	10.7			97/12/04	O500236	DNS Kel.STP	14	6.8	11.7		
97/12/07	0500847	Kala. D.B.	16	6.0	10.6			97/12/04	O500236	DNS Kel.STP	16	6.8	11.7		
97/12/07	0500847	Kala. D.B.	18	6.0	10.6			97/12/04	O500236	DNS Kel.STP	18	6.8	11.6		
97/12/07	0500847	Kala. D.B.	20	6.0	10.6			97/12/04	O500236	DNS Kel.STP	20	6.8	11.6		
97/12/07	0500847	Kala. D.B.	24	6.0	10.6			97/12/04	O500236	DNS Kel.STP	24	6.8	11.6		
97/12/07	0500847	Kala. D.B.	28	6.0	10.6			97/12/04	O500236	DNS Kel.STP	28	6.8	11.6		
97/12/07	0500847	Kala. D.B.	32	6.0	10.6			97/12/04	O500236	DNS Kel.STP	32	6.8	11.6		
97/12/07	0500847	Kala. D.B.	36	5.0	10.2			97/12/04	O500236	DNS Kel.STP	36	6.8	11.6		
97/12/07	0500847	Kala. D.B.	40	4.9	9.8			97/12/04	O500236	DNS Kel.STP	40	6.8	11.6		
97/12/07	0500847	Kala. D.B.	44	4.8	9.4			97/12/04	O500236	DNS Kel.STP	44	6.5	11.2		
97/12/06	0500239	Arm. Arm	0	5.9	10.4	5.0		97/12/04	E223295	Rattlesnake	0	6.8	11.6	10.8	
97/12/06	0500239	Arm. Arm	2	5.9	10.3			97/12/04	E223295	Rattlesnake	2	6.8	11.5		
97/12/06	0500239	Arm. Arm	4	5.9	10.2			97/12/04	E223295	Rattlesnake	4	6.8	11.4		
97/12/06	0500239	Arm. Arm	6	5.9	10.2			97/12/04	E223295	Rattlesnake	6	6.8	11.4		
97/12/06	0500239	Arm. Arm	8	5.9	10.2			97/12/04	E223295	Rattlesnake	8	6.8	11.4		
97/12/06	0500239	Arm. Arm	10	5.9	10.2			97/12/04	E223295	Rattlesnake	10	6.8	11.4		
97/12/06	0500239	Arm. Arm	12	5.9	10.2			97/12/04	E223295	Rattlesnake	12	6.8	11.3		
97/12/06	0500239	Arm. Arm	14	5.9	10.2			97/12/04	E223295	Rattlesnake	14	6.8	11.3		
97/12/06	0500239	Arm. Arm	16	5.9	10.2			97/12/04	E223295	Rattlesnake	16	6.8	11.3		
97/12/06	0500239	Arm. Arm	18	5.9	10.2			97/12/04	E223295	Rattlesnake	18	6.8	11.3		
97/12/06	0500239	Arm. Arm	20	5.9	10.2			97/12/04	E223295	Rattlesnake	20	6.8	11.2		
97/12/06	0500239	Arm. Arm	24	5.9	10.1			97/12/04	E223295	Rattlesnake	24	6.8	11.2		
97/12/06	0500239	Arm. Arm	28	5.9	10.1			97/12/04	E223295	Rattlesnake	28	6.8	11.2		
97/12/06	0500239	Arm. Arm	32	5.9	10.1			97/12/04	E223295	Rattlesnake	32	6.8	11.2		
97/12/06	0500239	Arm. Arm	36	5.9	10.1			97/12/04	E223295	Rattlesnake	36	6.8	11.2		
97/12/06	0500239	Arm. Arm	40	5.8	10.0			97/12/04	E223295	Rattlesnake	40	6.8	11.2		
97/12/06	0500239	Arm. Arm	44	5.8	2.2			97/12/04	E223295	Rattlesnake	44	6.8	11.2		

97/12/06	E206611	Vern.Out.	0	6.0	11.5	9.5		97/12/09	O500729	S.Squally Pt.	0	6.0	11.2	11.0	
97/12/06	E206611	Vern.Out.	2	6.0	11.4			97/12/09	O500729	S.Squally Pt.	2	6.0	11.2		
97/12/06	E206611	Vern.Out.	4	6.2	11.4			97/12/09	O500729	S.Squally Pt.	4	6.0	11.0		
97/12/06	E206611	Vern.Out.	6	6.9	11.4			97/12/09	O500729	S.Squally Pt.	6	6.0	11.0		
97/12/06	E206611	Vern.Out.	8	6.5	11.3			97/12/09	O500729	S.Squally Pt.	8	6.0	11.0		
97/12/06	E206611	Vern.Out.	10	6.5	11.4			97/12/09	O500729	S.Squally Pt.	10	6.0	11.0		
97/12/06	E206611	Vern.Out.	12	6.5	11.4			97/12/09	O500729	S.Squally Pt.	12	5.8	11.0		
97/12/06	E206611	Vern.Out.	14	6.4	11.4			97/12/09	O500729	S.Squally Pt.	14	5.8	11.0		
97/12/06	E206611	Vern.Out.	16	6.5	11.3			97/12/09	O500729	S.Squally Pt.	16	5.8	11.0		
97/12/06	E206611	Vern.Out.	18	6.5	11.3			97/12/09	O500729	S.Squally Pt.	18	5.8	11.0		
97/12/06	E206611	Vern.Out.	20	6.5	11.3			97/12/09	O500729	S.Squally Pt.	20	5.8	11.0		
97/12/06	E206611	Vern.Out.	24	6.5	11.2			97/12/09	O500729	S.Squally Pt.	24	5.5	11.0		
97/12/06	E206611	Vern.Out.	28	6.5	11.2			97/12/09	O500729	S.Squally Pt.	28	5.5	11.0		
97/12/06	E206611	Vern.Out.	32	6.4	11.2			97/12/09	O500729	S.Squally Pt.	32	5.5	11.0		
97/12/06	E206611	Vern.Out.	36	6.5	11.2			97/12/09	O500729	S.Squally Pt.	36	5.5	11.0		
97/12/06	E206611	Vern.Out.	40	6.5	11.2			97/12/09	O500729	S.Squally Pt.	40	5.5	11.0		
97/12/06	E206611	Vern.Out.	44	6.4	11.2			97/12/09	O500729	S.Squally Pt.	44	5.5	11.0		
97/12/06	O500730	N.OK.Centre	0	7.0	10.8	10.5		97/12/09	O500454	S.Prairie Cr.	0			11.0	
97/12/06	O500730	N.OK.Centre	2	7.0	10.8			97/12/09	O500454	S.Prairie Cr.	2				
97/12/06	O500730	N.OK.Centre	4	7.0	10.8			97/12/09	O500454	S.Prairie Cr.	4				
97/12/06	O500730	N.OK.Centre	6	7.0	10.8			97/12/09	O500454	S.Prairie Cr.	6				
97/12/06	O500730	N.OK.Centre	8	7.0	10.8			97/12/09	O500454	S.Prairie Cr.	8				
97/12/06	O500730	N.OK.Centre	10	7.0	10.8			97/12/09	O500454	S.Prairie Cr.	10				
97/12/06	O500730	N.OK.Centre	12	7.0	10.8			97/12/09	O500454	S.Prairie Cr.	12				
97/12/06	O500730	N.OK.Centre	14	7.0	10.8			97/12/09	O500454	S.Prairie Cr.	14				
97/12/06	O500730	N.OK.Centre	16	7.0	10.8			97/12/09	O500454	S.Prairie Cr.	16				
97/12/06	O500730	N.OK.Centre	18	7.0	10.8			97/12/09	O500454	S.Prairie Cr.	18				
97/12/06	O500730	N.OK.Centre	20	7.0	10.8			97/12/09	O500454	S.Prairie Cr.	20				
97/12/06	O500730	N.OK.Centre	24	7.0	10.8			97/12/09	O500454	S.Prairie Cr.	24				
97/12/06	O500730	N.OK.Centre	28	7.0	10.8			97/12/09	O500454	S.Prairie Cr.	28				
97/12/06	O500730	N.OK.Centre	32	7.0	10.8			97/12/09	O500454	S.Prairie Cr.	32				
97/12/06	O500730	N.OK.Centre	36	7.0	10.8			97/12/09	O500454	S.Prairie Cr.	36				
97/12/06	O500730	N.OK.Centre	40	6.0	10.8			97/12/09	O500454	S.Prairie Cr.	40				
97/12/06	O500730	N.OK.Centre	44	5.5	10.5			97/12/09	O500454	S.Prairie Cr.	44				
Date	Station No.	Location	Depth	Temp.	D.O.	Secchi		Date	Station No.	Location	Depth	Temp.	D.O.	Secchi	
			(m)	(C)	(mg/L)	(m)					(m)	(C)	(mg/L)	(m)	
98/02/03	E206611	Vern.Out.	0	4.0	11.5	12.8		98/02/03	0500730	N.OK.Centre	0	4.6	11.2	13.0	
98/02/03	E206611	Vern.Out.	2	4.0	11.5			98/02/03	0500730	N.OK.Centre	2	4.5	10.8		
98/02/03	E206611	Vern.Out.	4	4.0	11.6			98/02/03	0500730	N.OK.Centre	4	4.5	11.2		
98/02/03	E206611	Vern.Out.	6	4.0	11.6			98/02/03	0500730	N.OK.Centre	6	4.5	11.2		
98/02/03	E206611	Vern.Out.	8	4.0	11.6			98/02/03	0500730	N.OK.Centre	8	4.5	11.2		
98/02/03	E206611	Vern.Out.	10	4.0	11.6			98/02/03	0500730	N.OK.Centre	10	4.0	11.4		
98/02/03	E206611	Vern.Out.	12	4.0	11.6			98/02/03	0500730	N.OK.Centre	12	4.0	11.4		
98/02/03	E206611	Vern.Out.	14	4.0	11.6			98/02/03	0500730	N.OK.Centre	14	4.0	11.4		
98/02/03	E206611	Vern.Out.	16	4.0	11.6			98/02/03	0500730	N.OK.Centre	16	4.0	11.4		
98/02/03	E206611	Vern.Out.	18	4.0	11.6			98/02/03	0500730	N.OK.Centre	18	4.0	11.4		
98/02/03	E206611	Vern.Out.	20	4.0	11.6			98/02/03	0500730	N.OK.Centre	20	4.0	11.4		
98/02/03	E206611	Vern.Out.	24	4.0	11.6			98/02/03	0500730	N.OK.Centre	24	4.0	11.4		
98/02/03	E206611	Vern.Out.	28	4.0	11.6			98/02/03	0500730	N.OK.Centre	28	4.0	11.4		
98/02/03	E206611	Vern.Out.	32	4.0	11.6			98/02/03	0500730	N.OK.Centre	32	4.0	11.4		
98/02/03	E206611	Vern.Out.	36	4.0	11.6			98/02/03	0500730	N.OK.Centre	36	4.0	11.4		
98/02/03	E206611	Vern.Out.	40	4.0	11.4			98/02/03	0500730	N.OK.Centre	40	4.0	11.4		
98/02/03	E206611	Vern.Out.	44	4.0	11.4			98/02/03	0500730	N.OK.Centre	44	4.0	11.4		
98/02/05	0500456	UPS Kel.STP	0	4.2	11.6	12.5		98/02/02	0500236	DNS Kel.STP	0	5.0	11.4	11.5	
98/02/05	0500456	UPS Kel.STP	2	4.0	11.6			98/02/02	0500236	DNS Kel.STP	2	4.3	11.8		
98/02/05	0500456	UPS Kel.STP	4	4.0	11.6			98/02/02	0500236	DNS Kel.STP	4	4.0	12.1		
98/02/05	0500456	UPS Kel.STP	6	4.0	11.6			98/02/02	0500236	DNS Kel.STP	6	4.0	12.0		
98/02/05	0500456	UPS Kel.STP	8	4.0	11.6			98/02/02	0500236	DNS Kel.STP	8	4.0	12.0		
98/02/05	0500456	UPS Kel.STP	10	4.0	11.6			98/02/02	0500236	DNS Kel.STP	10	4.0	12.0		
98/02/05	0500456	UPS Kel.STP	12	4.0	11.6			98/02/02	0500236	DNS Kel.STP	12	4.0	12.0		
98/02/05	0500456	UPS Kel.STP	14	4.0	11.6			98/02/02	0500236	DNS Kel.STP	14	4.0	12.0		
98/02/05	0500456	UPS Kel.STP	16	4.0	11.6			98/02/02	0500236	DNS Kel.STP	16	4.0	12.0		
98/02/05	0500456	UPS Kel.STP	18	4.0	11.6			98/02/02	0500236	DNS Kel.STP	18	4.0	12.0		
98/02/05	0500456	UPS Kel.STP	20	4.0	11.6			98/02/02	0500236	DNS Kel.STP	20	4.0	12.0		
98/02/05	0500456	UPS Kel.STP	24	4.0	11.5			98/02/02	0500236	DNS Kel.STP	24	4.0	12.0		
98/02/05	0500456	UPS Kel.STP	28	4.0	11.5			98/02/02	0500236	DNS Kel.STP	28	4.0	12.0		
98/02/05	0500456	UPS Kel.STP	32	4.0	11.5			98/02/02	0500236	DNS Kel.STP	32	4.0	12.0		
98/02/05	0500456	UPS Kel.STP	36	4.0	11.5			98/02/02	0500236	DNS Kel.STP	36	4.0	12.0		
98/02/05	0500456	UPS Kel.STP	40	4.0	11.4			98/02/02	0500236	DNS Kel.STP	40	4.0	12.0		
98/02/05	0500456	UPS Kel.STP	44	4.0	11.4			98/02/02	0500236	DNS Kel.STP	44	4.0	12.0		

98/02/09	E223295	Rattlesnake	0	4.5	11.5	11.8		98/02/09	050729	S.Squally Pt.	0	4.5	11.8	11.5	
98/02/09	E223295	Rattlesnake	2	4.0	11.9			98/02/09	050729	S.Squally Pt.	2	4.0	12.1		
98/02/09	E223295	Rattlesnake	4	4.0	12.0			98/02/09	050729	S.Squally Pt.	4	3.8	12.3		
98/02/09	E223295	Rattlesnake	6	4.0	12.0			98/02/09	050729	S.Squally Pt.	6	3.8	12.3		
98/02/09	E223295	Rattlesnake	8	4.0	12.0			98/02/09	050729	S.Squally Pt.	8	3.8	12.3		
98/02/09	E223295	Rattlesnake	10	4.0	12.0			98/02/09	050729	S.Squally Pt.	10	3.8	12.3		
98/02/09	E223295	Rattlesnake	12	3.9	12.0			98/02/09	050729	S.Squally Pt.	12	3.8	12.3		
98/02/09	E223295	Rattlesnake	14	3.9	12.0			98/02/09	050729	S.Squally Pt.	14	3.8	12.3		
98/02/09	E223295	Rattlesnake	16	3.9	12.0			98/02/09	050729	S.Squally Pt.	16	3.8	12.3		
98/02/09	E223295	Rattlesnake	18	3.9	12.0			98/02/09	050729	S.Squally Pt.	18	3.8	12.3		
98/02/09	E223295	Rattlesnake	20	3.9	12.0			98/02/09	050729	S.Squally Pt.	20	3.8	12.3		
98/02/09	E223295	Rattlesnake	24	3.9	12.0			98/02/09	050729	S.Squally Pt.	24	3.8	12.3		
98/02/09	E223295	Rattlesnake	28	3.9	12.0			98/02/09	050729	S.Squally Pt.	28	3.8	12.3		
98/02/09	E223295	Rattlesnake	32	3.9	12.0			98/02/09	050729	S.Squally Pt.	32	3.8	12.3		
98/02/09	E223295	Rattlesnake	36	3.9	12.0			98/02/09	050729	S.Squally Pt.	36	3.8	12.2		
98/02/09	E223295	Rattlesnake	40	3.9	12.0			98/02/09	050729	S.Squally Pt.	40	3.8	12.2		
98/02/09	E223295	Rattlesnake	44	3.9	12.0			98/02/09	050729	S.Squally Pt.	44	3.8	12.2		
98/02/09	0500454	S.Prairie Cr.	0	5.0	12.4	11.8									
98/02/09	0500454	S.Prairie Cr.	2	4.0	12.6										
98/02/09	0500454	S.Prairie Cr.	4	3.8	12.6										
98/02/09	0500454	S.Prairie Cr.	6	3.8	12.6										
98/02/09	0500454	S.Prairie Cr.	8	3.8	12.6										
98/02/09	0500454	S.Prairie Cr.	10	3.8	12.6										
98/02/09	0500454	S.Prairie Cr.	12	3.8	12.6										
98/02/09	0500454	S.Prairie Cr.	14	3.8	12.6										
98/02/09	0500454	S.Prairie Cr.	16	3.8	12.6										
98/02/09	0500454	S.Prairie Cr.	18	3.8	12.6										
98/02/09	0500454	S.Prairie Cr.	20	3.8	12.6										
98/02/09	0500454	S.Prairie Cr.	24	3.8	12.6										
98/02/09	0500454	S.Prairie Cr.	28	3.8	12.6										
98/02/09	0500454	S.Prairie Cr.	32	3.8	12.8										
98/02/09	0500454	S.Prairie Cr.	36	3.8	12.8										
98/02/09	0500454	S.Prairie Cr.	40	3.8	12.8										
98/02/09	0500454	S.Prairie Cr.	44	3.8	12.8										
February															
Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth		Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth	
			(m)	(C)	(mg/L)	(m)					(m)	(C)	(mg/L)	(m)	
98/02/23	0500246	Kala. S.E.	0	4.2	10.9	9.5		98/02/23	0500847	Kala. D.B.	0	4.0	11.0	11.5	
98/02/23	0500246	Kala. S.E.	2	3.8	11.3			98/02/23	0500847	Kala. D.B.	2	3.6	11.2		
98/02/23	0500246	Kala. S.E.	4	3.8	11.2			98/02/23	0500847	Kala. D.B.	4	3.6	11.3		
98/02/23	0500246	Kala. S.E.	6	3.8	11.2			98/02/23	0500847	Kala. D.B.	6	3.6	11.2		
98/02/23	0500246	Kala. S.E.	8	3.8	11.2			98/02/23	0500847	Kala. D.B.	8	3.6	11.2		
98/02/23	0500246	Kala. S.E.	10	3.8	11.2			98/02/23	0500847	Kala. D.B.	10	3.6	11.2		
98/02/23	0500246	Kala. S.E.	12	3.8	11.3			98/02/23	0500847	Kala. D.B.	12	3.6	11.2		
98/02/23	0500246	Kala. S.E.	14	3.8	11.3			98/02/23	0500847	Kala. D.B.	14	3.6	11.0		
98/02/23	0500246	Kala. S.E.	16	3.8	11.2			98/02/23	0500847	Kala. D.B.	16	3.6	11.1		
98/02/23	0500246	Kala. S.E.	18	3.8	11.2			98/02/23	0500847	Kala. D.B.	18	3.6	11.1		
98/02/23	0500246	Kala. S.E.	20	3.8	11.2			98/02/23	0500847	Kala. D.B.	20	3.6	11.0		
98/02/23	0500246	Kala. S.E.	24	3.8	11.2			98/02/23	0500847	Kala. D.B.	24	3.6	11.1		
98/02/23	0500246	Kala. S.E.	28	3.8	11.2			98/02/23	0500847	Kala. D.B.	28	3.6	11.2		
98/02/23	0500246	Kala. S.E.	32	3.8	11.2			98/02/23	0500847	Kala. D.B.	32	3.6	11.1		
98/02/23	0500246	Kala. S.E.	36	3.8	11.2			98/02/23	0500847	Kala. D.B.	36	3.6	11.0		
98/02/23	0500246	Kala. S.E.	40	3.8	11.2			98/02/23	0500847	Kala. D.B.	40	3.6	11.0		
98/02/23	0500246	Kala. S.E.	44	3.8	11.0			98/02/23	0500847	Kala. D.B.	44	3.6	11.0		
98/03/11	E206611	Vern.Out.	0	5.1	11.4	9.5		98/03/12	0500730	N.OK.Centre	0	4.8	11.8	13.2	
98/03/11	E206611	Vern.Out.	2	4.9	11.4			98/03/12	0500730	N.OK.Centre	2	4.3	12.0		
98/03/11	E206611	Vern.Out.	4	4.2	11.8			98/03/12	0500730	N.OK.Centre	4	4.3	12.0		
98/03/11	E206611	Vern.Out.	6	4.0	11.9			98/03/12	0500730	N.OK.Centre	6	4.1	12.0		
98/03/11	E206611	Vern.Out.	8	4.0	11.9			98/03/12	0500730	N.OK.Centre	8	4.1	12.1		
98/03/11	E206611	Vern.Out.	10	4.0	11.9			98/03/12	0500730	N.OK.Centre	10	4.1	12.1		
98/03/11	E206611	Vern.Out.	12	4.0	11.9			98/03/12	0500730	N.OK.Centre	12	4.1	12.0		
98/03/11	E206611	Vern.Out.	14	4.0	11.8			98/03/12	0500730	N.OK.Centre	14	4.1	12.0		
98/03/11	E206611	Vern.Out.	16	4.0	11.8			98/03/12	0500730	N.OK.Centre	16	4.0	12.0		
98/03/11	E206611	Vern.Out.	18	4.0	11.8			98/03/12	0500730	N.OK.Centre	18	4.0	12.0		
98/03/11	E206611	Vern.Out.	20	4.0	11.8			98/03/12	0500730	N.OK.Centre	20	4.0	12.0		
98/03/11	E206611	Vern.Out.	24	4.0	11.7			98/03/12	0500730	N.OK.Centre	24	4.0	12.1		
98/03/11	E206611	Vern.Out.	28	4.0	11.7			98/03/12	0500730	N.OK.Centre	28	4.0	12.1		
98/03/11	E206611	Vern.Out.	32	4.0	11.7			98/03/12	0500730	N.OK.Centre	32	4.0	12.0		
98/03/11	E206611	Vern.Out.	36	4.0	11.6			98/03/12	0500730	N.OK.Centre	36	4.0	12.0		
98/03/11	E206611	Vern.Out.	40	4.0	11.6			98/03/12	0500730	N.OK.Centre	40	4.0	12.0		
98/03/11	E206611	Vern.Out.	44	4.0	11.6			98/03/12	0500730	N.OK.Centre	44	4.0	12.0		

98/03/09	0500456	UPS Kel.STP	0	5.0	11.2	13.0		98/03/09	0500236	DNS Kel.STP	0	4.6	11.9	10.0	
98/03/09	0500456	UPS Kel.STP	2	4.5	11.5			98/03/09	0500236	DNS Kel.STP	2	4.3	12.0		
98/03/09	0500456	UPS Kel.STP	4	4.3	11.6			98/03/09	0500236	DNS Kel.STP	4	4.1	12.2		
98/03/09	0500456	UPS Kel.STP	6	4.3	11.6			98/03/09	0500236	DNS Kel.STP	6	4.1	12.2		
98/03/09	0500456	UPS Kel.STP	8	4.3	11.6			98/03/09	0500236	DNS Kel.STP	8	4.1	12.2		
98/03/09	0500456	UPS Kel.STP	10	4.3	11.6			98/03/09	0500236	DNS Kel.STP	10	4.1	12.2		
98/03/09	0500456	UPS Kel.STP	12	4.3	11.6			98/03/09	0500236	DNS Kel.STP	12	4.1	12.2		
98/03/09	0500456	UPS Kel.STP	14	4.3	11.6			98/03/09	0500236	DNS Kel.STP	14	4.1	12.2		
98/03/09	0500456	UPS Kel.STP	16	4.3	11.6			98/03/09	0500236	DNS Kel.STP	16	4.1	12.2		
98/03/09	0500456	UPS Kel.STP	18	4.3	11.6			98/03/09	0500236	DNS Kel.STP	18	4.1	12.2		
98/03/09	0500456	UPS Kel.STP	20	4.3	11.6			98/03/09	0500236	DNS Kel.STP	20	4.1	12.2		
98/03/09	0500456	UPS Kel.STP	24	4.3	11.5			98/03/09	0500236	DNS Kel.STP	24	4.1	12.2		
98/03/09	0500456	UPS Kel.STP	28	4.3	11.5			98/03/09	0500236	DNS Kel.STP	28	4.1	12.2		
98/03/09	0500456	UPS Kel.STP	32	4.3	11.5			98/03/09	0500236	DNS Kel.STP	32	4.1	12.1		
98/03/09	0500456	UPS Kel.STP	36	4.3	11.5			98/03/09	0500236	DNS Kel.STP	36	4.1	12.1		
98/03/09	0500456	UPS Kel.STP	40	4.3	11.5			98/03/09	0500236	DNS Kel.STP	40	4.1	12.1		
98/03/09	0500456	UPS Kel.STP	44	4.3	11.5			98/03/09	0500236	DNS Kel.STP	44	4.1	12.1		
98/03/10	E223295	Rattlesnake	0	4.5	11.2	13.5		98/03/10	0500729	S.Squally Pt.	0	4.3	11.7	12.0	
98/03/10	E223295	Rattlesnake	2	4.0	11.4			98/03/10	0500729	S.Squally Pt.	2	4.0	11.9		
98/03/10	E223295	Rattlesnake	4	4.0	11.4			98/03/10	0500729	S.Squally Pt.	4	4.0	11.9		
98/03/10	E223295	Rattlesnake	6	4.0	11.4			98/03/10	0500729	S.Squally Pt.	6	4.0	11.9		
98/03/10	E223295	Rattlesnake	8	4.0	11.4			98/03/10	0500729	S.Squally Pt.	8	4.0	12.0		
98/03/10	E223295	Rattlesnake	10	4.0	11.4			98/03/10	0500729	S.Squally Pt.	10	4.0	12.0		
98/03/10	E223295	Rattlesnake	12	4.0	11.4			98/03/10	0500729	S.Squally Pt.	12	4.0	12.0		
98/03/10	E223295	Rattlesnake	14	4.0	11.4			98/03/10	0500729	S.Squally Pt.	14	4.0	12.0		
98/03/10	E223295	Rattlesnake	16	4.0	11.4			98/03/10	0500729	S.Squally Pt.	16	4.0	12.0		
98/03/10	E223295	Rattlesnake	18	4.0	11.4			98/03/10	0500729	S.Squally Pt.	18	3.9	12.0		
98/03/10	E223295	Rattlesnake	20	4.0	11.4			98/03/10	0500729	S.Squally Pt.	20	3.9	12.0		
98/03/10	E223295	Rattlesnake	24	3.8	11.4			98/03/10	0500729	S.Squally Pt.	24	3.9	12.0		
98/03/10	E223295	Rattlesnake	28	3.8	11.3			98/03/10	0500729	S.Squally Pt.	28	3.9	11.9		
98/03/10	E223295	Rattlesnake	32	3.8	11.3			98/03/10	0500729	S.Squally Pt.	32	3.9	11.9		
98/03/10	E223295	Rattlesnake	36	3.8	11.3			98/03/10	0500729	S.Squally Pt.	36	3.9	11.9		
98/03/10	E223295	Rattlesnake	40	3.8	11.3			98/03/10	0500729	S.Squally Pt.	40	3.9	11.9		
98/03/10	E223295	Rattlesnake	44	3.0	11.5			98/03/10	0500729	S.Squally Pt.	44	3.9	11.9		
98/03/10	0500454	S.Prairie Cr.	0	4.3	12.0	10.5									
98/03/10	0500454	S.Prairie Cr.	2	4.0	12.2										
98/03/10	0500454	S.Prairie Cr.	4	4.0	12.3										
98/03/10	0500454	S.Prairie Cr.	6	3.9	12.2										
98/03/10	0500454	S.Prairie Cr.	8	3.9	12.2										
98/03/10	0500454	S.Prairie Cr.	10	3.9	12.2										
98/03/10	0500454	S.Prairie Cr.	12	3.9	12.2										
98/03/10	0500454	S.Prairie Cr.	14	3.9	12.2										
98/03/10	0500454	S.Prairie Cr.	16	3.9	12.2										
98/03/10	0500454	S.Prairie Cr.	18	3.9	12.2										
98/03/10	0500454	S.Prairie Cr.	20	3.8	12.2										
98/03/10	0500454	S.Prairie Cr.	24	3.8	12.2										
98/03/10	0500454	S.Prairie Cr.	28	3.8	12.2										
98/03/10	0500454	S.Prairie Cr.	32	3.8	12.2										
98/03/10	0500454	S.Prairie Cr.	36	3.8	12.2										
98/03/10	0500454	S.Prairie Cr.	40	3.8	12.2										
98/03/10	0500454	S.Prairie Cr.	44	3.8	12.2										
March															
Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth		Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth	
			(m)	(C)	(mg/L)	(m)					(m)	(C)	(mg/L)	(m)	
98/03/23	0500246	Kala. S.E.	0	5.7	12.6	4.5		98/03/23	0500847	Kala. D.B.	0	5.0	12.3	4.5	
98/03/23	0500246	Kala. S.E.	2	5.0	13.0			98/03/23	0500847	Kala. D.B.	2	4.8	12.7		
98/03/23	0500246	Kala. S.E.	4	4.5	12.6			98/03/23	0500847	Kala. D.B.	4	4.5	12.8		
98/03/23	0500246	Kala. S.E.	6	4.3	12.4			98/03/23	0500847	Kala. D.B.	6	4.3	12.6		
98/03/23	0500246	Kala. S.E.	8	4.1	12.2			98/03/23	0500847	Kala. D.B.	8	4.0	12.4		
98/03/23	0500246	Kala. S.E.	10	4.0	11.9			98/03/23	0500847	Kala. D.B.	10	4.0	12.2		
98/03/23	0500246	Kala. S.E.	12	4.0	11.9			98/03/23	0500847	Kala. D.B.	12	4.0	12.0		
98/03/23	0500246	Kala. S.E.	14	4.0	11.9			98/03/23	0500847	Kala. D.B.	14	3.9	11.8		
98/03/23	0500246	Kala. S.E.	16	4.0	11.8			98/03/23	0500847	Kala. D.B.	16	3.9	11.8		
98/03/23	0500246	Kala. S.E.	18	4.0	11.8			98/03/23	0500847	Kala. D.B.	18	3.9	11.7		
98/03/23	0500246	Kala. S.E.	20	4.0	11.7			98/03/23	0500847	Kala. D.B.	20	3.9	11.7		
98/03/23	0500246	Kala. S.E.	24	3.9	11.8			98/03/23	0500847	Kala. D.B.	24	3.9	11.6		
98/03/23	0500246	Kala. S.E.	28	3.9	11.8			98/03/23	0500847	Kala. D.B.	28	3.9	11.6		
98/03/23	0500246	Kala. S.E.	32	3.9	11.7			98/03/23	0500847	Kala. D.B.	32	3.8	11.5		
98/03/23	0500246	Kala. S.E.	36	3.8	11.6			98/03/23	0500847	Kala. D.B.	36	3.8	11.4		
98/03/23	0500246	Kala. S.E.	40	3.8	11.3			98/03/23	0500847	Kala. D.B.	40	3.8	11.5		
98/03/23	0500246	Kala. S.E.	44	3.8	11.6			98/03/23	0500847	Kala. D.B.	44	3.8	11.5		

98/04/02	0500239	Arm. Arm	0	7.0	12.3	2.5			98/04/02	E206611	Vern. Outfall	0	6.9	11.5	6.3	
98/04/02	0500239	Arm. Arm	2	6.8	12.4				98/04/02	E206611	Vern. Outfall	2	6.4	11.7		
98/04/02	0500239	Arm. Arm	4	6.3	12.4				98/04/02	E206611	Vern. Outfall	4	5.5	11.8		
98/04/02	0500239	Arm. Arm	6	6.0	12.4				98/04/02	E206611	Vern. Outfall	6	5.3	11.8		
98/04/02	0500239	Arm. Arm	8	5.5	12.2				98/04/02	E206611	Vern. Outfall	8	5.1	11.8		
98/04/02	0500239	Arm. Arm	10	5.5	11.8				98/04/02	E206611	Vern. Outfall	10	5.1	11.8		
98/04/02	0500239	Arm. Arm	12	5.3	11.7				98/04/02	E206611	Vern. Outfall	12	5.1	11.8		
98/04/02	0500239	Arm. Arm	14	5.3	11.6				98/04/02	E206611	Vern. Outfall	14	5.1	11.8		
98/04/02	0500239	Arm. Arm	16	5.3	11.5				98/04/02	E206611	Vern. Outfall	16	5.1	11.7		
98/04/02	0500239	Arm. Arm	18	5.0	11.4				98/04/02	E206611	Vern. Outfall	18	5.0	11.6		
98/04/02	0500239	Arm. Arm	20	5.0	11.2				98/04/02	E206611	Vern. Outfall	20	5.0	11.5		
98/04/02	0500239	Arm. Arm	24	5.0	10.9				98/04/02	E206611	Vern. Outfall	24	4.8	11.4		
98/04/02	0500239	Arm. Arm	28	4.1	10.6				98/04/02	E206611	Vern. Outfall	28	4.8	11.3		
98/04/02	0500239	Arm. Arm	32	4.0	10.4				98/04/02	E206611	Vern. Outfall	32	4.8	11.1		
98/04/02	0500239	Arm. Arm	36	4.0	10.0				98/04/02	E206611	Vern. Outfall	36	4.8	11.2		
98/04/02	0500239	Arm. Arm	40	4.0	9.9				98/04/02	E206611	Vern. Outfall	40	4.8	11.2		
98/04/02	0500239	Arm. Arm	44	4.0	9.4				98/04/02	E206611	Vern. Outfall	44	4.8	11.2		
98/04/04	0500730	N.OK.Centre	0	6.9	12.6	6.0			98/04/04	0500456	UPS Kel.STP	0	7.2	12.3	6.5	
98/04/04	0500730	N.OK.Centre	2	6.0	12.7				98/04/04	0500456	UPS Kel.STP	2	6.6	12.4		
98/04/04	0500730	N.OK.Centre	4	5.8	12.8				98/04/04	0500456	UPS Kel.STP	4	6.5	12.6		
98/04/04	0500730	N.OK.Centre	6	5.5	12.9				98/04/04	0500456	UPS Kel.STP	6	6.2	12.6		
98/04/04	0500730	N.OK.Centre	8	5.5	12.9				98/04/04	0500456	UPS Kel.STP	8	5.7	12.8		
98/04/04	0500730	N.OK.Centre	10	5.3	12.8				98/04/04	0500456	UPS Kel.STP	10	5.2	12.6		
98/04/04	0500730	N.OK.Centre	12	5.0	12.8				98/04/04	0500456	UPS Kel.STP	12	5.1	12.6		
98/04/04	0500730	N.OK.Centre	14	4.9	12.6				98/04/04	0500456	UPS Kel.STP	14	5.0	12.5		
98/04/04	0500730	N.OK.Centre	16	4.9	12.4				98/04/04	0500456	UPS Kel.STP	16	5.0	12.4		
98/04/04	0500730	N.OK.Centre	18	4.7	12.2				98/04/04	0500456	UPS Kel.STP	18	5.0	12.3		
98/04/04	0500730	N.OK.Centre	20	4.6	12.0				98/04/04	0500456	UPS Kel.STP	20	5.0	12.2		
98/04/04	0500730	N.OK.Centre	24	4.4	11.8				98/04/04	0500456	UPS Kel.STP	24	4.9	12.3		
98/04/04	0500730	N.OK.Centre	28	4.1	11.8				98/04/04	0500456	UPS Kel.STP	28	4.7	12.2		
98/04/04	0500730	N.OK.Centre	32	4.0	11.8				98/04/04	0500456	UPS Kel.STP	32	4.2	11.8		
98/04/04	0500730	N.OK.Centre	36	4.0	11.8				98/04/04	0500456	UPS Kel.STP	36	4.5	11.8		
98/04/04	0500730	N.OK.Centre	40	4.0	11.6				98/04/04	0500456	UPS Kel.STP	40	4.3	11.6		
98/04/04	0500730	N.OK.Centre	44	4.0	11.6				98/04/04	0500456	UPS Kel.STP	44	4.3	11.6		
98/03/31	0500236	DNS Kel. STP	0	6.0	12.2	7.0			98/03/31	E223295	Rattlesnake	0	5.2	12.3	9.0	
98/03/31	0500236	DNS Kel. STP	2	5.5	12.5				98/03/31	E223295	Rattlesnake	2	5.0	12.5		
98/03/31	0500236	DNS Kel. STP	4	5.3	12.6				98/03/31	E223295	Rattlesnake	4	4.9	12.6		
98/03/31	0500236	DNS Kel. STP	6	5.3	12.6				98/03/31	E223295	Rattlesnake	6	4.9	12.6		
98/03/31	0500236	DNS Kel. STP	8	5.3	12.7				98/03/31	E223295	Rattlesnake	8	4.7	12.6		
98/03/31	0500236	DNS Kel. STP	10	5.2	12.7				98/03/31	E223295	Rattlesnake	10	4.7	12.6		
98/03/31	0500236	DNS Kel. STP	12	5.2	12.7				98/03/31	E223295	Rattlesnake	12	4.7	12.6		
98/03/31	0500236	DNS Kel. STP	14	5.2	12.7				98/03/31	E223295	Rattlesnake	14	4.5	12.6		
98/03/31	0500236	DNS Kel. STP	16	5.1	12.6				98/03/31	E223295	Rattlesnake	16	4.5	12.6		
98/03/31	0500236	DNS Kel. STP	18	5.1	12.6				98/03/31	E223295	Rattlesnake	18	4.5	12.6		
98/03/31	0500236	DNS Kel. STP	20	5.0	12.6				98/03/31	E223295	Rattlesnake	20	4.3	12.6		
98/03/31	0500236	DNS Kel. STP	24	5.0	12.6				98/03/31	E223295	Rattlesnake	24	4.3	12.5		
98/03/31	0500236	DNS Kel. STP	28	5.0	12.5				98/03/31	E223295	Rattlesnake	28	4.2	12.4		
98/03/31	0500236	DNS Kel. STP	32	4.9	12.5				98/03/31	E223295	Rattlesnake	32	4.2	12.4		
98/03/31	0500236	DNS Kel. STP	36	4.9	12.5				98/03/31	E223295	Rattlesnake	36	4.1	12.4		
98/03/31	0500236	DNS Kel. STP	40	4.8	12.5				98/03/31	E223295	Rattlesnake	40	4.1	12.4		
98/03/31	0500236	DNS Kel. STP	44	4.5	12.4				98/03/31	E223295	Rattlesnake	44	4.1	12.3		
98/03/31	0500729	S.Squally Pt.	0	5.5	11.9	10.0			98/03/31	0500454	S.Prairie Cr.	0	5.5	12.5	8.0	
98/03/31	0500729	S.Squally Pt.	2	5.0	12.4				98/03/31	0500454	S.Prairie Cr.	2	5.0	12.7		
98/03/31	0500729	S.Squally Pt.	4	4.8	12.4				98/03/31	0500454	S.Prairie Cr.	4	5.0	12.8		
98/03/31	0500729	S.Squally Pt.	6	4.7	12.5				98/03/31	0500454	S.Prairie Cr.	6	5.0	12.8		
98/03/31	0500729	S.Squally Pt.	8	4.7	12.5				98/03/31	0500454	S.Prairie Cr.	8	4.9	12.8		
98/03/31	0500729	S.Squally Pt.	10	4.5	12.6				98/03/31	0500454	S.Prairie Cr.	10	4.9	12.8		
98/03/31	0500729	S.Squally Pt.	12	4.5	12.6				98/03/31	0500454	S.Prairie Cr.	12	4.9	12.8		
98/03/31	0500729	S.Squally Pt.	14	4.5	12.6				98/03/31	0500454	S.Prairie Cr.	14	4.9	12.8		
98/03/31	0500729	S.Squally Pt.	16	4.5	12.6				98/03/31	0500454	S.Prairie Cr.	16	4.9	12.8		
98/03/31	0500729	S.Squally Pt.	18	4.5	12.6				98/03/31	0500454	S.Prairie Cr.	18	4.8	12.8		
98/03/31	0500729	S.Squally Pt.	20	4.5	12.6				98/03/31	0500454	S.Prairie Cr.	20	4.8	12.7		
98/03/31	0500729	S.Squally Pt.	24	4.5	12.6				98/03/31	0500454	S.Prairie Cr.	24	4.8	12.7		
98/03/31	0500729	S.Squally Pt.	28	4.3	12.6				98/03/31	0500454	S.Prairie Cr.	28	4.8	12.6		
98/03/31	0500729	S.Squally Pt.	32	4.2	12.5				98/03/31	0500454	S.Prairie Cr.	32	4.7	12.6		
98/03/31	0500729	S.Squally Pt.	36	4.2	12.4				98/03/31	0500454	S.Prairie Cr.	36	4.5	12.6		
98/03/31	0500729	S.Squally Pt.	40	4.1	12.5				98/03/31	0500454	S.Prairie Cr.	40	4.4	12.6		
98/03/31	0500729	S.Squally Pt.	44	4.1	12.4				98/03/31	0500454	S.Prairie Cr.	44	4.3	12.6		

April													
Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth	Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth
			(m)	(C)	(mg/L)	(m)				(m)	(C)	(mg/L)	(m)
98/04/20	0500847	Kala. D.B.	0	8.8	12.6	5.5	98/04/28	0500239	Arm. Arm	0	14.5	11.7	2.5
98/04/20	0500847	Kala. D.B.	2	8.2	12.8		98/04/28	0500239	Arm. Arm	2	13.9	11.9	
98/04/20	0500847	Kala. D.B.	4	7.0	13.0		98/04/28	0500239	Arm. Arm	4	12.0	12.6	
98/04/20	0500847	Kala. D.B.	6	6.7	13.2		98/04/28	0500239	Arm. Arm	6	11.2	12.8	
98/04/20	0500847	Kala. D.B.	8	6.4	13.2		98/04/28	0500239	Arm. Arm	8	10.0	13.0	
98/04/20	0500847	Kala. D.B.	10	6.2	13.2		98/04/28	0500239	Arm. Arm	10	8.9	13.0	
98/04/20	0500847	Kala. D.B.	12	6.0	13.2		98/04/28	0500239	Arm. Arm	12	7.0	12.4	
98/04/20	0500847	Kala. D.B.	14	5.8	13.2		98/04/28	0500239	Arm. Arm	14	6.0	11.9	
98/04/20	0500847	Kala. D.B.	16	5.5	13.2		98/04/28	0500239	Arm. Arm	16	5.6	11.7	
98/04/20	0500847	Kala. D.B.	18	5.5	13.1		98/04/28	0500239	Arm. Arm	18	5.5	11.5	
98/04/20	0500847	Kala. D.B.	20	5.1	13.0		98/04/28	0500239	Arm. Arm	20	5.2	11.4	
98/04/20	0500847	Kala. D.B.	24	5.0	12.8		98/04/28	0500239	Arm. Arm	24	5.0	11.4	
98/04/20	0500847	Kala. D.B.	28	4.6	12.6		98/04/28	0500239	Arm. Arm	28	5.0	11.1	
98/04/20	0500847	Kala. D.B.	32	4.3	12.3		98/04/28	0500239	Arm. Arm	32	4.9	11.0	
98/04/20	0500847	Kala. D.B.	36	4.2	12.1		98/04/28	0500239	Arm. Arm	36	4.9	11.0	
98/04/20	0500847	Kala. D.B.	40	4.1	12.0		98/04/28	0500239	Arm. Arm	40	4.9	10.4	
98/04/20	0500847	Kala. D.B.	44	4.1	12.0		98/04/28	0500239	Arm. Arm	44	4.9	10.4	
98/04/28	0500730	N. OK. Centre	0	12.0	12.2	5.0	98/04/22	E223295	Rattlesnake	0	8.5	12.6	7.8
98/04/28	0500730	N. OK. Centre	2	9.6	13.2		98/04/22	E223295	Rattlesnake	2	7.6	13.2	
98/04/28	0500730	N. OK. Centre	4	9.0	13.4		98/04/22	E223295	Rattlesnake	4	7.0	13.3	
98/04/28	0500730	N. OK. Centre	6	8.4	13.6		98/04/22	E223295	Rattlesnake	6	6.6	13.3	
98/04/28	0500730	N. OK. Centre	8	8.2	13.6		98/04/22	E223295	Rattlesnake	8	6.4	13.4	
98/04/28	0500730	N. OK. Centre	10	8.0	13.7		98/04/22	E223295	Rattlesnake	10	6.1	13.4	
98/04/28	0500730	N. OK. Centre	12	7.8	13.6		98/04/22	E223295	Rattlesnake	12	5.9	13.4	
98/04/28	0500730	N. OK. Centre	14	7.5	13.6		98/04/22	E223295	Rattlesnake	14	5.7	13.4	
98/04/28	0500730	N. OK. Centre	16	7.5	13.6		98/04/22	E223295	Rattlesnake	16	5.5	13.4	
98/04/28	0500730	N. OK. Centre	18	7.3	13.6		98/04/22	E223295	Rattlesnake	18	5.3	13.2	
98/04/28	0500730	N. OK. Centre	20	7.3	13.6		98/04/22	E223295	Rattlesnake	20	5.1	13.2	
98/04/28	0500730	N. OK. Centre	24	7.0	13.6		98/04/22	E223295	Rattlesnake	24	5.0	13.2	
98/04/28	0500730	N. OK. Centre	28	6.0	13.6		98/04/22	E223295	Rattlesnake	28	4.8	13.2	
98/04/28	0500730	N. OK. Centre	32	5.1	13.4		98/04/22	E223295	Rattlesnake	32	4.7	13.2	
98/04/28	0500730	N. OK. Centre	36	4.7	13.3		98/04/22	E223295	Rattlesnake	36	4.7	13.1	
98/04/28	0500730	N. OK. Centre	40	4.5	12.8		98/04/22	E223295	Rattlesnake	40	4.4	13.0	
98/04/28	0500730	N. OK. Centre	44	4.2	12.8		98/04/22	E223295	Rattlesnake	44	4.4	13.0	
98/04/22	0500454	S.Prairie Cr.	0	9.2	12.6	6.5							
98/04/22	0500454	S.Prairie Cr.	2	8.1	13.4								
98/04/22	0500454	S.Prairie Cr.	4	7.5	13.5								
98/04/22	0500454	S.Prairie Cr.	6	7.2	13.6								
98/04/22	0500454	S.Prairie Cr.	8	6.9	13.7								
98/04/22	0500454	S.Prairie Cr.	10	6.1	13.8								
98/04/22	0500454	S.Prairie Cr.	12	6.0	13.7								
98/04/22	0500454	S.Prairie Cr.	14	5.8	13.7								
98/04/22	0500454	S.Prairie Cr.	16	5.5	13.7								
98/04/22	0500454	S.Prairie Cr.	18	5.5	13.7								
98/04/22	0500454	S.Prairie Cr.	20	5.2	13.6								
98/04/22	0500454	S.Prairie Cr.	24	5.1	13.6								
98/04/22	0500454	S.Prairie Cr.	28	5.0	13.6								
98/04/22	0500454	S.Prairie Cr.	32	5.0	13.5								
98/04/22	0500454	S.Prairie Cr.	36	4.8	13.5								
98/04/22	0500454	S.Prairie Cr.	40	4.8	13.5								
98/04/22	0500454	S.Prairie Cr.	44	4.8	13.4								
May													
Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth	Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth
			(m)	(C)	(mg/L)	(m)				(m)	(C)	(mg/L)	(m)
98/05/26	0500847	Kala. D.B.	0	14.3	11.8	4.5	98/06/10	0500239	Arm. Arm	0	21.5	9.0	3.8
98/05/26	0500847	Kala. D.B.	2	13.7	12.3		98/06/10	0500239	Arm. Arm	2	20.2	9.4	
98/05/26	0500847	Kala. D.B.	4	13.1	12.3		98/06/10	0500239	Arm. Arm	4	19.8	9.4	
98/05/26	0500847	Kala. D.B.	6	13.0	12.3		98/06/10	0500239	Arm. Arm	6	19.0	9.4	
98/05/26	0500847	Kala. D.B.	8	12.6	12.5		98/06/10	0500239	Arm. Arm	8	15.7	9.6	
98/05/26	0500847	Kala. D.B.	10	12.0	12.6		98/06/10	0500239	Arm. Arm	10	14.0	9.2	
98/05/26	0500847	Kala. D.B.	12	10.5	12.8		98/06/10	0500239	Arm. Arm	12	12.9	9.1	
98/05/26	0500847	Kala. D.B.	14	8.8	12.8		98/06/10	0500239	Arm. Arm	14	11.1	9.0	
98/05/26	0500847	Kala. D.B.	16	7.9	12.8		98/06/10	0500239	Arm. Arm	16	9.9	8.9	
98/05/26	0500847	Kala. D.B.	18	6.9	12.7		98/06/10	0500239	Arm. Arm	18	8.5	8.8	
98/05/26	0500847	Kala. D.B.	20	6.3	12.5		98/06/10	0500239	Arm. Arm	20	7.5	8.5	
98/05/26	0500847	Kala. D.B.	24	5.5	12.5		98/06/10	0500239	Arm. Arm	24	6.2	8.4	
98/05/26	0500847	Kala. D.B.	28	4.9	12.3		98/06/10	0500239	Arm. Arm	28	5.8	8.2	
98/05/26	0500847	Kala. D.B.	32	4.7	12.0		98/06/10	0500239	Arm. Arm	32	5.3	7.8	
98/05/26	0500847	Kala. D.B.	36	4.4	12.0		98/06/10	0500239	Arm. Arm	36	5.0	7.5	
98/05/26	0500847	Kala. D.B.	40	4.3	12.0		98/06/10	0500239	Arm. Arm	40	5.0	7.3	
98/05/26	0500847	Kala. D.B.	44	4.1	12.2		98/06/10	0500239	Arm. Arm	44	5.0	7.2	

98/06/10	E206611	Vern. Outfall	0	20.0	9.1	6.1	98/06/10	0500730	N. Ok. Centre	0	18.4	9.6	6.8
98/06/10	E206611	Vern. Outfall	2	19.0	9.4		98/06/10	0500730	N. Ok. Centre	2	18.0	9.2	
98/06/10	E206611	Vern. Outfall	4	18.7	9.6		98/06/10	0500730	N. Ok. Centre	4	17.5	9.9	
98/06/10	E206611	Vern. Outfall	6	17.9	9.6		98/06/10	0500730	N. Ok. Centre	6	17.2	10.0	
98/06/10	E206611	Vern. Outfall	8	16.9	9.9		98/06/10	0500730	N. Ok. Centre	8	15.0	10.6	
98/06/10	E206611	Vern. Outfall	10	14.0	10.0		98/06/10	0500730	N. Ok. Centre	10	14.2	10.6	
98/06/10	E206611	Vern. Outfall	12	11.8	10.4		98/06/10	0500730	N. Ok. Centre	12	13.1	10.8	
98/06/10	E206611	Vern. Outfall	14	11.0	10.5		98/06/10	0500730	N. Ok. Centre	14	12.0	10.8	
98/06/10	E206611	Vern. Outfall	16	10.5	10.6		98/06/10	0500730	N. Ok. Centre	16	11.5	10.8	
98/06/10	E206611	Vern. Outfall	18	9.6	10.8		98/06/10	0500730	N. Ok. Centre	18	11.0	10.9	
98/06/10	E206611	Vern. Outfall	20	8.7	11.1		98/06/10	0500730	N. Ok. Centre	20	10.1	10.9	
98/06/10	E206611	Vern. Outfall	24	7.0	11.4		98/06/10	0500730	N. Ok. Centre	24	8.0	11.4	
98/06/10	E206611	Vern. Outfall	28	5.9	11.4		98/06/10	0500730	N. Ok. Centre	28	7.5	11.4	
98/06/10	E206611	Vern. Outfall	32	5.5	11.6		98/06/10	0500730	N. Ok. Centre	32	6.9	11.4	
98/06/10	E206611	Vern. Outfall	36	5.3	11.5		98/06/10	0500730	N. Ok. Centre	36	6.0	11.5	
98/06/10	E206611	Vern. Outfall	40	5.1	11.6		98/06/10	0500730	N. Ok. Centre	40	5.4	11.7	
98/06/10	E206611	Vern. Outfall	44	5.1	11.5		98/06/10	0500730	N. Ok. Centre	44	5.1	11.8	
98/05/28	E223295	Rattlesnake	0	10.5	11.2	6.5	98/05/28	0500454	S. Prairie Cr.	0	10.2	11.3	7.0
98/05/28	E223295	Rattlesnake	2	9.2	11.8		98/05/28	0500454	S. Prairie Cr.	2	7.5	12.4	
98/05/28	E223295	Rattlesnake	4	9.0	11.9		98/05/28	0500454	S. Prairie Cr.	4	6.7	12.7	
98/05/28	E223295	Rattlesnake	6	9.0	11.9		98/05/28	0500454	S. Prairie Cr.	6	6.3	12.6	
98/05/28	E223295	Rattlesnake	8	9.0	11.9		98/05/28	0500454	S. Prairie Cr.	8	6.0	12.7	
98/05/28	E223295	Rattlesnake	10	8.8	11.9		98/05/28	0500454	S. Prairie Cr.	10	5.8	12.7	
98/05/28	E223295	Rattlesnake	12	8.8	11.9		98/05/28	0500454	S. Prairie Cr.	12	5.8	12.6	
98/05/28	E223295	Rattlesnake	14	8.3	11.9		98/05/28	0500454	S. Prairie Cr.	14	5.6	12.6	
98/05/28	E223295	Rattlesnake	16	8.2	12.0		98/05/28	0500454	S. Prairie Cr.	16	5.5	12.6	
98/05/28	E223295	Rattlesnake	18	8.1	11.9		98/05/28	0500454	S. Prairie Cr.	18	5.5	12.6	
98/05/28	E223295	Rattlesnake	20	7.9	12.1		98/05/28	0500454	S. Prairie Cr.	20	5.5	12.6	
98/05/28	E223295	Rattlesnake	24	7.5	12.0		98/05/28	0500454	S. Prairie Cr.	24	5.3	12.6	
98/05/28	E223295	Rattlesnake	28	6.8	12.2		98/05/28	0500454	S. Prairie Cr.	28	5.1	12.7	
98/05/28	E223295	Rattlesnake	32	5.9	12.2		98/05/28	0500454	S. Prairie Cr.	32	4.8	12.7	
98/05/28	E223295	Rattlesnake	36	5.5	12.2		98/05/28	0500454	S. Prairie Cr.	36	4.6	12.6	
98/05/28	E223295	Rattlesnake	40	5.1	12.2		98/05/28	0500454	S. Prairie Cr.	40	4.5	12.6	
98/05/28	E223295	Rattlesnake	44	5.0	12.2		98/05/28	0500454	S. Prairie Cr.	44	4.5	12.4	
June													
Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth	Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth
			(m)	(C)	(mg/L)	(m)				(m)	(C)	(mg/L)	(m)
98/06/17	0500847	Kala. D.B.	0	17.5	10.0	4.8	98/07/06	0500239	Arm. Arm	0	24.7	9.0	3.8
98/06/17	0500847	Kala. D.B.	2	17.3	10.2		98/07/06	0500239	Arm. Arm	2	22.5	9.6	
98/06/17	0500847	Kala. D.B.	4	17.0	10.3		98/07/06	0500239	Arm. Arm	4	21.9	9.8	
98/06/17	0500847	Kala. D.B.	6	16.0	10.7		98/07/06	0500239	Arm. Arm	6	21.1	9.6	
98/06/17	0500847	Kala. D.B.	8	14.9	11.0		98/07/06	0500239	Arm. Arm	8	21.0	9.6	
98/06/17	0500847	Kala. D.B.	10	14.3	11.2		98/07/06	0500239	Arm. Arm	10	17.9	9.6	
98/06/17	0500847	Kala. D.B.	12	9.8	11.3		98/07/06	0500239	Arm. Arm	12	14.3	9.3	
98/06/17	0500847	Kala. D.B.	14	9.3	11.3		98/07/06	0500239	Arm. Arm	14	11.5	8.9	
98/06/17	0500847	Kala. D.B.	16	8.5	11.1		98/07/06	0500239	Arm. Arm	16	10.0	8.8	
98/06/17	0500847	Kala. D.B.	18	8.0	11.0		98/07/06	0500239	Arm. Arm	18	8.8	7.8	
98/06/17	0500847	Kala. D.B.	20	7.8	10.9		98/07/06	0500239	Arm. Arm	20	8.1	7.8	
98/06/17	0500847	Kala. D.B.	24	6.6	10.8		98/07/06	0500239	Arm. Arm	24	7.0	7.7	
98/06/17	0500847	Kala. D.B.	28	6.1	10.6		98/07/06	0500239	Arm. Arm	28	6.1	7.6	
98/06/17	0500847	Kala. D.B.	32	5.3	10.6		98/07/06	0500239	Arm. Arm	32	5.7	7.2	
98/06/17	0500847	Kala. D.B.	36	5.1	10.6		98/07/06	0500239	Arm. Arm	36	5.5	6.9	
98/06/17	0500847	Kala. D.B.	40	4.8	10.8		98/07/06	0500239	Arm. Arm	40	5.3	6.6	
98/06/17	0500847	Kala. D.B.	44	4.5	10.9		98/07/06	0500239	Arm. Arm	44	5.3	6.2	
98/07/06	E206611	Vern. Outfall	0	24.5	8.5	6.5	98/07/06	0500730	N. Ok. Centre	0	22.8	8.9	8.0
98/07/06	E206611	Vern. Outfall	2	21.6	9.2		98/07/06	0500730	N. Ok. Centre	2	21.0	9.2	
98/07/06	E206611	Vern. Outfall	4	21.3	9.2		98/07/06	0500730	N. Ok. Centre	4	20.3	9.4	
98/07/06	E206611	Vern. Outfall	6	21.0	9.3		98/07/06	0500730	N. Ok. Centre	6	20.0	9.5	
98/07/06	E206611	Vern. Outfall	8	20.0	9.6		98/07/06	0500730	N. Ok. Centre	8	19.5	9.6	
98/07/06	E206611	Vern. Outfall	10	18.4	9.8		98/07/06	0500730	N. Ok. Centre	10	17.4	9.8	
98/07/06	E206611	Vern. Outfall	12	17.0	10.1		98/07/06	0500730	N. Ok. Centre	12	14.9	10.2	
98/07/06	E206611	Vern. Outfall	14	14.8	9.7		98/07/06	0500730	N. Ok. Centre	14	12.5	10.4	
98/07/06	E206611	Vern. Outfall	16	12.1	9.7		98/07/06	0500730	N. Ok. Centre	16	11.0	10.6	
98/07/06	E206611	Vern. Outfall	18	9.8	10.3		98/07/06	0500730	N. Ok. Centre	18	9.2	10.7	
98/07/06	E206611	Vern. Outfall	20	8.2	10.9		98/07/06	0500730	N. Ok. Centre	20	8.0	11.0	
98/07/06	E206611	Vern. Outfall	24	7.0	11.2		98/07/06	0500730	N. Ok. Centre	24	7.2	11.2	
98/07/06	E206611	Vern. Outfall	28	6.2	11.4		98/07/06	0500730	N. Ok. Centre	28	6.5	11.4	
98/07/06	E206611	Vern. Outfall	32	5.9	11.5		98/07/06	0500730	N. Ok. Centre	32	6.1	11.4	
98/07/06	E206611	Vern. Outfall	36	5.6	11.6		98/07/06	0500730	N. Ok. Centre	36	5.7	11.6	
98/07/06	E206611	Vern. Outfall	40	5.2	11.8		98/07/06	0500730	N. Ok. Centre	40	5.2	11.8	
98/07/06	E206611	Vern. Outfall	44	5.2	11.8		98/07/06	0500730	N. Ok. Centre	44	5.0	11.7	

98/06/23	E223295	Rattlesnake	0	18.3	10.0	6.0	98/06/22	0500454	S. Prairie Cr.	0	21.3	8.2	5.5
98/06/23	E223295	Rattlesnake	2	17.8	10.2		98/06/22	0500454	S. Prairie Cr.	2	19.3	8.8	
98/06/23	E223295	Rattlesnake	4	17.0	10.4		98/06/22	0500454	S. Prairie Cr.	4	17.1	9.6	
98/06/23	E223295	Rattlesnake	6	15.0	11.0		98/06/22	0500454	S. Prairie Cr.	6	16.0	9.9	
98/06/23	E223295	Rattlesnake	8	13.2	11.2		98/06/22	0500454	S. Prairie Cr.	8	15.0	10.1	
98/06/23	E223295	Rattlesnake	10	12.8	11.2		98/06/22	0500454	S. Prairie Cr.	10	14.0	10.2	
98/06/23	E223295	Rattlesnake	12	11.8	11.5		98/06/22	0500454	S. Prairie Cr.	12	13.2	10.4	
98/06/23	E223295	Rattlesnake	14	11.1	11.4		98/06/22	0500454	S. Prairie Cr.	14	11.3	10.5	
98/06/23	E223295	Rattlesnake	16	10.8	11.4		98/06/22	0500454	S. Prairie Cr.	16	10.5	10.7	
98/06/23	E223295	Rattlesnake	18	10.0	11.8		98/06/22	0500454	S. Prairie Cr.	18	9.5	10.8	
98/06/23	E223295	Rattlesnake	20	9.0	12.0		98/06/22	0500454	S. Prairie Cr.	20	8.8	10.5	
98/06/23	E223295	Rattlesnake	24	7.1	11.9		98/06/22	0500454	S. Prairie Cr.	24	7.7	10.8	
98/06/23	E223295	Rattlesnake	28	6.6	11.9		98/06/22	0500454	S. Prairie Cr.	28	6.7	10.8	
98/06/23	E223295	Rattlesnake	32	6.0	11.8		98/06/22	0500454	S. Prairie Cr.	32	6.0	10.9	
98/06/23	E223295	Rattlesnake	36	5.6	11.8		98/06/22	0500454	S. Prairie Cr.	36	5.5	10.8	
98/06/23	E223295	Rattlesnake	40	5.4	11.8		98/06/22	0500454	S. Prairie Cr.	40	5.0	10.9	
98/06/23	E223295	Rattlesnake	44	5.1	12.0		98/06/22	0500454	S. Prairie Cr.	44	5.0	11.0	
July													
Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth	Date	Station No.	Location	Depth	Temp.	D.O.	Secchi Depth
			(m)	(C)	(mg/L)	(m)				(m)	(C)	(mg/L)	(m)
98/07/30	0500847	Kala. D.B.	0	25.5	8.0	5.8	98/07/29	0500239	Arm. Arm	0	26.6	9.0	2.3
98/07/30	0500847	Kala. D.B.	2	24.6	8.4		98/07/29	0500239	Arm. Arm	2	25.4	9.2	
98/07/30	0500847	Kala. D.B.	4	24.0	8.5		98/07/29	0500239	Arm. Arm	4	24.5	9.5	
98/07/30	0500847	Kala. D.B.	6	23.7	8.6		98/07/29	0500239	Arm. Arm	6	22.7	9.8	
98/07/30	0500847	Kala. D.B.	8	22.9	8.8		98/07/29	0500239	Arm. Arm	8	20.8	9.0	
98/07/30	0500847	Kala. D.B.	10	21.3	9.4		98/07/29	0500239	Arm. Arm	10	18.6	8.9	
98/07/30	0500847	Kala. D.B.	12	16.0	10.4		98/07/29	0500239	Arm. Arm	12	16.5	8.2	
98/07/30	0500847	Kala. D.B.	14	10.6	11.6		98/07/29	0500239	Arm. Arm	14	12.0	7.3	
98/07/30	0500847	Kala. D.B.	16	9.3	10.8		98/07/29	0500239	Arm. Arm	16	10.2	6.2	
98/07/30	0500847	Kala. D.B.	18	8.9	10.4		98/07/29	0500239	Arm. Arm	18	9.0	6.4	
98/07/30	0500847	Kala. D.B.	20	7.9	9.9		98/07/29	0500239	Arm. Arm	20	8.2	6.4	
98/07/30	0500847	Kala. D.B.	24	7.0	9.8		98/07/29	0500239	Arm. Arm	24	7.0	6.3	
98/07/30	0500847	Kala. D.B.	28	6.3	9.9		98/07/29	0500239	Arm. Arm	28	6.1	6.1	
98/07/30	0500847	Kala. D.B.	32	5.8	9.9		98/07/29	0500239	Arm. Arm	32	5.8	5.6	
98/07/30	0500847	Kala. D.B.	36	5.1	10.1		98/07/29	0500239	Arm. Arm	36	5.6	5.2	
98/07/30	0500847	Kala. D.B.	40	4.9	10.3		98/07/29	0500239	Arm. Arm	40	5.5	4.7	
98/07/30	0500847	Kala. D.B.	44	4.8	10.2		98/07/29	0500239	Arm. Arm	44	5.5	3.8	
98/07/29	E206611	Vern. Outfall	0	25.0	8.9	6.0	98/07/29	0500730	N. Ok. Centre	0	26.9	8.4	11.6
98/07/29	E206611	Vern. Outfall	2	24.3	9.1		98/07/29	0500730	N. Ok. Centre	2	24.4	8.9	
98/07/29	E206611	Vern. Outfall	4	24.0	9.2		98/07/29	0500730	N. Ok. Centre	4	24.0	9.1	
98/07/29	E206611	Vern. Outfall	6	23.0	9.4		98/07/29	0500730	N. Ok. Centre	6	23.5	9.2	
98/07/29	E206611	Vern. Outfall	8	21.5	9.9		98/07/29	0500730	N. Ok. Centre	8	22.0	9.5	
98/07/29	E206611	Vern. Outfall	10	20.1	10.0		98/07/29	0500730	N. Ok. Centre	10	21.0	9.8	
98/07/29	E206611	Vern. Outfall	12	19.5	9.9		98/07/29	0500730	N. Ok. Centre	12	18.0	10.1	
98/07/29	E206611	Vern. Outfall	14	15.2	9.8		98/07/29	0500730	N. Ok. Centre	14	16.0	10.4	
98/07/29	E206611	Vern. Outfall	16	12.0	10.4		98/07/29	0500730	N. Ok. Centre	16	13.8	10.6	
98/07/29	E206611	Vern. Outfall	18	9.6	10.5		98/07/29	0500730	N. Ok. Centre	18	11.7	10.7	
98/07/29	E206611	Vern. Outfall	20	8.2	11.0		98/07/29	0500730	N. Ok. Centre	20	10.5	10.9	
98/07/29	E206611	Vern. Outfall	24	7.5	10.8		98/07/29	0500730	N. Ok. Centre	24	8.0	11.2	
98/07/29	E206611	Vern. Outfall	28	6.8	11.1		98/07/29	0500730	N. Ok. Centre	28	7.0	11.1	
98/07/29	E206611	Vern. Outfall	32	6.1	11.4		98/07/29	0500730	N. Ok. Centre	32	6.3	11.4	
98/07/29	E206611	Vern. Outfall	36	5.5	11.7		98/07/29	0500730	N. Ok. Centre	36	6.0	11.7	
98/07/29	E206611	Vern. Outfall	40	5.5	11.7		98/07/29	0500730	N. Ok. Centre	40	5.5	11.8	
98/07/29	E206611	Vern. Outfall	44	5.2	11.8		98/07/29	0500730	N. Ok. Centre	44	5.2	11.8	
98/07/28	E223295	Rattlesnake	0	24.2	8.3	12.0	98/07/28	0500454	S. Prairie Cr.	0	24.4	8.4	11.0
98/07/28	E223295	Rattlesnake	2	24.0	8.3		98/07/28	0500454	S. Prairie Cr.	2	24.2	8.4	
98/07/28	E223295	Rattlesnake	4	23.5	8.3		98/07/28	0500454	S. Prairie Cr.	4	24.2	8.6	
98/07/28	E223295	Rattlesnake	6	23.0	8.8		98/07/28	0500454	S. Prairie Cr.	6	23.6	8.6	
98/07/28	E223295	Rattlesnake	8	22.0	8.8		98/07/28	0500454	S. Prairie Cr.	8	23.1	8.8	
98/07/28	E223295	Rattlesnake	10	20.0	9.4		98/07/28	0500454	S. Prairie Cr.	10	21.6	9.1	
98/07/28	E223295	Rattlesnake	12	18.0	9.6		98/07/28	0500454	S. Prairie Cr.	12	19.3	9.5	
98/07/28	E223295	Rattlesnake	14	16.0	9.6		98/07/28	0500454	S. Prairie Cr.	14	15.5	10.6	
98/07/28	E223295	Rattlesnake	16	12.5	10.8		98/07/28	0500454	S. Prairie Cr.	16	12.0	11.1	
98/07/28	E223295	Rattlesnake	18	11.0	11.0		98/07/28	0500454	S. Prairie Cr.	18	10.0	11.2	
98/07/28	E223295	Rattlesnake	20	9.0	11.0		98/07/28	0500454	S. Prairie Cr.	20	9.1	11.4	
98/07/28	E223295	Rattlesnake	24	8.0	11.0		98/07/28	0500454	S. Prairie Cr.	24	7.7	11.4	
98/07/28	E223295	Rattlesnake	28	7.0	11.0		98/07/28	0500454	S. Prairie Cr.	28	6.8	11.6	
98/07/28	E223295	Rattlesnake	32	6.0	11.5		98/07/28	0500454	S. Prairie Cr.	32	6.0	11.9	
98/07/28	E223295	Rattlesnake	36	6.0	11.6		98/07/28	0500454	S. Prairie Cr.	36	5.7	11.9	
98/07/28	E223295	Rattlesnake	40	5.5	11.7		98/07/28	0500454	S. Prairie Cr.	40	5.3	12.0	
98/07/28	E223295	Rattlesnake	44	5.0	11.6		98/07/28	0500454	S. Prairie Cr.	44	5.1	12.1	

98/08/26	0500847	Kala. D.B.	0	21.5	8.8	4.2		98/08/23	0500239	Arm. Arm	0	23.0	8.2	3.1	
98/08/26	0500847	Kala. D.B.	2	21.3	8.8			98/08/23	0500239	Arm. Arm	2	22.4	8.3		
98/08/26	0500847	Kala. D.B.	4	21.3	8.8			98/08/23	0500239	Arm. Arm	4	22.2	8.2		
98/08/26	0500847	Kala. D.B.	6	21.1	8.8			98/08/23	0500239	Arm. Arm	6	22.1	8.2		
98/08/26	0500847	Kala. D.B.	8	21.0	8.8			98/08/23	0500239	Arm. Arm	8	22.0	8.2		
98/08/26	0500847	Kala. D.B.	10	20.5	8.9			98/08/23	0500239	Arm. Arm	10	21.3	7.6		
98/08/26	0500847	Kala. D.B.	12	15.0	10.7			98/08/23	0500239	Arm. Arm	12	17.0	6.3		
98/08/26	0500847	Kala. D.B.	14	12.0	10.7			98/08/23	0500239	Arm. Arm	14	12.9	5.8		
98/08/26	0500847	Kala. D.B.	16	10.1	10.3			98/08/23	0500239	Arm. Arm	16	10.8	5.4		
98/08/26	0500847	Kala. D.B.	18	8.8	9.8			98/08/23	0500239	Arm. Arm	18	9.5	4.9		
98/08/26	0500847	Kala. D.B.	20	7.5	9.6			98/08/23	0500239	Arm. Arm	20	8.7	4.8		
98/08/26	0500847	Kala. D.B.	24	6.4	9.7			98/08/23	0500239	Arm. Arm	24	7.5	5.0		
98/08/26	0500847	Kala. D.B.	28	5.6	10.0			98/08/23	0500239	Arm. Arm	28	6.2	5.0		
98/08/26	0500847	Kala. D.B.	32	5.1	10.2			98/08/23	0500239	Arm. Arm	32	5.9	4.4		
98/08/26	0500847	Kala. D.B.	36	5.0	10.4			98/08/23	0500239	Arm. Arm	36	5.9	4.0		
98/08/26	0500847	Kala. D.B.	40	4.8	10.5			98/08/23	0500239	Arm. Arm	40	5.7	3.5		
98/08/26	0500847	Kala. D.B.	44	4.7	10.6			98/08/23	0500239	Arm. Arm	44	5.7	3.2		
98/08/23	E206611	Vern. Outfall	0	23.0	8.1	4.8		98/08/23	0500730	N. Ok. Centre	0	23.1	8.2	7.1	
98/08/23	E206611	Vern. Outfall	2	22.5	8.2			98/08/23	0500730	N. Ok. Centre	2	22.0	8.4		
98/08/23	E206611	Vern. Outfall	4	22.1	8.4			98/08/23	0500730	N. Ok. Centre	4	21.5	8.5		
98/08/23	E206611	Vern. Outfall	6	22.0	8.4			98/08/23	0500730	N. Ok. Centre	6	21.5	8.5		
98/08/23	E206611	Vern. Outfall	8	21.8	8.4			98/08/23	0500730	N. Ok. Centre	8	21.3	8.5		
98/08/23	E206611	Vern. Outfall	10	19.0	8.9			98/08/23	0500730	N. Ok. Centre	10	21.3	8.5		
98/08/23	E206611	Vern. Outfall	12	16.0	9.4			98/08/23	0500730	N. Ok. Centre	12	19.5	9.0		
98/08/23	E206611	Vern. Outfall	14	13.6	9.1			98/08/23	0500730	N. Ok. Centre	14	15.3	9.6		
98/08/23	E206611	Vern. Outfall	16	11.0	9.4			98/08/23	0500730	N. Ok. Centre	16	11.5	9.8		
98/08/23	E206611	Vern. Outfall	18	9.7	9.6			98/08/23	0500730	N. Ok. Centre	18	10.0	10.2		
98/08/23	E206611	Vern. Outfall	20	8.5	9.6			98/08/23	0500730	N. Ok. Centre	20	9.1	10.3		
98/08/23	E206611	Vern. Outfall	24	7.2	9.9			98/08/23	0500730	N. Ok. Centre	24	7.8	10.2		
98/08/23	E206611	Vern. Outfall	28	6.5	10.3			98/08/23	0500730	N. Ok. Centre	28	6.9	10.4		
98/08/23	E206611	Vern. Outfall	32	6.0	10.7			98/08/23	0500730	N. Ok. Centre	32	6.3	10.6		
98/08/23	E206611	Vern. Outfall	36	5.8	10.9			98/08/23	0500730	N. Ok. Centre	36	5.9	10.9		
98/08/23	E206611	Vern. Outfall	40	5.5	11.0			98/08/23	0500730	N. Ok. Centre	40	5.5	11.2		
98/08/23	E206611	Vern. Outfall	44	5.4	11.0			98/08/23	0500730	N. Ok. Centre	44	5.3	11.3		
98/08/24	0500236	DNS Kel STP	0	22.0	8.5	8.5		98/08/24	E223295	Rattlesnake	0	21.2	8.4	8.5	
98/08/24	0500236	DNS Kel STP	2	21.5	8.6			98/08/24	E223295	Rattlesnake	2	20.8	8.6		
98/08/24	0500236	DNS Kel STP	4	21.2	8.7			98/08/24	E223295	Rattlesnake	4	20.5	8.7		
98/08/24	0500236	DNS Kel STP	6	21.2	8.7			98/08/24	E223295	Rattlesnake	6	20.5	8.7		
98/08/24	0500236	DNS Kel STP	8	21.2	8.7			98/08/24	E223295	Rattlesnake	8	20.5	8.7		
98/08/24	0500236	DNS Kel STP	10	20.9	8.8			98/08/24	E223295	Rattlesnake	10	20.3	8.7		
98/08/24	0500236	DNS Kel STP	12	18.1	9.4			98/08/24	E223295	Rattlesnake	12	20.0	8.8		
98/08/24	0500236	DNS Kel STP	14	15.2	10.2			98/08/24	E223295	Rattlesnake	14	16.1	9.8		
98/08/24	0500236	DNS Kel STP	16	10.5	10.8			98/08/24	E223295	Rattlesnake	16	14.0	10.2		
98/08/24	0500236	DNS Kel STP	18	9.0	10.9			98/08/24	E223295	Rattlesnake	18	12.0	10.6		
98/08/24	0500236	DNS Kel STP	20	8.3	10.8			98/08/24	E223295	Rattlesnake	20	11.0	10.8		
98/08/24	0500236	DNS Kel STP	24	7.0	11.0			98/08/24	E223295	Rattlesnake	24	8.0	10.8		
98/08/24	0500236	DNS Kel STP	28	6.3	11.0			98/08/24	E223295	Rattlesnake	28	6.9	10.8		
98/08/24	0500236	DNS Kel STP	32	6.0	11.0			98/08/24	E223295	Rattlesnake	32	6.1	10.9		
98/08/24	0500236	DNS Kel STP	36	5.6	11.2			98/08/24	E223295	Rattlesnake	36	5.9	10.9		
98/08/24	0500236	DNS Kel STP	40	5.5	11.2			98/08/24	E223295	Rattlesnake	40	5.5	11.2		
98/08/24	0500236	DNS Kel STP	44	5.1	11.3			98/08/24	E223295	Rattlesnake	44	5.0	11.3		
98/08/25	0500454	S. Prairie Cr.	0	21.3	9.0	7.8					0				
98/08/25	0500454	S. Prairie Cr.	2	21.3	9.2						2				
98/08/25	0500454	S. Prairie Cr.	4	21.0	9.3						4				
98/08/25	0500454	S. Prairie Cr.	6	21.0	9.3						6				
98/08/25	0500454	S. Prairie Cr.	8	20.8	9.3						8				
98/08/25	0500454	S. Prairie Cr.	10	20.8	9.3						10				
98/08/25	0500454	S. Prairie Cr.	12	15.5	10.7						12				
98/08/25	0500454	S. Prairie Cr.	14	10.8	11.5						14				
98/08/25	0500454	S. Prairie Cr.	16	9.0	11.6						16				
98/08/25	0500454	S. Prairie Cr.	18	8.0	11.7						18				
98/08/25	0500454	S. Prairie Cr.	20	7.4	11.6						20				
98/08/25	0500454	S. Prairie Cr.	24	6.8	11.9						24				
98/08/25	0500454	S. Prairie Cr.	28	6.0	12.0						28				
98/08/25	0500454	S. Prairie Cr.	32	5.5	12.2						32				
98/08/25	0500454	S. Prairie Cr.	36	5.3	12.3						36				
98/08/25	0500454	S. Prairie Cr.	40	5.2	12.2						40				
98/08/25	0500454	S. Prairie Cr.	44	5.0	12.4						44				
98/09/24	0500847	Kala. D.B.	0	19.4	8.6	4.5		98/10/01	0500239	Arm. Arm	0	17.8	8.8	3.5	
98/09/24	0500847	Kala. D.B.	2	19.4	8.7			98/10/01	0500239	Arm. Arm	2	17.8	8.8		
98/09/24	0500847	Kala. D.B.	4	19.5	8.7			98/10/01	0500239	Arm. Arm	4	17.5	8.9		
98/09/24	0500847	Kala. D.B.	6	19.4	8.6			98/10/01	0500239	Arm. Arm	6	17.5	8.8		
98/09/24	0500847	Kala. D.B.	8	19.4	8.6			98/10/01	0500239	Arm. Arm	8	17.5	8.8		
98/09/24	0500847	Kala. D.B.	10	19.4	8.7			98/10/01	0500239	Arm. Arm	10	17.4	8.8		
98/09/24	0500847	Kala. D.B.	12	16.1	9.2			98/10/01	0500239	Arm. Arm	12	17.2	8.6		
98/09/24	0500847	Kala. D.B.	14	12.0	8.9			98/10/01	0500239	Arm. Arm	14	13.5	3.9		
98/09/24	0500847	Kala. D.B.	16	10.4	8.5			98/10/01	0500239	Arm. Arm	16	11.0	3.3		

98/09/24	0500847	Kala. D.B.	18	8.8	7.8			98/10/01	0500239	Arm. Arm	18	9.8	3.0		
98/09/24	0500847	Kala. D.B.	20	7.8	7.8			98/10/01	0500239	Arm. Arm	20	8.9	3.2		
98/09/24	0500847	Kala. D.B.	24	6.9	7.7			98/10/01	0500239	Arm. Arm	24	7.3	3.2		
98/09/24	0500847	Kala. D.B.	28	6.1	7.9			98/10/01	0500239	Arm. Arm	28	6.3	3.2		
98/09/24	0500847	Kala. D.B.	32	5.8	8.0			98/10/01	0500239	Arm. Arm	32	5.9	2.6		
98/09/24	0500847	Kala. D.B.	36	5.4	8.2			98/10/01	0500239	Arm. Arm	36	5.8	2.2		
98/09/24	0500847	Kala. D.B.	40	5.2	8.3			98/10/01	0500239	Arm. Arm	40	5.5	1.8		
98/09/24	0500847	Kala. D.B.	44	5.1	8.4			98/10/01	0500239	Arm. Arm	44	5.5	0.9		
98/10/04	E206611	Vern. Outfall	0	18.0	8.4	6.5		98/10/04	0500730	N. Ok. Centre	0	17.5	8.7	7.0	
98/10/04	E206611	Vern. Outfall	2	17.5	8.6			98/10/04	0500730	N. Ok. Centre	2	17.3	8.8		
98/10/04	E206611	Vern. Outfall	4	17.3	8.6			98/10/04	0500730	N. Ok. Centre	4	17.3	8.8		
98/10/04	E206611	Vern. Outfall	6	17.3	8.6			98/10/04	0500730	N. Ok. Centre	6	17.3	8.8		
98/10/04	E206611	Vern. Outfall	8	17.3	8.7			98/10/04	0500730	N. Ok. Centre	8	17.3	8.8		
98/10/04	E206611	Vern. Outfall	10	17.3	8.6			98/10/04	0500730	N. Ok. Centre	10	17.1	8.8		
98/10/04	E206611	Vern. Outfall	12	17.3	8.6			98/10/04	0500730	N. Ok. Centre	12	17.1	8.8		
98/10/04	E206611	Vern. Outfall	14	17.1	8.6			98/10/04	0500730	N. Ok. Centre	14	17.1	8.9		
98/10/04	E206611	Vern. Outfall	16	12.7	8.2			98/10/04	0500730	N. Ok. Centre	16	17.1	8.9		
98/10/04	E206611	Vern. Outfall	18	10.0	8.4			98/10/04	0500730	N. Ok. Centre	18	17.0	8.9		
98/10/04	E206611	Vern. Outfall	20	8.9	8.4			98/10/04	0500730	N. Ok. Centre	20	12.7	8.9		
98/10/04	E206611	Vern. Outfall	24	6.8	9.1			98/10/04	0500730	N. Ok. Centre	24	9.5	9.2		
98/10/04	E206611	Vern. Outfall	28	6.2	9.8			98/10/04	0500730	N. Ok. Centre	28	7.0	9.4		
98/10/04	E206611	Vern. Outfall	32	5.8	10.0			98/10/04	0500730	N. Ok. Centre	32	6.4	9.8		
98/10/04	E206611	Vern. Outfall	36	5.5	10.2			98/10/04	0500730	N. Ok. Centre	36	6.0	10.1		
98/10/04	E206611	Vern. Outfall	40	5.3	10.3			98/10/04	0500730	N. Ok. Centre	40	5.8	10.4		
98/10/04	E206611	Vern. Outfall	44	5.3	10.4			98/10/04	0500730	N. Ok. Centre	44	5.5	10.6		
98/10/06	E223295	Rattlesnake	0	16.7	9.0	8.3		98/10/06	0500454	S. Prairie Cr.	0	17.6	8.7	7.8	
98/10/06	E223295	Rattlesnake	2	16.5	9.1			98/10/06	0500454	S. Prairie Cr.	2	17.3	8.8		
98/10/06	E223295	Rattlesnake	4	16.5	9.1			98/10/06	0500454	S. Prairie Cr.	4	17.1	8.98.9		
98/10/06	E223295	Rattlesnake	6	16.5	9.1			98/10/06	0500454	S. Prairie Cr.	6	17.0	8.9		
98/10/06	E223295	Rattlesnake	8	16.5	9.1			98/10/06	0500454	S. Prairie Cr.	8	17.0	8.9		
98/10/06	E223295	Rattlesnake	10	16.5	9.1			98/10/06	0500454	S. Prairie Cr.	10	17.0	8.9		
98/10/06	E223295	Rattlesnake	12	16.5	9.1			98/10/06	0500454	S. Prairie Cr.	12	17.0	8.9		
98/10/06	E223295	Rattlesnake	14	15.5	9.2			98/10/06	0500454	S. Prairie Cr.	14	16.8	8.9		
98/10/06	E223295	Rattlesnake	16	12.3	9.9			98/10/06	0500454	S. Prairie Cr.	16	11.5	9.9		
98/10/06	E223295	Rattlesnake	18	10.0	10.2			98/10/06	0500454	S. Prairie Cr.	18	9.0	10.2		
98/10/06	E223295	Rattlesnake	20	8.3	10.2			98/10/06	0500454	S. Prairie Cr.	20	7.9	10.2		
98/10/06	E223295	Rattlesnake	24	7.1	10.2			98/10/06	0500454	S. Prairie Cr.	24	6.8	10.2		
98/10/06	E223295	Rattlesnake	28	6.5	10.2			98/10/06	0500454	S. Prairie Cr.	28	6.0	10.4		
98/10/06	E223295	Rattlesnake	32	6.0	10.4			98/10/06	0500454	S. Prairie Cr.	32	5.9	10.4		
98/10/06	E223295	Rattlesnake	36	5.8	10.5			98/10/06	0500454	S. Prairie Cr.	36	5.5	10.6		
98/10/06	E223295	Rattlesnake	40	5.8	10.6			98/10/06	0500454	S. Prairie Cr.	40	5.3	10.7		
98/10/06	E223295	Rattlesnake	44	5.5	10.7			98/10/06	0500454	S. Prairie Cr.	44	5.1	10.8		
98/10/25	0500847	Kala. D.B.	0	13.8		3.3		98/10/21	0500239	Arm. Arm	0	12.9	9.0	4.0	
	0500847	Kala. D.B.	2					98/10/21	0500239	Arm. Arm	2	12.9	8.9		
	0500847	Kala. D.B.	4					98/10/21	0500239	Arm. Arm	4	12.9	8.8		
	0500847	Kala. D.B.	6					98/10/21	0500239	Arm. Arm	6	12.9	8.8		
	0500847	Kala. D.B.	8					98/10/21	0500239	Arm. Arm	8	12.9	8.7		
	0500847	Kala. D.B.	10					98/10/21	0500239	Arm. Arm	10	12.9	8.7		
	0500847	Kala. D.B.	12					98/10/21	0500239	Arm. Arm	12	12.9	8.6		
	0500847	Kala. D.B.	14					98/10/21	0500239	Arm. Arm	14	12.7	8.6		
	0500847	Kala. D.B.	16					98/10/21	0500239	Arm. Arm	16	12.4	8.1		
	0500847	Kala. D.B.	18					98/10/21	0500239	Arm. Arm	18	10.1	2.2		
	0500847	Kala. D.B.	20					98/10/21	0500239	Arm. Arm	20	9.0	2.2		
	0500847	Kala. D.B.	24					98/10/21	0500239	Arm. Arm	24	7.3	2.4		
	0500847	Kala. D.B.	28					98/10/21	0500239	Arm. Arm	28	6.4	2.2		
	0500847	Kala. D.B.	32					98/10/21	0500239	Arm. Arm	32	6.0	1.9		
	0500847	Kala. D.B.	36					98/10/21	0500239	Arm. Arm	36	5.8	1.4		
	0500847	Kala. D.B.	40					98/10/21	0500239	Arm. Arm	40	5.6	0.9		
	0500847	Kala. D.B.	44					98/10/21	0500239	Arm. Arm	44	5.6	0.6		
98/10/21	E206611	Vern. Outfall	0	14.0	8.7	6.5		98/10/20	0500730	N. Ok. Centre	0	15.0	9.1	7.5	
98/10/21	E206611	Vern. Outfall	2	14.0	8.8			98/10/20	0500730	N. Ok. Centre	2	14.9	9.1		
98/10/21	E206611	Vern. Outfall	4	14.0	8.8			98/10/20	0500730	N. Ok. Centre	4	14.5	9.3		
98/10/21	E206611	Vern. Outfall	6	14.0	8.8			98/10/20	0500730	N. Ok. Centre	6	14.5	9.3		
98/10/21	E206611	Vern. Outfall	8	14.0	8.8			98/10/20	0500730	N. Ok. Centre	8	14.3	9.3		
98/10/21	E206611	Vern. Outfall	10	14.0	8.7			98/10/20	0500730	N. Ok. Centre	10	14.3	9.3		
98/10/21	E206611	Vern. Outfall	12	14.0	8.7			98/10/20	0500730	N. Ok. Centre	12	14.3	9.2		
98/10/21	E206611	Vern. Outfall	14	14.0	8.7			98/10/20	0500730	N. Ok. Centre	14	14.3	9.3		
98/10/21	E206611	Vern. Outfall	16	10.5	7.9			98/10/20	0500730	N. Ok. Centre	16	14.3	9.2		
98/10/21	E206611	Vern. Outfall	18	9.0	7.8			98/10/20	0500730	N. Ok. Centre	18	14.3	9.2		
98/10/21	E206611	Vern. Outfall	20	8.0	8.1			98/10/20	0500730	N. Ok. Centre	20	10.6	9.2		
98/10/21	E206611	Vern. Outfall	24	6.8	8.5			98/10/20	0500730	N. Ok. Centre	24	7.9	9.2		
98/10/21	E206611	Vern. Outfall	28	6.3	8.8			98/10/20	0500730	N. Ok. Centre	28	7.0	9.4		
98/10/21	E206611	Vern. Outfall	32	6.0	9.0			98/10/20	0500730	N. Ok. Centre	32	6.5	9.6		
98/10/21	E206611	Vern. Outfall	36	5.8	9.5			98/10/20	0500730	N. Ok. Centre	36	6.0	9.8		
98/10/21	E206611	Vern. Outfall	40	5.5	9.6			98/10/20	0500730	N. Ok. Centre	40	6.0	9.9		
98/10/21	E206611	Vern. Outfall	44	5.3	9.7			98/10/20	0500730	N. Ok. Centre	44	5.6	10.2		

98/10/27	E223295	Rattlesnake	0	12.3	10.0	8.0		98/10/27	0500454	S. Prairie Cr.	0	12.2	9.8	8.0	
98/10/27	E223295	Rattlesnake	2	12.3	9.9			98/10/27	0500454	S. Prairie Cr.	2	12.2	9.9		
98/10/27	E223295	Rattlesnake	4	12.3	9.9			98/10/27	0500454	S. Prairie Cr.	4	12.2	9.9		
98/10/27	E223295	Rattlesnake	6	12.3	9.9			98/10/27	0500454	S. Prairie Cr.	6	12.2	10.0		
98/10/27	E223295	Rattlesnake	8	12.3	9.9			98/10/27	0500454	S. Prairie Cr.	8	12.2	10.0		
98/10/27	E223295	Rattlesnake	10	12.3	9.9			98/10/27	0500454	S. Prairie Cr.	10	12.2	9.9		
98/10/27	E223295	Rattlesnake	12	12.2	9.9			98/10/27	0500454	S. Prairie Cr.	12	12.2	9.9		
98/10/27	E223295	Rattlesnake	14	12.2	9.8			98/10/27	0500454	S. Prairie Cr.	14	12.2	9.9		
98/10/27	E223295	Rattlesnake	16	12.2	9.8			98/10/27	0500454	S. Prairie Cr.	16	12.2	9.9		
98/10/27	E223295	Rattlesnake	18	12.2	9.8			98/10/27	0500454	S. Prairie Cr.	18	12.1	9.9		
98/10/27	E223295	Rattlesnake	20	11.9	9.8			98/10/27	0500454	S. Prairie Cr.	20	11.3	9.8		
98/10/27	E223295	Rattlesnake	24	8.4	9.7			98/10/27	0500454	S. Prairie Cr.	24	6.9	9.8		
98/10/27	E223295	Rattlesnake	28	6.8	9.7			98/10/27	0500454	S. Prairie Cr.	28	5.8	9.9		
98/10/27	E223295	Rattlesnake	32	5.8	9.7			98/10/27	0500454	S. Prairie Cr.	32	5.3	9.9		
98/10/27	E223295	Rattlesnake	36	5.4	9.8			98/10/27	0500454	S. Prairie Cr.	36	5.0	10.0		
98/10/27	E223295	Rattlesnake	40	5.0	9.9			98/10/27	0500454	S. Prairie Cr.	40	4.8	10.1		
98/10/27	E223295	Rattlesnake	44	4.9	10.0			98/10/27	0500454	S. Prairie Cr.	44	4.8	10.2		
	0500847	Kala. D.B.	0					98/11/30	0500239	Arm. Arm	0	7.5	11.0	3.0	
	0500847	Kala. D.B.	2					98/11/30	0500239	Arm. Arm	2	7.5	11.0		
	0500847	Kala. D.B.	4					98/11/30	0500239	Arm. Arm	4	7.5	11.0		
	0500847	Kala. D.B.	6					98/11/30	0500239	Arm. Arm	6	7.5	11.1		
	0500847	Kala. D.B.	8					98/11/30	0500239	Arm. Arm	8	7.5	11.0		
	0500847	Kala. D.B.	10					98/11/30	0500239	Arm. Arm	10	7.5	10.9		
	0500847	Kala. D.B.	12					98/11/30	0500239	Arm. Arm	12	7.5	10.8		
	0500847	Kala. D.B.	14					98/11/30	0500239	Arm. Arm	14	7.5	10.8		
	0500847	Kala. D.B.	16					98/11/30	0500239	Arm. Arm	16	7.5	10.8		
	0500847	Kala. D.B.	18					98/11/30	0500239	Arm. Arm	18	7.5	10.8		
	0500847	Kala. D.B.	20					98/11/30	0500239	Arm. Arm	20	7.5	10.8		
	0500847	Kala. D.B.	24					98/11/30	0500239	Arm. Arm	24	7.5	10.8		
	0500847	Kala. D.B.	28					98/11/30	0500239	Arm. Arm	28	7.5	10.8		
	0500847	Kala. D.B.	32					98/11/30	0500239	Arm. Arm	32	7.5	10.8		
	0500847	Kala. D.B.	36					98/11/30	0500239	Arm. Arm	36	7.2	10.2		
	0500847	Kala. D.B.	40					98/11/30	0500239	Arm. Arm	40	6.6	4.2		
	0500847	Kala. D.B.	44					98/11/30	0500239	Arm. Arm	44	6.5	2.9		
98/11/30	E206611	Vern. Outfall	0	9.1	10.6	8.5		98/11/30	0500730	N. Ok. Centre	0	9.4	10.2	8.3	
98/11/30	E206611	Vern. Outfall	2	9.1	10.6			98/11/30	0500730	N. Ok. Centre	2	9.0	10.4		
98/11/30	E206611	Vern. Outfall	4	9.0	10.7			98/11/30	0500730	N. Ok. Centre	4	9.0	10.4		
98/11/30	E206611	Vern. Outfall	6	9.0	10.7			98/11/30	0500730	N. Ok. Centre	6	9.0	10.4		
98/11/30	E206611	Vern. Outfall	8	9.0	10.7			98/11/30	0500730	N. Ok. Centre	8	9.0	10.4		
98/11/30	E206611	Vern. Outfall	10	9.0	10.7			98/11/30	0500730	N. Ok. Centre	10	8.8	10.5		
98/11/30	E206611	Vern. Outfall	12	99.0	10.7			98/11/30	0500730	N. Ok. Centre	12	8.8	10.5		
98/11/30	E206611	Vern. Outfall	14	9.0	10.7			98/11/30	0500730	N. Ok. Centre	14	8.8	10.5		
98/11/30	E206611	Vern. Outfall	16	9.0	10.7			98/11/30	0500730	N. Ok. Centre	16	8.8	10.5		
98/11/30	E206611	Vern. Outfall	18	9.0	10.7			98/11/30	0500730	N. Ok. Centre	18	8.8	10.6		
98/11/30	E206611	Vern. Outfall	20	9.0	10.7			98/11/30	0500730	N. Ok. Centre	20	8.8	10.5		
98/11/30	E206611	Vern. Outfall	24	8.9	10.6			98/11/30	0500730	N. Ok. Centre	24	8.8	10.5		
98/11/30	E206611	Vern. Outfall	28	8.9	10.7			98/11/30	0500730	N. Ok. Centre	28	8.8	10.5		
98/11/30	E206611	Vern. Outfall	32	8.7	10.7			98/11/30	0500730	N. Ok. Centre	32	8.8	10.5		
98/11/30	E206611	Vern. Outfall	36	7.8	10.7			98/11/30	0500730	N. Ok. Centre	36	8.5	10.4		
98/11/30	E206611	Vern. Outfall	40	7.0	10.6			98/11/30	0500730	N. Ok. Centre	40	7.8	10.2		
98/11/30	E206611	Vern. Outfall	44	6.5	10.6			98/11/30	0500730	N. Ok. Centre	44	7.0	10.2		
98/12/02	0500236	DNS Kel STP	0	8.2	10.4	8.5			E223295	Rattlesnake	0				
98/12/02	0500236	DNS Kel STP	2	8.0	10.7				E223295	Rattlesnake	2				
98/12/02	0500236	DNS Kel STP	4	8.0	10.7				E223295	Rattlesnake	4				
98/12/02	0500236	DNS Kel STP	6	8.0	10.7				E223295	Rattlesnake	6				
98/12/02	0500236	DNS Kel STP	8	8.0	10.7				E223295	Rattlesnake	8				
98/12/02	0500236	DNS Kel STP	10	8.0	10.7				E223295	Rattlesnake	10				
98/12/02	0500236	DNS Kel STP	12	8.0	10.7				E223295	Rattlesnake	12				
98/12/02	0500236	DNS Kel STP	14	88.0	10.7				E223295	Rattlesnake	14				
98/12/02	0500236	DNS Kel STP	16	8.0	10.7				E223295	Rattlesnake	16				
98/12/02	0500236	DNS Kel STP	18	8.0	10.7				E223295	Rattlesnake	18				
98/12/02	0500236	DNS Kel STP	20	7.8	10.8				E223295	Rattlesnake	20				
98/12/02	0500236	DNS Kel STP	24	7.5	10.7				E223295	Rattlesnake	24				
98/12/02	0500236	DNS Kel STP	28	7.0	10.6				E223295	Rattlesnake	28				
98/12/02	0500236	DNS Kel STP	32	6.8	10.6				E223295	Rattlesnake	32				
98/12/02	0500236	DNS Kel STP	36	6.6	10.6				E223295	Rattlesnake	36				
98/12/02	0500236	DNS Kel STP	40	6.5	10.7				E223295	Rattlesnake	40				
98/12/02	0500236	DNS Kel STP	44	6.3	10.8				E223295	Rattlesnake	44				

98/12/08	0500454	S. Prairie Cr.	0	5.6	10.8	10.5									
98/12/08	0500454	S. Prairie Cr.	2	5.6	10.7										
98/12/08	0500454	S. Prairie Cr.	4	5.6	10.6										
98/12/08	0500454	S. Prairie Cr.	6	5.6	10.6										
98/12/08	0500454	S. Prairie Cr.	8	5.6	10.6										
98/12/08	0500454	S. Prairie Cr.	10	5.6	10.6										
98/12/08	0500454	S. Prairie Cr.	12	5.6	10.6										
98/12/08	0500454	S. Prairie Cr.	14	5.6	10.6										
98/12/08	0500454	S. Prairie Cr.	16	5.6	10.6										
98/12/08	0500454	S. Prairie Cr.	18	5.6	10.6										
98/12/08	0500454	S. Prairie Cr.	20	5.6	10.6										
98/12/08	0500454	S. Prairie Cr.	24	5.6	10.6										
98/12/08	0500454	S. Prairie Cr.	28	5.6	10.6										
98/12/08	0500454	S. Prairie Cr.	32	5.6	10.6										
98/12/08	0500454	S. Prairie Cr.	36	5.6	10.6										
98/12/08	0500454	S. Prairie Cr.	40	5.6	10.6										
98/12/08	0500454	S. Prairie Cr.	44	5.6	10.6										