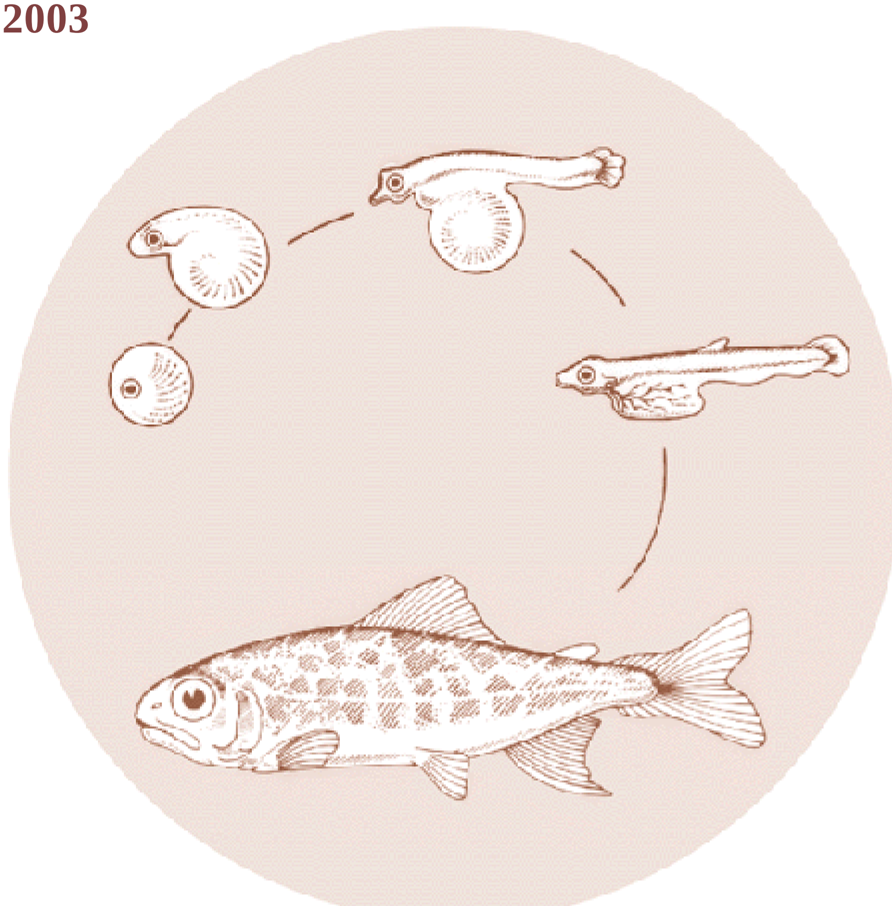
Coeur d'Alene Tribal Production Facility, Volume I of III

Submittal to the Northwest Power Planning Council

Technical Report
2003



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Coeur d'Alene Tribe Trout Production
Step 1 Submittal

January 2003

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Coeur d' Alene Tribal Hatchery
INTERDISCIPLINARY TEAM

The attached Step 1 submittal is the culmination of much hard work and dedication to the development of the Coeur d' Alene Tribe's cutthroat trout fishery plan. The development of the hatchery master plan has evolved through time, beginning with the introduction of the vision in the 1987 Northwest Power Planning Council's Fish and Wildlife Program. Since that time, much effort has been applied to the areas of data collection, fish management, and management planning. Most recently, the Coeur d' Alene Tribe assembled a diverse group of scientists to review and guide the project towards an updated hatchery master plan.

This assemblage of scientists agreed to form the Coeur d' Alene Hatchery Interdisciplinary Team (IDT) which is comprised of a diverse ensemble of fish scientists, aquaculture specialists, and engineers (see attached biographies). The team reviewed the voluminous amounts of existing information; participated in numerous site investigations; and assembled many times to engage in scientific discussions regarding the best scientific approach to the hatchery project. The (IDT) team was gratefully un-tethered in their review, deliberations, and final recommendations for the updated program.

The IDT agreed that a hatchery master plan would need defined near-term and long-term goals, measurable benchmarks, and strong monitoring and evaluation plans. These parameters led to the development of: 1) tribal subsistence related goals 2) significant research design and methodology and 3) monitoring and evaluation protocol.

The IDT felt that it was very important to build upon concerns and comments from previous review cycles. The team developed the updated master plan to be reflective, and mindful, of the past processes and peer review that the project had undergone.

As chair of the IDT, it gives me great pleasure to present the Coeur d' Alene Tribe Updated Hatchery Master Plan and the Step 1 submittal package. It is the sincere belief of the team that careful implementation of these guiding documents will ensure long-term sustainability, and understanding of the Coeur d' Alene Tribe's cutthroat trout fishery.

Sincerely,

Dr. Paul Anders, Chair
Coeur d' Alene Hatchery Interdisciplinary Team

Coeur d' Alene Tribal Hatchery

INTERDISCIPLINARY TEAM

Paul J. Anders, Ph.D.
Research Support Scientist II
University of Idaho

Paul has over seventeen years of fisheries research experience. He has been involved in a wide array of fisheries and aquatic ecology research. Paul authored or co-authored over 46 publications and reports involving fish genetics, population structure, early life history, reproductive biology, ecology, and conservation aquaculture.

Raymond C.P. Beamesderfer
Senior Fisheries Consultant
S.P. Cramer & Associates, Inc.

Ray has conducted original research and analyzed applied problems of fish biology for almost 20 years. He has extensive experience with salmon, steelhead, sturgeon, warmwater sportfish, and nongame species; has published numerous scientific articles on fish sampling, population dynamics, and species interactions; and has special expertise in the use of statistics and computer modeling to solve difficult fish questions.

Dr. Ernest Brannon
Director, Aquaculture Research Institute
University of Idaho

Ernie has nearly 50 years of experience related to fisheries management issues. Currently he a state aquaculture extension specialist, a professor of fisheries resources and animal science and director of the Aquaculture Research Institute at the University of Idaho. Dr. Brannon has authored numerous scientific publications and is well known for his contributions to fisheries science.

John Cussigh
Hatchery Scientist
JC Aquaculture

John is a world renowned expert in the life support requirements for an array of different fish species. John has assisted the design team on options and solutions for life support systems.

Douglas E. Ensor, P.E.
Civil Engineer
J-U-B Engineers, Inc.

Doug brings to the team over twenty years of applied engineering experience. He is a well respected engineer who specializes in hydraulics, water resources, irrigation, and fish passage issues. Doug has concentrated his efforts on water supply and site design for the proposed fish hatchery.

Jeffery Jay Jordan
Tribal Fisheries Biologist
Coeur d' Alene Tribe

Jeff has three years of professional experience in the evaluation and management of aquatic ecosystems. Currently he is serving as a tribal biologist on the trout production facility and is conducting a bathymetric study on Coeur d' Alene Lake.

Ron Peters
Fisheries Program Manager
Coeur d' Alene Tribe

Ron is responsible for the oversight, coordination and implementation of all fisheries projects undertaken be the Coeur d' Alene Tribe. Mr. Peters has over ten-years of professional experience in the evaluation and management of aquatic ecosystems. Prior to his tenure at the Coeur d' Alene Tribe, Ron was employed by the Quinault Indian Nation, in charge of their sockeye salmon management and water quality laboratory.

Dr. Dale R. Ralston
Ralston Hydrologic Services, Inc.

Dale presently serves as President of Ralston Hydrologic Services, Inc. based in Moscow, Idaho. He started the company in 2000 after taking an early retirement from the University of Idaho after 25 years of running the hydrology masters and P.h.D. programs. Dale has spent his entire career working in hydrogeology with research and consulting in topics as varied as well hydraulics, ground water management, contaminant characterization and remediation and design/construction of wells. Part of his consulting business involves teaching short-courses around the country for the National Ground Water Association.

Jason R. Scott, CFP
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Jason is a professional biologist providing expertise in aquatic research, aquatic habitat evaluation and enhancement, natural resource management, limiting factors analysis, and strategic watershed planning. Mr. Scott is currently working with the Coeur d' Alene Tribal staff on implementing a predation study on Coeur d' Alene Lake.

David L. Smith
Habitat Research Specialist
University of Idaho

David has a diverse background involving the integration of biology and engineering into solutions to complex environmental problems. His current research is focused on linking hydraulics and biology as it relates to salmonid habitat.

William T. Towey
Environmental Group Manager
J-U-B Engineers, Inc.

William has over a decade of experience with natural resource issues within the Columbia River Basin. He is the J-U-B project manager for the design and permitting of the Coeur d' Alene Hatchery. William is currently assisting the tribal efforts in their engagement in the regional three-step hatchery review process.

Executive Summary

In fulfillment of the NWPPC's 3-Step Process for the implementation of new hatcheries in the Columbia Basin, this Step 1 submission package to the Council includes four items:

1) Cover letter from the Coeur d'Alene Tribe, Interdisciplinary Team Chair, and the USFWS,
2) References to key information (Attachments 1-4),
3) The updated Master Plan for the Tribe's native cutthroat restoration project, and
4) Appendices

In support of the Master Plan submitted by the Coeur d'Alene Tribe the reference chart (Item 2) was developed to allow reviewers to quickly access information necessary for accurate peer review. The Northwest Power Planning Council identified pertinent issues to be addressed in the master planning process for new artificial production facilities. References to this key information are provided in three attachments: 1) NWPPC Program language regarding the Master Planning Process, 2) Questions Identified in the September 1997 Council Policy, and 3) Program language identified by the Council's Independent Scientific Review Panel (ISRP).

To meet the need for off-site mitigation for fish losses on the mainstem Columbia River, in a manner consistent with the objectives of the Council's Program, the Coeur d'Alene Tribe is proposing that the BPA fund the design, construction, operation, and maintenance of a trout production facility located adjacent to Coeur d'Alene Lake on the Coeur d'Alene Indian Reservation. The updated Master Plan (Item 3) represents the needs associated with the re-evaluation of the Coeur d'Alene Tribe's Trout Production Facility (#199004402). This plan addresses issues and concerns expressed by the NWPPC as part of the issue summary for the Mountain Columbia provincial review, and the 3-step hatchery review process.

Finally, item 4 (Appendices) documents the 3-Step process correspondence to date between the Coeur d'Alene Tribe and additional relevant entities. Item 4 provides a chronological account of previous ISRP reviews, official Coeur d'Alene fisheries program responses to a series of ISRP reviews, master planning documentation, and annual reports dating back to 1990.

Collectively, the materials provided by the Coeur d'Alene Tribe in this Step-1 submission package comprehensively assesses key research, habitat improvement activities, and hatchery production issues to best protect and enhance native cutthroat trout populations and the historically and culturally important tribal fisheries they support.

Master Plan and Supporting Documentation Reference Chart

In support of the master plan submitted by the Coeur d'Alene Tribe this reference chart was developed to help reviewers quickly access information contained in the plan. The Northwest Power Planning Council identified the following issues as ones that need to be addressed in the master planning process for new artificial production facilities. This document will act as a quick reference guide to the Tribe's responses to each of the individual issues. Unless otherwise noted, page numbers and section guides refer to locations in the master plan.

Attachment 1: Program Language Regarding Master Planning Process

- **project goals**;

  The project goal is to produce adfluvial cutthroat trout for harvest, research, conservation and tribal involvement purposes (See page 3 ,*Project Goal*).

- **measurable and time-limited objectives**;

  The four phased approach, which provides interim fishery benefits while the hatchery program is developed and becomes refined based on evaluations of critical uncertainties, is depicted on page 10 (*Phased Approach 3.2.2*).

- **factors limiting production of the target species**;

  Habitat conditions, predation, water levels (low) and temperatures (high) are some of the discussed limiting factors that influence population sizes for cutthroat trout (See page 20 (*Biological Requirements 5.4*)). Detailed research, monitoring, and evaluation design (Section 7), will address key limiting factors. Additional information is contained in the supplementation feasibility report.

- **expected project benefits (e.g., gene conservation, preservation of biological diversity, fishery enhancement and/or new information)**;

  Project objectives and benefits include: (1) Providing fishery opportunities that yield increased harvestable populations; (2) Increased understanding of population dynamics, gene conservation, carrying capacity, use of habitat, preservation of biological diversity, and limiting factors through rigorous research; (3) Allows the CDA tribe to become an active participant in fish conservation, fishery development and fish management (See page 6 (*Project Objectives and Benefits 2.0*)).

- **alternatives for resolving the resource problem**;

A combined rainbow trout and cutthroat trout production facility, a chinook-kokanee hatchery facility and a no action alternative were other alternatives studied prior to selecting the proposed action (See page 50 (*Alternatives to the proposed action 10.0*). Additionally, Scholz et.al. (1985) includes an assessment of different resource alternatives.

- **rationale for the proposed project**;

Declining resident fish populations (identified as unique populations) coupled with habitat impacts associated with decades of urbanization, conversions of forested lands to agricultural uses, and changes in lake conditions related to the construction of the Post Falls Dam have supported the rationale for a project of this magnitude (See page 3 (*Project Rationale 1.0*)).

- **how the proposed production project will maintain or sustain increases in production**;

At full production, the CDA trout facility is conservatively designed to hold a maximum of approximately 247,600 cutthroat (23,780 pounds) at various sizes and ages (See page 30 (*Table 8*). Research/M&E component will allow for adaptive management strategies through time.

- **the historical and current status of anadromous and resident fish in the subbasin**;

Current distribution and abundance of westslope cutthroat trout appear to be severely restricted when compared to historical conditions. Westslope cutthroat trout are now believed to persist in only 27% of their historical range. Rieman and Apperson (1989) estimated that populations considered as “strong” (greater than or equal to 50% of historical potential) by Idaho Department of Fish and Game (IDFG) remained in only 11% of the historical range within the State of Idaho. Currently only 4% of the existing populations are not threatened by hybridization with non-native salmonids (Rieman and Apperson 1989).
Large and diverse cutthroat trout populations remain in heavily-forested upper elevation portions of the St. Joe and Coeur d’Alene River basins. However, cutthroat populations in low elevation tributaries of Coeur d’Alene Lake have been severely impacted by cumulative impacts of habitat ecological community changes (See pages 16-18 (*5.2 Status*)).

- **the current (and planned) management of anadromous and resident fish in the subbasin**;

Since 2000, Idaho State regulations have limited the number of cutthroat harvested in the St. Joe and CDA systems to two per day and none between 8 and 16 inches (See page 28 *(Fishing and Fish Management 5.5.6*). The Coeur d'Alene Tribe has cooperatively adapted similar regulations on waters managed exclusively by the Tribe. Current and future harvest management plans are described on page 46 Section 8 *Harvest Plan.*

- **consistency of proposed project with Council policies, National Marine Fisheries Service recovery plans, other fishery management plans, watershed plans and activities**;

  The consistency of the proposed project with the aforementioned entities is described in pages 46-49 (See *Management Context 9.0-9.3*).

- **potential impact of other recovery activities on project outcome**;

  None identified.

- **production objectives, methods and strategies**;

  Table 9 displays the cutthroat trout production schedule (See page 29 (*Production Capacity 6.2*)). Release objectives are discussed in section 6.1(See page 29).

- **brood stock selection and acquisition strategies**;

  Sources of hatchery broodstock will be developed consistent with program fishery and conservation goals based on fish availability and a careful benefit risk analysis (See page 30 (*Broodstock Selection and Acquisition 6.3*)).

- **rationale for the number and life-history stage of the fish to be stocked, particularly as they relate to the carrying capacity of the target stream and potential impact on other species**;

  M&E will also focus on experimentation on the effects of density on life history strategy, inheritance of life history trait expression (resident vs. adfluvial), and the influence of habitat improvement on rearing density (Box 3, Table 12). Annual estimates of population abundance in study streams will direct hatchery release numbers, provide information on the role of habitat on life history selection, and ultimately provide programmatic direction for the hatchery regarding stock selection and breeding matrices. These activities will provide a framework to assess the impact of management actions on the abundance, distribution, and ultimately harvest of cutthroat trout in the Coeur d'Alene Lake basin. To measure the impact of management actions, the change in abundance of cutthroat trout will be monitored over the next four generations, or approximately 15 years (See pages 38-39 (*Resident-Adfluvial Interactions 7.2.3; Limiting Life Stages and Factors 7.2.4*)).

- **production profiles and release strategies**;

Annual production of cutthroat fingerlings and adults will require separate raceways (See page A-10; *Production Raceways*)).

- **production policies and procedures**;

  Operations will closely adhere to policies articulated in the Northwest Power Planning Council's (NPPC) Artificial Production Review (See page 9 (*Production Policies 3.1*)). Box 2, also on page 9, summarizes the policies to guide the use of artificial production.

- **production management structure and process**;

  (See page 10 (*Implementation Strategy 3.2*)).

- **related harvest plans**;

  The harvest plan's emphasis is to optimize conditions for expansion of wild stocks, while upholding a strict wild fish management policy for traditional fishing areas (see page 46 (*Harvest Plan 8.0*)).

- **constraints and uncertainties, including genetic and ecological risk assessments and cumulative impacts**;

  Ten limiting factors and critical uncertainties have been identified in Box 1 (See page 7 (*Limiting Factor Evaluations*)).

- **monitoring and evaluation plans, including a genetics monitoring program**;

  (See page 36 (*Core Monitoring Program 7.1*)).

- **conceptual design of the proposed production and monitoring facilities, including an assessment of the availability and utility of existing facilities;**

  Conceptual drawings can be located in Appendix A.

- **cost estimates for various components, such as fish culture, facility design and construction, monitoring and evaluation, and operation and maintenance.**

  Cost estimates are located on pages A-20 through A-23; the total estimated cost for the hatchery facility is $3,685,572.00.

ATTACHMENT 2: Questions Identified in the September 1997 Council Policy Document for FY98 Project Funding

- **Has the project been the subject of appropriate independent scientific review in the past? If so, how has the project responded to the results of independent review?**

  The Coeur d' Alene Hatchery has been peer reviewed by the ISRP and most recently by the Interdisciplinary Team. The previous 3-Step process review documentation can be found electronically in the Step 1 submittal package appendix. The Coeur d'Alene Tribe feels that all concerns described by entities including the NPPC and the ISRP have been taken into account. Additionally, the Tribe assembled a Team of Experts in ecology, supplementation and artificial production to provide the best solution to the Tribes harvest needs. This can be found in the newly revised master plan.

- **Have project sponsors demonstrated adequately at earlier stages that the project is consistent with the Council's policies on artificial/natural production in Section 7 (the specific concern of the Panel)? If not, can these points be demonstrated now?**

  The updated hatchery Master Plan addresses the Council's policies on artificial/natural production.

- **Is the final design of the project consistent with any master plan and preliminary design?**

  The hatchery is currently at the preliminary stages of design for the facility. The preliminary designs are located in the Master Plan in Appendix A.

- **If not, do the changes raise any underlying scientific questions for further review?**

  N/A

- **Has information about the project or its purposes changed in such a way to raise new scientific concerns?**

  No

- **Has the underlying science or the way it is understood changed so as to raise new scientific issues?**

  No

- **How technically appropriate are the monitoring and evaluation elements of the project?**

  See section 5.3 of the master plan developed by the Interdisciplinary Team.

- **Are there ways to obtain the same production benefits with facilities that are lower in cost or less permanent, should monitoring and evaluation later indicate that the effort be abandoned?**

  This issue was discussed by the Interdisciplinary Team. Final conclusions and recommendations can be found within the updated hatchery Master Plan.

ATTACHMENT 3: Program Language Identified by the ISRP

- **Measure 7.0D: Comprehensive environmental analysis assessing the impacts on naturally produced salmon of hatchery produced anadromous fish.**

Measure 7.0D of the Council's 1994 Fish and Wildlife Program calls for a comprehensive environmental analysis assessing the impacts on naturally produced salmon of hatchery produced anadromous fish. The primary question we would like to have addressed with regard to the project is, does the environmental assessment adequately deal with the question of interactions of hatchery-produced salmonids and naturally spawning salmonids and steelhead in the Columbia River Basin? If so, how? If not, what are the potential or posited interactions and impacts?

The final EA will discuss interactions with naturally produced salmonids. However, the revised Master Plan takes this into account with additional changes placed as conditions to the plan by the IRSP. The impacts to native stocks are expected to be minimal. The concept is to encourage mating on an experimental basis of f_1 hatchery progeny with native populations within the system with the intent of producing a self-sustaining fishable population within the project area. Numbers of hatchery fish allowed to pass into primary spawning areas will be monitored such that the hatchery population does not exceed the wild population. Catchable sterile releases within the project are also contemplated, with the intent of alleviating the issue of interactions of hatchery and wild fish on the spawning grounds.

- **Measure 7.1A: Evaluation of carrying capacity and limiting factors that influence salmon survival.**

Measure 7.1A of the Council's 1994 Fish and Wildlife Program calls for a basin-wide study on the ecology, carrying capacity, and limiting factors that influence salmon survival. The primary question we would like to have addressed with regard to this measure is, how does the project intend to address the issue of carrying capacity within the watershed(s) into which fish will be placed? Do these fish originate from the most appropriate native stock? Specifically, how will the artificial production which is proposed, impact natural production? What are the impacts on mainstem and ocean harvest? How are these impacts addressed?

This information can be found in the supplementation feasibility report as well as the master plan. Supplementation efforts are scheduled for times during natural emigration from the targeted tributaries to the lake. This action poses less likelihood of displacement of natives within the specific system because interaction with wild fish occurs during a time when the populations are less likely to be habitat limited. Stocking efforts are also planned into paired systems where the overall interaction can be monitored and evaluated for future adaptive management strategies. The release of migrating juveniles and catchable sized fish will alleviate risks associated with rearing habitat limitations. There is little risk or acceptable amounts of risk associated with the carrying capacity of the lake.

- **Measure 7.1C: Collection of population status, life history and other data on wild and naturally spawning populations of salmon and steelhead.**

  Measure 7.1C calls for the collection of population status, life history and other data on wild and naturally spawning populations of salmon and steelhead. The primary question we would like to have addressed with regard to this measure, especially with regard to listed species is, what biological baseline information on naturally spawning populations of salmon and steelhead have been collected, and what high priority populations and "provisional population units" have been identified? Does this baseline information include a profile on the genetic and morphological characteristics of wild and naturally spawning populations? What characteristics are to be maintained by management actions? What are the limiting factors for wild and naturally spawning populations? What is the natural carrying capacity for the identified populations? What monitoring of identified populations of salmon and steelhead is identified as part of the project? Are these efforts being coordinated with the USFWS? NMFS? If so, how?

  This information was addressed in the supporting documentation and outlined in Attachment 1 of this document. Baseline information has been completed for the targeted watersheds and been recorded in BPA reports since 1990. The Baseline data information includes genetic information of the species in question and the goal is to produce progeny with identical characteristics as those of wild/natural produce fish.

  At this time fish densities are believed to be extremely depressed in the targeted tributaries with imminent risk of extirpation and it is believed that by the time the Coeur d'Alene Tribe is able to release fish, the tributaries will be able to support many additional fish.
  All activities are coordinated with efforts of the USFWS regarding any ESA issues.

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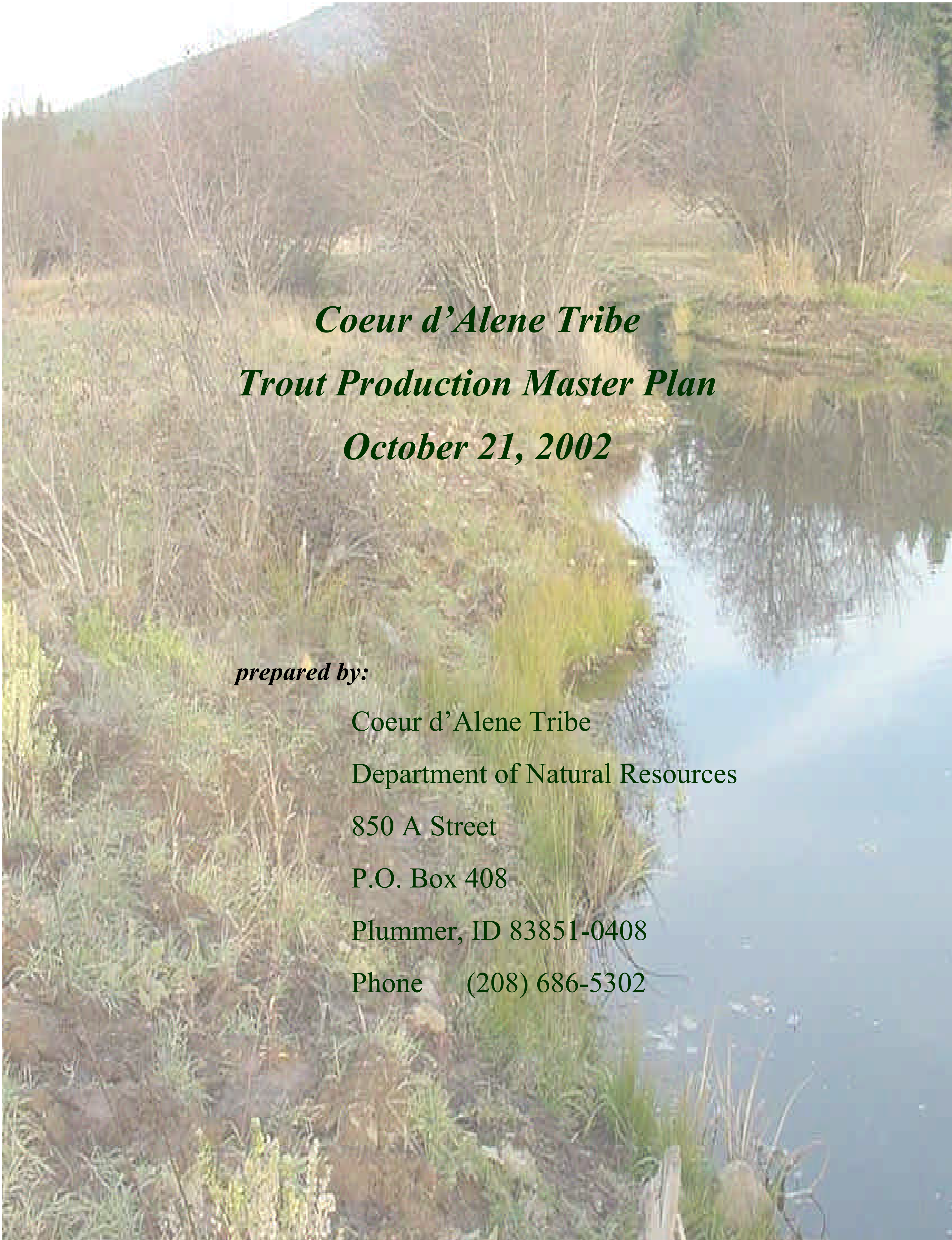
- **Measure 7.1F: Systemwide and cumulative impacts of existing and proposed artificial production projects on the ecology, genetics and other important characteristics of the Columbia River Basin anadromous and resident fish.**

  Measure 7.1F calls for a study to address the system wide and cumulative impacts of existing and proposed artificial production activities on the ecology, genetics and other important characteristics of Columbia River Basin anadromous and resident fish. This study is to be coordinated with the genetic impact assessment of Columbia River Basin hatcheries called for in measure 7.2A.2 of the Council's program. How does the project Final Environmental Assessment address the direct, indirect and cumulative effects of the proposed project production activities on anadromous and resident fish? Have those effects commonly associated with cumulative hatchery releases -- density dependent, competition, predation, disease transmission and genetic effects on other fish in the mainstem and oceanic environments been addressed? If so how? Have the genetic effects of project production on fish within and outside the Columbia River Basin been specifically addressed?`

  This information was addressed in the master plan as well as other supporting documentation. The EA or EIS will address direct, indirect and cumulative effects of the proposed project. No system wide effects are expected to be incurred. Effects will be contained within the confines of Coeur d'Alene Lake and through monitor and evaluation of activities of the facility changes will be made according to adaptive processes

  Genetic concerns are addressed in the Master Plan see Knudsen and Spruell 1999.



Coeur d'Alene Tribe

Trout Production Master Plan

October 21, 2002

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Table 12. Array of theoretical outcomes from increasing juvenile cutthroat trout densities in streams using adfluvial and resident broodstocks. Experimental treatment involves annually doubling juvenile rearing densities in all four streams during years 4-6 of this study. 44

EXECUTIVE SUMMARY

To meet the need for off-site mitigation for fish losses on the mainstem Columbia River, in a manner consistent with the objectives of the Council's Program, the Coeur d'Alene Tribe is proposing that the Bonneville Power Administration (BPA) fund the design, construction, operation, and maintenance of a trout production facility located adjacent to Coeur d'Alene Lake on the Coeur d'Alene Indian Reservation. This updated Master Plan represents the needs associated with the re-evaluation of the Coeur d'Alene Tribe's Trout Production Facility (#199004402). This plan addresses issues and concerns expressed by the NWPPC as part of the issue summary for the Mountain Columbia provincial review, and the 3-step hatchery review process.

A native fish re-introduction hatchery is the sole alternative for producing sufficient numbers of locally-adapted fish to meet harvest and research needs of the Coeur d'Alene Tribe. Facilities include a hatchery building, production raceways, broodstock raceways, and off-site acclimation sites. Specific objectives of the Coeur d'Alene tribal trout hatchery are to: 1) Provide interim fishery opportunities until such time as habitat measures can restore natural westslope cutthroat trout (*Oncorhynchus clarki lewisi*) populations to productive self-sustaining levels. 2) Identify factors limiting the viability and productivity of native cutthroat trout populations and resolve critical uncertainties in cutthroat biology and population dynamics that currently constrain preservation and restoration planning. 3) Experimentally evaluate the feasibility of conservation-based hatchery measures for cutthroat trout protection, restoration, and use, including reintroduction and supplementation. 4) Participate as an active and fully-vested partner in fish conservation, fishery development, and fish management.

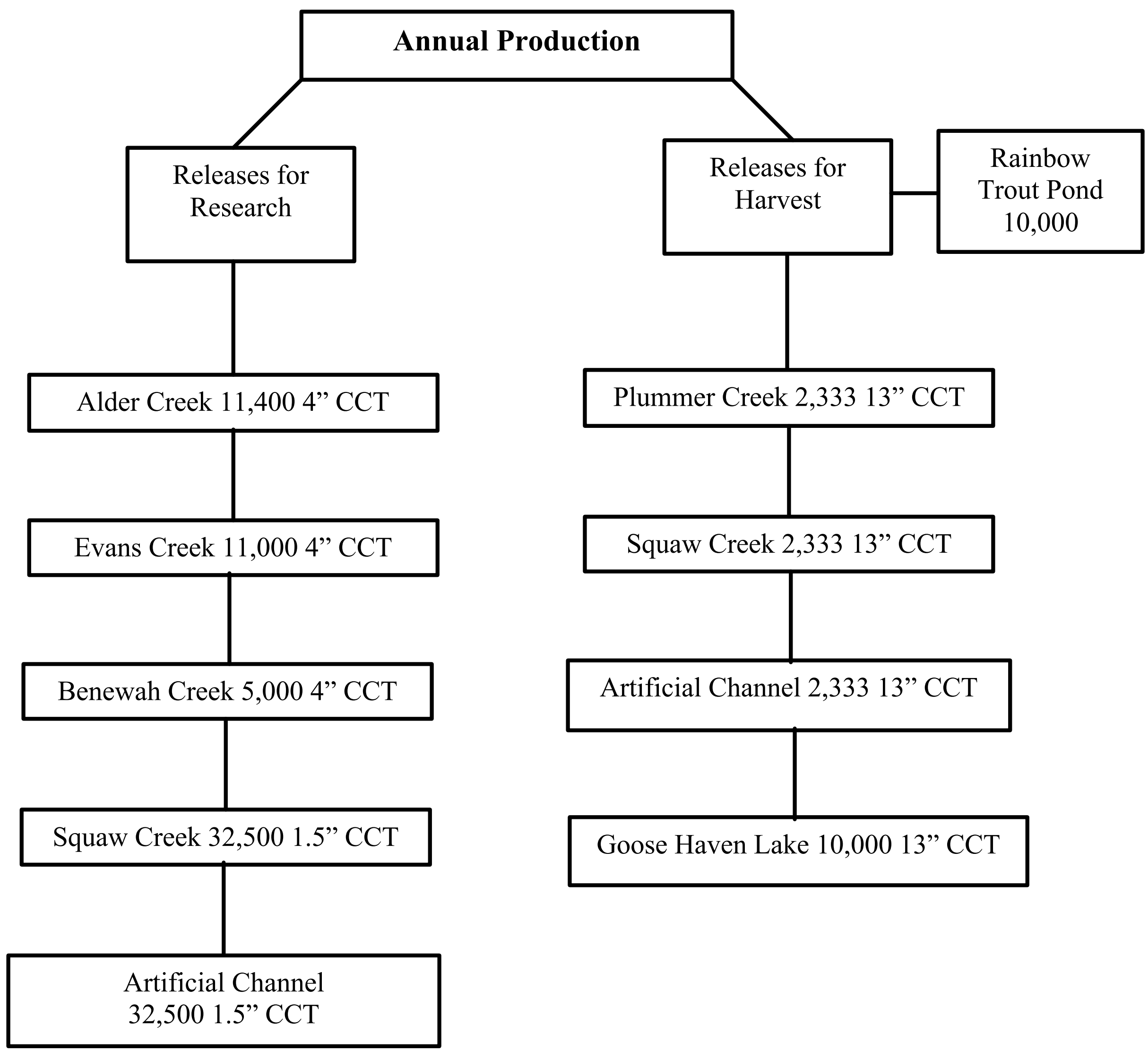
To optimize benefits, while avoiding the pitfalls of past hatchery activities, operations will closely adhere to policies articulated in the Northwest Power Planning Council (NPPC) Artificial Production Review. Hatchery activities will concentrate on native resident adfluvial cutthroat trout. Implementation will occur in phases to provide interim fishery benefits while the hatchery program is developed and refined based on evaluations of critical uncertainties. ***Phase 1*** allows for immediate harvest opportunities utilizing trout ponds for purchased rainbow trout release, ***Phase 2*** allows for harvest opportunities of released cutthroat trout in reservation streams currently lacking fishable populations, ***Phase 3*** calls for the re-establishment of sustainable native cutthroat trout populations in natal streams, and ***Phase 4*** represents the ultimate goal of providing sustainable harvest opportunities of cutthroat trout on the Coeur d' Alene Reservation. Successful habitat restoration is assumed to be a prerequisite to realizing Phases 3 and 4. The long-term health of native cutthroat trout populations will ultimately depend on effective habitat restoration measures currently being implemented by the Coeur d'Alene Tribe in cooperation with Federal, State, and local partners.

High priority will be placed on protecting remaining wild populations from significant fishery, genetic, and ecological risks. Thus, research and interim fishery development activities will be concentrated in streams that do not currently contain cutthroat trout. Ten critical uncertainties have been identified and are an integral part of this master plan. Answers to these uncertainties will refine production and release strategies for the hatchery program. The ten critical uncertainties are: 1) Efficient practices for producing significant numbers of adfluvial cutthroat trout from the hatchery. 2) Accessibility, use, and benefits of adfluvial cutthroat fisheries established using hatchery fish. 3) Relationship of resident and adfluvial life history traits in cutthroat trout. 4) Life stages and survival rates that currently regulate cutthroat trout population sizes. 5) Habitat and rearing density limitations on cutthroat trout production. 6) Constraints in tributaries associated with other species, especially including brook trout. 7) Interactions in stream habitats between hatchery and naturally-produced fish. 8) Interactions in lake between wild cutthroat, hatchery cutthroat, and potential fish predators. 9) Feasibility of using the hatchery to reintroduce resident and adfluvial cutthroat into streams where they do not currently exist. 10) Feasibility of hatchery supplementation to increase natural production of adfluvial fish in an existing population.

By implementing this phased approach, coupled with ongoing habitat restoration efforts, hatchery activities will be conducted consistent with the highest standards of fish management science.

Based on the production objectives identified by the Tribe, the facility will contribute 65,000 fingerlings (1.5 inches), 27,000 juveniles (4.0 inches), and either 20,000 adults (8-10 inches) or 17,000 adults (13 inches) at full capacity. At full production, the Coeur d'Alene trout facility is conservatively designed to hold a maximum of approximately 247,200 cutthroat (23,780 pounds) at various sizes and ages. It is anticipated that 6 to 8 years will be required to fully develop a cutthroat broodstock and achieve full cutthroat trout production. Releases of fish will target specific water bodies for research and harvest (Figure 1).

Figure 1. Annual Releases



PROJECT GOAL

The goal of the Coeur d’Alene Tribal Trout Hatchery and the applied fisheries research program addressed by this Master Plan is to produce adfluvial cutthroat trout for harvest, research, conservation, and tribal involvement purposes as partial mitigation for losses of anadromous fisheries caused by the construction and operation of the Federal Columbia River Power System.

1 PROJECT RATIONALE

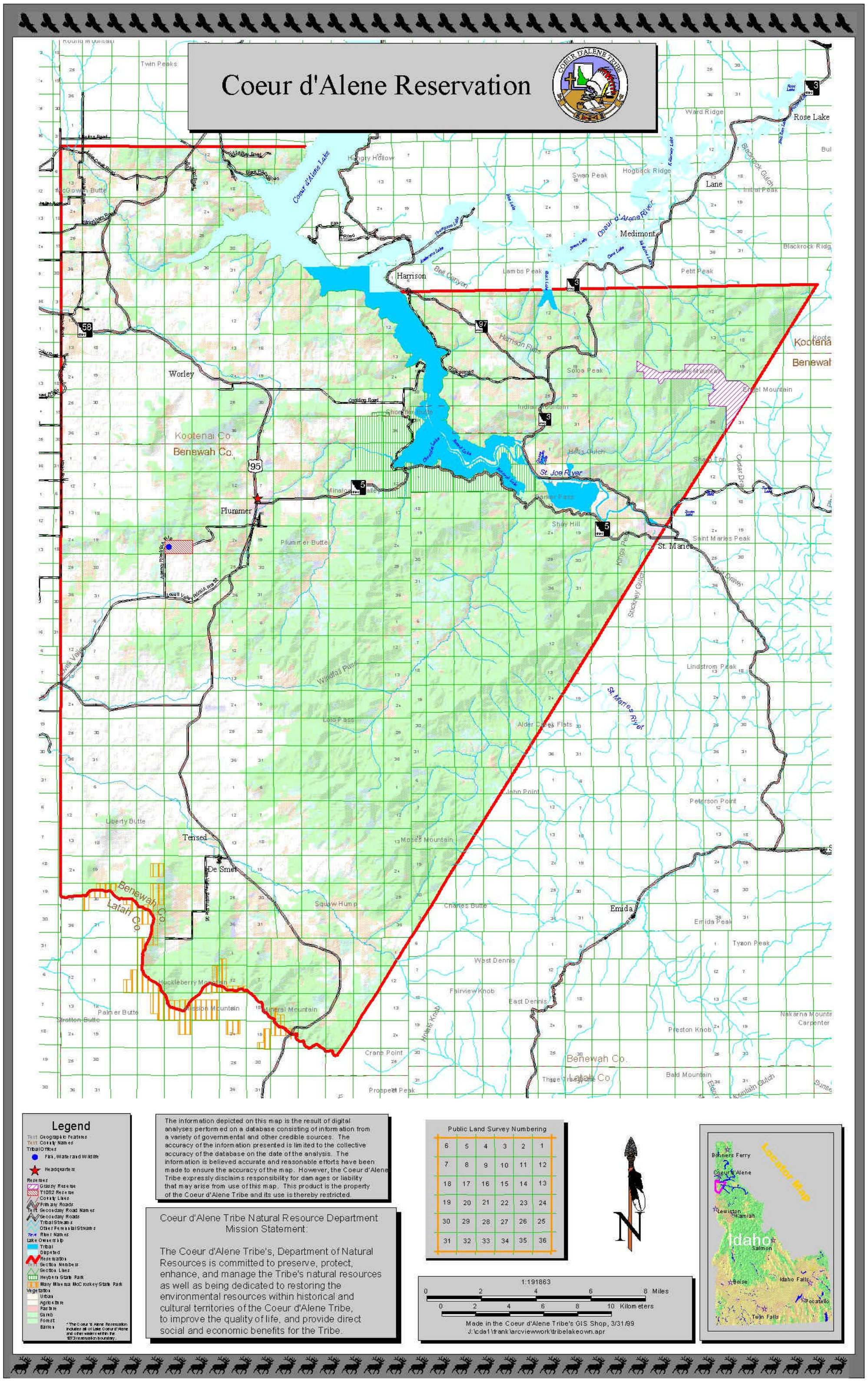
Completion of Grand Coulee Dam in 1941 irrevocably blocked upstream movements of anadromous salmon and steelhead and extirpated populations from hundreds of miles of rivers and streams. Loss of the salmon and inundation by the reservoir eliminated traditional Coeur d'Alene Tribal fishing areas and forced the Tribe to rely on the resident fish resources of Coeur d'Alene Lake. However, opportunities to harvest native resident fish have been severely limited by habitat impacts of urbanization, introduction of exotic fish species, conversion of forest lands to agriculture, and changes in lake conditions associated with Post Falls Dam.

Adfluvial westslope cutthroat trout historically supported productive traditional subsistence fisheries by Coeur d'Alene Tribal members and the general Coeur d’Alene Reservation community. Adfluvial cutthroat spawn and rear in tributaries associated with the lake and migrate to the lake to feed, grow, and mature. Prior to basin development, cutthroat trout were among the most abundant resident fish species in Coeur d'Alene Lake according to written accounts from Euro-American settlers and oral testimony from Coeur d'Alene Tribal Members. Historic catches of cutthroat trout by the Coeur d’Alene Tribe were estimated at 42,000 fish per year (Scholz et. al. 1985).

Habitat changes have collapsed cutthroat trout fisheries and placed the adfluvial life history at risk, especially in low elevation tributaries such as those found throughout the Coeur d’Alene Indian Reservation. (Figure 2) The patchwork of remnant cutthroat populations represent subpopulations at different risks of extinction. Populations have been fragmented and restricted to core production areas as basin development and land use reduced habitat availability and degraded habitat quality. Habitat fragmentation and patch sizes have been widely related to sustainability of trout populations (Dunham et al. 1997, Rieman and Allendorf 2001). Small effective breeding populations contribute to loss of diversity which also reduces productivity and increases extinction risk (Soule 1980, Lande and Barrowclough 1987, McElhany et al. 2000). Very small population sizes result in inbreeding depression and depensatory processes that hasten the slide to extinction (Thompson 1991). Thus, relatively large areas of suitable habitat continue to support significant cutthroat populations. Populations in marginal habitats are smaller, less diverse, and at significant risk of extinction. Finally, populations in small or unsuitable areas have been extirpated.

Cutthroat trout in low elevation tributaries of Coeur d’Alene Lake represent unique populations that are the sole surviving remnants of much more widely distributed historic stocks. These populations are likely adapted to a specific suite of local environmental conditions. Low elevation tributaries are typically small and subject to wide seasonal and annual variation in flow and temperature conditions. Habitat conditions are more heavily influenced by storm cycles than spring snowmelt and timing of spring runoff is much earlier than from higher elevation tributaries. Summer flows are typically much lower and water temperatures much warmer than winter and spring conditions. Adfluvial life history expression is an effective strategy for capitalizing on seasonally available tributary spawning and rearing habitats.

Figure 2. Map of Coeur d'Alene Indian Reservation



The long term health of native cutthroat trout populations ultimately depends on effective habitat restoration measures currently being implemented by the Coeur d'Alene Tribe in cooperation with Federal, State, and local partners. However, habitat restoration is a slow process and reliance on habitat measures alone may not be adequate to preserve existing populations or to rebuild population productivity throughout the historic range. Nor will habitat measures alone provide significant fishing opportunities during the interim until productive self-sustaining cutthroat trout populations can be rebuilt. More aggressive actions are needed to preserve existing population diversity, restore fish productivity, and provide fishing opportunities. All of these needs can be addressed with a carefully designed, implemented, and evaluated hatchery program. A hatchery provides the means for implementation of an aggressive, experimental approach to resolving fundamental uncertainties in current limiting factors, testing potential risks and benefits of hatchery use, and providing interim fishery opportunities. Past production programs by the Idaho Department of Fish and Game have demonstrated the efficacy of a hatchery approach for producing cutthroat trout in the system (see for instance Ortman 1972).

Hatcheries are a tremendously powerful tool for fishery development and fish conservation. In areas cut off from anadromous runs or faced with severe habitat degradation, hatcheries provide one of the few feasible alternatives for providing significant fishery mitigation. Historically, most artificial production facilities in the Columbia Basin were operated solely for harvest objectives with little regard or understanding of direct and indirect interactions between hatchery and natural production (Cone and Ridlington 1996, NRC 1996, Lichatowich 1999). A growing volume of evidence highlights the natural production risks inherent in such a one-sided approach. In reaction to problems associated with past hatchery practices, the pendulum of popular opinion subsequently swung in the opposite direction with hatcheries widely vilified as the root cause of many problems. However, recent assessments have determined that the truth lies in between – that a well designed hatchery program can be an effective tool for fish production for both harvest purposes and conservation of natural fish populations.

Hatchery methods and applications have undergone extensive reviews by a series of agencies and independent review boards. Significant reviews are contained in *Return to the River* by the Independent Scientific Group (1996), Report of the National Fish Hatchery Review Panel (1994), *Upstream: Salmon and Society in the Pacific Northwest* by the National Academy of Science (1996), the *Supplementation in the Columbia Basin* Regional Assessment of Supplementation Project (RASP) Bonneville Power Administration (1992), and NWPPC's basin-wide Artificial Production Review. Based on the evaluations and recommendations contained in these reviews, hatchery programs for harvest mitigation purposes have been widely revised to protect naturally-spawning fish populations and new programs have been initiated to preserve threatened or endangered species, reintroduce extirpated populations, and supplement natural production of depressed stocks.

2 PROJECT OBJECTIVES & BENEFITS

Specific objectives of the Coeur d'Alene Tribal Trout Hatchery are:

1. Provide interim fishery opportunities until habitat measures can restore natural cutthroat trout populations to productive self-sustaining harvestable levels.
2. Identify factors limiting the viability and productivity of native cutthroat trout populations and resolve critical uncertainties in cutthroat biology and population dynamics that currently constrain preservation and restoration planning.
3. Experimentally evaluate the feasibility of conservation-based hatchery measures for cutthroat trout protection, restoration, and use, including reintroduction and supplementation.
4. Participate as an active and fully-vested partner in fish conservation, fishery development, and fish management.

2.1 Fishing Opportunity

A primary benefit of the trout production program will be an increased and consistent opportunity for harvest by Coeur d'Alene Tribal members and surrounding communities. Fish populations in southern Coeur d'Alene Lake are currently dominated by nongame species that provide little harvest opportunity, especially in shallow waters of the lake created adjacent to the Reservation by construction of Post Falls Dam. Significant lake fisheries are limited to introduced species including kokanee and fall chinook although the fall chinook fishery is concentrated in the north end of the lake where juvenile hatchery chinook are released. Harvest objectives will be addressed by production of adfluvial cutthroat trout for release in reservation streams or standing waters where risks to natural populations can be better controlled. The facility will also be used, where cost effective, to produce or grow out rainbow trout for release into five isolated catchout ponds that provide a 'put and take' sport fishery on the reservation.

As natural cutthroat trout productivity is restored to fishable levels by the combination of habitat and population enhancement measures, hatchery-based adfluvial cutthroat and rainbow trout fisheries will be reduced or phased out. However, given the extent of habitat loss from the encroachment of man into the riparian and adjacent lands of tributaries on the Coeur d'Alene Indian Reservation, it is unlikely that natural production in a partially-recovered ecosystem would support all tribal subsistence, and sport harvest interests. In this case, policy options would include (a) scale fishery expectations consistent with the realized capacity of the system based on managed natural populations, or (b) manage for greater harvest potential from a combination of natural and hatchery production focusing harvest efforts primarily on hatchery produced fish. The option ultimately selected will depend on the actual productivity of the recovered ecosystem.

2.2 Limiting Factor Evaluations

Project benefits also include an improved understanding of limiting factors and the effectiveness of alternative recovery measures. Effective protection and restoration efforts for depleted adfluvial cutthroat populations are constrained by fundamental uncertainties in biology and population dynamics (Box 1). Many of these questions are best addressed with experiments using hatchery-reared progeny of locally adapted wild parents. With this approach, hatchery production contributes to needed production goals for restoration and experimental purposes, and the use of native broodstock is designed to provide locally adapted genotypes, phenotypes, behaviors, and life history expressions. Analyses are currently constrained by low numbers of wild fish remaining in the system and a long time frame required to investigate these questions based on monitoring of temporal variation in the system. The hatchery program provides the means of producing significant numbers of fish in a controlled setting to experimentally estimate stage-specific survival rates, determine if adfluvial fish can be produced from resident parents, and weigh the significance of density dependence and habitat effects. In addition, a series of small lake tributaries with and without existing cutthroat populations provide experimental units for carefully controlled study designs that also protect existing natural cutthroat trout populations.

Box 1. Critical Uncertainties Regarding Cutthroat Trout Use, Limiting Factors, and Restoration

1. Efficient practices for producing significant numbers of adfluvial cutthroat trout from the hatchery.
2. Accessibility, use, and benefits of adfluvial cutthroat fisheries established using hatchery fish.
3. Relationship of resident and adfluvial life history traits in cutthroat trout.
4. Life stages and survival rates that currently regulate cutthroat trout population sizes.
5. Habitat and rearing density limitations on cutthroat trout production.
6. Constraints in tributaries associated with other species, especially including brook trout.
7. Interactions in stream habitats between hatchery and naturally-produced fish.
8. Interactions in lake between wild cutthroat, hatchery cutthroat, and potential fish predators.
9. Feasibility of using the hatchery to reintroduce resident and adfluvial cutthroat into streams where they do not currently exist.
10. Feasibility of hatchery supplementation to increase natural production of adfluvial fish in an existing populations.

2.3 Reintroduction & Supplementation Experiments

A third project benefit is the opportunity to use a controlled experimental evaluation of the feasibility of reintroduction and supplementation. Mellina and Hinch (1995) noted that paired streams offered the best opportunity to determine causality between salmonid production and habitat management. The series of small streams draining into southern Coeur d'Alene Lake provide a perfect series of paired reference and experimental systems that support carefully controlled experiments to evaluate fundamental assumptions of supplementation alternatives for increasing natural fish production. Supplementation involves stocking fish into the natural habitat to increase the abundance of naturally reproducing fish populations. Risks and benefits of supplementation are currently a subject of intense debate throughout the region. Local empirical evaluations provide the best hope for informing this debate but effective research designs for anadromous species are confounded by the large scale of out-of-basin impacts that must be considered.

Unlike many traditional hatchery programs, the objective of supplementation is to increase the abundance of a naturally reproducing fish populations while maintaining the long-term genetic fitness and ecological function of the target population. A supplementation hatchery program theoretically provides a survival advantage to depressed stocks by increasing early life history survival rate (egg through smolt) relative to its survival rate under natural conditions. Thus, supplementation can theoretically boost population size to reduce extinction risks, ensure seeding of habitat to capacity, and minimize risks to natural populations associated with harvest.

However, the concept of supplementation is still relatively new and uncertainties remain about its effectiveness and safety (Cuenco et. al. 1993). It remains unclear whether fish can be reared in the hatchery without significant changes in genetic composition, behavior, or health that may prove detrimental to wild population and offset intended hatchery survival benefits. Past examples of supplementation include some apparent successes (e.g. Hanford bright fall chinook) but also some conspicuous failures (Oregon coastal coho). Supplementation has proven particularly successful in reintroducing native species after suitable habitat conditions were restored (e.g. Umatilla River spring chinook, Sandy River spring chinook).

Supplementation assumptions and effectiveness can be evaluated for cutthroat trout in reservation tributaries to Coeur d'Alene Lake using a carefully-controlled combination of naturally and captively produced progeny of wild parents. Key assumptions include the availability of underseeded rearing habitat, the importance of density dependent population processes, and the ability to rear fish in a hatchery that does not compromise wild populations. Hatchery-produced fish also provide the means to experimentally evaluate the feasibility of reintroducing cutthroat trout into tributaries where they have been extirpated by habitat conditions. Many of these streams may support significant cutthroat production during average or wet years, and therefore may provide an alternative to increasing fish numbers with minimal risk to existing populations.

2.4 Tribal Involvement

Although the Coeur d'Alene Tribal Trout Hatchery is necessary to address critical biological issues, the program also provides significant social benefits to the Tribe and the local community. Restoration of fisheries and operation of the hatchery will enhance tribal and local economies as well as fulfilling legal/policy obligations. Hatchery development and operation will also enhance the opportunity of the Tribe for participation as an active and fully-vested partner in fish conservation, fishery development, and fish management. Blum and Bodi (1996) noted that development of fish biology and management expertise by Columbia Basin tribes has resulted in more effective interaction with state and federal agencies on a government-to-government basis. Tribal biologists have added important new perspectives to the science of fish management, helped advance the state of the art, and established an effective alliance to facilitate habitat protection efforts (Blum and Bodi 1996).

3 PROJECT IMPLEMENTATION

3.1 Production Policies

Operations will closely adhere to policies articulated in the Northwest Power Planning Council's (NPPC) Artificial Production Review. In 1997, Congress directed the NPPC to review all federally funded artificial production facilities in the Columbia River basin in order to establish a set of policies to be used in operating these facilities. Their goal, as well as, the goals of the other reviewing agencies and independent review boards was to establish a set of scientifically based hatchery operating principles to guide operations to more effectively reach recovery and harvest goals. These performance standards and indicators are detailed in the September 15th, 1999 Draft *Artificial Production Review Volume I Report and Recommendations of the Northwest Power Planning Council*, Council document 99-13 and summarized in Box 2.

Box 2. Policies to Guide Use of Artificial Production

1. The manner of use and the value of artificial production must be considered in the context of the environment in which it will be used.
2. Artificial production must be implemented within an experimental, adaptive management design that includes an aggressive program to evaluate benefits and address scientific uncertainties.
3. Hatcheries must be operated in a manner that recognizes that they exist within ecological systems whose behavior is constrained by larger-scale basin, regional and global factors.
4. A diversity of life history types and species needs to be maintained in order to sustain a system of populations in the face of environmental variation.
5. Naturally selected populations should provide the model for successful artificially reared populations, in regard to population structure, mating protocol, behavior, growth, morphology, nutrient cycling, and other biological characteristics.
6. The entities authorizing or managing a hatchery facility or program should explicitly identify whether the artificial propagation product is intended for the purpose of augmentation, mitigation, restoration, preservation, research, or some combination of those purposes for each population of fish addressed.
7. Decisions on the use of the artificial production tool need to be made in the context of deciding on fish and wildlife goals, objectives and strategies at the subbasin and province levels.
8. Appropriate risk management needs to be maintained in using the tool of artificial propagation.
9. Production for harvest is a legitimate management objective of artificial production, but to minimize adverse impacts on natural populations associated with harvest management of hatchery populations, harvest rates and practices must reflect or be dictated by the requirements to sustain naturally spawning populations.
10. Federal and other legal mandates and obligations for fish protection, mitigation, and enhancement must be fully addressed.

3.2 Implementation Strategy

The program is designed foremost to protect and complement existing natural production. It will be implemented within an experimental, adaptive management design that includes an aggressive research, monitoring, and evaluation program to thoroughly evaluate fundamental assumptions including those which would determine whether a supplementation program should be developed at some future date. The facility and program will thus initially address a combination of research, preservation, and mitigation purposes. Activities of a Coeur d'Alene hatchery program are expected to evolve over time based on results of initial evaluations. Augmentation and restoration uses would be contingent on research results. Specific implementation strategies include:

3.2.1 Adfluvial Cutthroat Trout.

Concentrate hatchery activities on native resident adfluvial cutthroat trout. The adfluvial life stage has suffered serious declines and its loss would represent a significant reduction in the diversity and potential productivity of the species. Westslope cutthroat is a species of special concern throughout the region, and have provided meaningful traditional fisheries.

3.2.2 Phased Approach.

Implement a phased approach that provides interim fishery benefits while the hatchery program is developed and refined based on evaluations of critical uncertainties. Provision of harvest opportunities will be achieved in four sequential and additive project phases (Figure 3).

Phase 1 involves immediate provision of harvest opportunities. Five rainbow trout fishing ponds on the Coeur d'Alene reservation will provide immediate harvest opportunities in partial fulfillment of mitigation for lost anadromous fish resources.

Phase 2 provides a put-and-take cutthroat trout fishery in reservation streams currently lacking fishable populations. Following completion and successful operation, the hatchery will produce captively-reared progeny of wild parents for release into streams for put-and-take cutthroat trout fisheries. This phase of the project will simultaneously address the feasibility of enhancing existing wild populations and re-establishing and creating populations where they currently do not exist. Phase 2 is expected to require 6-8 years after hatchery completion.

Phase 3 involves re-establishment of sustainable native cutthroat trout populations in natal streams. Phase 3 recognizes that re-establishment of sustainable populations must precede provision of sustainable harvest opportunities. Thus, after immediate harvest opportunities are successfully provided by the rainbow trout ponds (Phase 1) and put-and-take cutthroat fisheries (not sustained by natural production; Phase 2), Phase 3 focuses on creation of sustainable native cutthroat populations on the Coeur d'Alene Reservation. Phase 3 is expected to begin 13 years after hatchery completion.

Phase 4 involves sustainable harvest of native cutthroat populations in reservation streams. Completion of this final phase is designed to provide sustainable harvest fishing opportunities on the Coeur d'Alene Reservation. The distinction between Phase 3 and Phase 4 is based on the important notion that sustainable populations (Phase 3) are prerequisites for sustainable harvest (Phase 4). Representing the ultimate goal of this Master Plan, Phase 4 can only be accomplished after completion of the previous phases. Furthermore, Phase 4 completion is predicated on increasing the availability of suitable habitat and enhancing natural production, in conjunction with increased fish numbers from the hatchery to first identify limiting factors (e.g. spawning and/or rearing habitat, predation) to ultimately provide sustainable harvest. Phase 4 is contingent upon rebuilding survival and growth rates of wild populations.

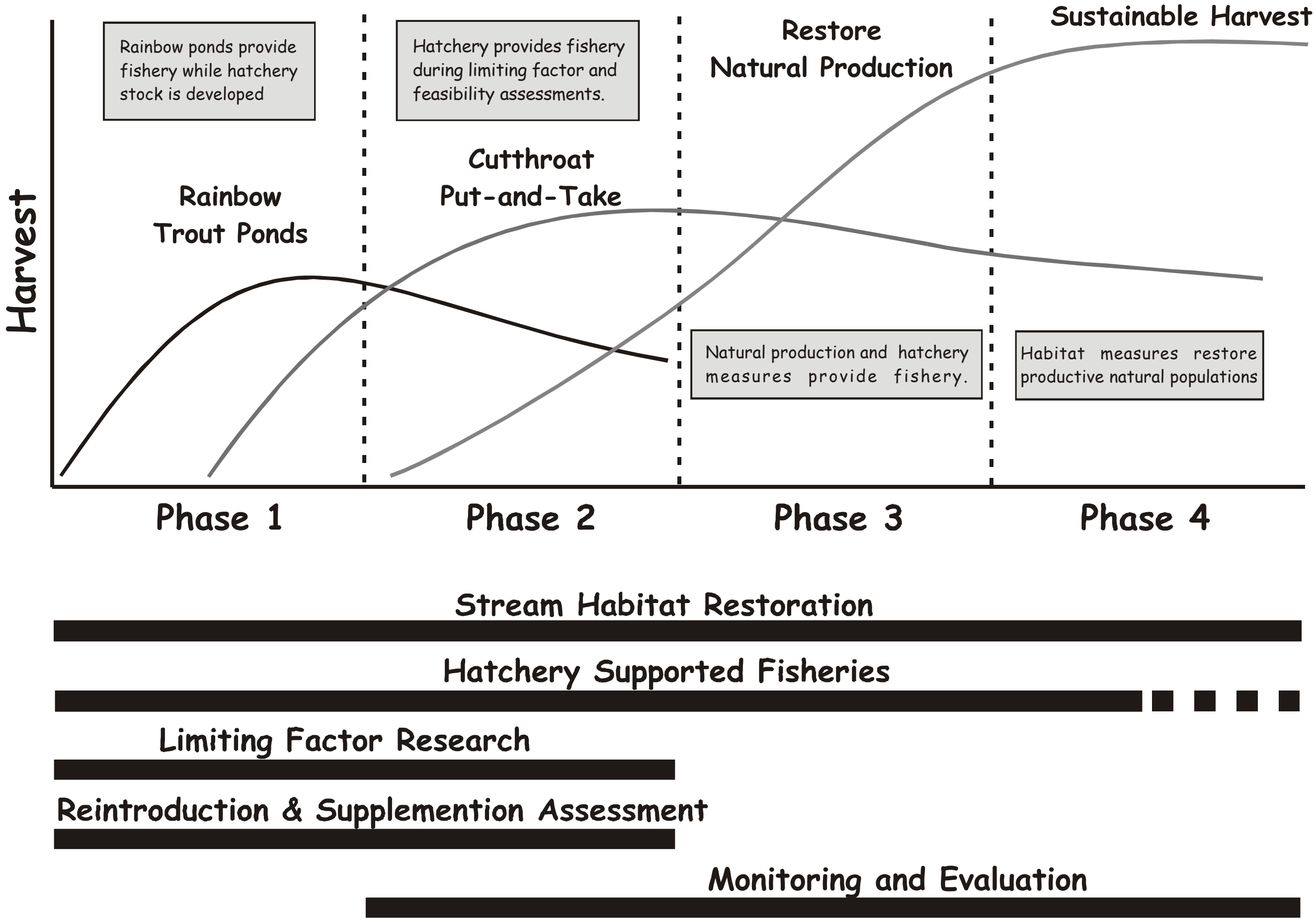


Figure 3. Coeur d'Alene Trout Production Facility Implementation Phases

3.2.3 Wild Fish Protection

Protect remaining wild populations from significant fishery, genetic, and ecological risks by concentrating research and interim fishery development activities, wherever possible, in streams that do not currently contain cutthroat trout. Current natural production levels are not sufficient to sustain significant harvest impacts. Any added mortality is likely to collapse adfluvial populations in these marginal habitats. Existing production is not sufficient to support meaningful tribal subsistence or mitigation uses. Thus, Genetic and ecological hazards associated with supplementation currently exist (e.g. extinction, inbreeding depression, loss of within-and among-population genetic variability). Therefore, aggressive supplementation activities are not appropriate at this time outside the context of a carefully controlled supplementation experiment. However, the risks associated with these hazards (i.e. their probability of occurrence) is currently unknown. Thus, supplementation experiments in streams with natural populations are appropriate as long as significant portions of the existing stock are protected. For instance, a series of experiments using paired treatment and control streams is planned for Benewah/Lake, Evans/Cherry, and Alder/Hells Gulch creeks. Hatchery-origin fish will not be released into control streams. Benewah Creek (treatment)/Lake Creek (control) pair will be used to test whether acclimation sites are a suitable supplementation strategy. Evans Creek (treatment) and Cherry Creek (control) will be used to evaluate if out-planting is a suitable strategy. Alder Creek and Hells Gulch Creek will be used to estimate the effects of brook trout removal. No hatchery reared fish will be placed in these two streams during the initial research portion of the project. Treatment streams, currently lacking, cutthroat populations such as Plummer and Squaw creeks, also provide the opportunity to conduct research on limiting factors and hatchery measures, and to develop fisheries with minimal risk to existing populations. Work in these areas can also be used to evaluate the potential for reintroduction. (See Section 9 for details on experimental design.)

3.2.4 Hatchery and Habitat Integration

Closely integrate hatchery and habitat activities. The small systems of the reservation are areas where relatively small investments can be made with significant effect. Stabilization and recovery of cutthroat stocks is thus imminently feasible in contrast to many of the other fish problems in the basin. Habitat research, monitoring, and evaluation activities are detailed in Vitale et al. (2002).

3.2.5 Scientific Standards

Conduct work consistent with the highest standards of fishery science and fish management. Project implementation and adjustments will be based on a scientifically rigorous monitoring and evaluation plan consistent with the standards applied by the Interdisciplinary Team in development of this Master Plan. Future decisions regarding program direction including supplementation will be based on scientific peer review of results and conclusions by state and federal co-managers and independent scientists.

4 BASIN DESCRIPTION

The Coeur d'Alene subbasin lies in three north Idaho counties Shoshone, Kootenai and Benewah. The basin is approximately 3840 square miles and extends from the Coeur d'Alene Lake upstream to the Bitterroot Divide along the Idaho-Montana border. Elevations range from 2,120 feet at the lake to over 7,000 feet along the divide. A portion of the watershed lies within the boundaries of the Coeur d’Alene Indian Reservation.

Coeur d'Alene Lake is the principle waterbody in the subbasin. The lake is the second largest in Idaho and is located in the northern panhandle section of the state (Figure 2). Population centers are located on the Northern most shoreline of Coeur d'Alene Lake (Coeur d'Alene) and at the mouth of the Coeur d'Alene River (Harrison). The lake is located in two Idaho counties: Kootenai and Benewah. The city of Coeur d'Alene is the largest in Kootenai County and Harrison is the second largest in Kootenai County. The largest town in Benewah County (St. Maries) lies about 12 miles upstream of Coeur d'Alene Lake on the St. Joe River.

Coeur d'Alene Lake occupies a naturally dammed river valley with the outflow currently controlled by Post Falls Dam. Post Falls Dam controls the level of the St. Joe River at the town of St. Maries. At full pool (lake elevation 2,128.28 ft.) the lake covers 80 square miles and at minimum pool level (lake elevation of 2,120.18 ft.) the lake covers 75.8 square miles. The lake is 26 miles long and anywhere from 1 to 6 miles wide. The lakes mean depth is 72 feet with a maximum depth of 209 feet.

Many tributaries feed Coeur d'Alene Lake. The two main tributaries of the lake are the Coeur d'Alene and St. Joe rivers that drain the Coeur d'Alene and St. Joe Mountains, respectively. Recently completed Geographic Assessments of the Coeur d’Alene and St. Joe river basins describe geologic and geomorphic processes affecting the Coeur d’Alene Lake basin. The underlying geology of much of the basin is primarily Belt meta sediments, but the southern portion of the St. Joe basin and the St. Maries basin have been modified or influenced by intrusions of the granitic Idaho Batholith. These intrusions have resulted in the formation of re-metamorphosed sedimentary rock that tends to be less stable than landforms based primarily on Belt meta sediments. Lower elevations are composed primarily of glaciofluvial deposits.

The watersheds of interest have evolved and adapted to a series of geologic and climatic events, including general regional uplift, volcanism, intrusion of granite materials, and several stages of glaciation and climate change. The historic range of conditions resulted in watersheds and biotic communities that have developed and evolved with an operating range and resiliency that allows them to adjust to both frequent and rare events. Recently, dramatically increased human populations have exerted stresses on the aquatic and terrestrial ecosystems. Anthropogenic changes, such as, urbanization, construction of Post Falls Dam, conversion of forests and wetlands to pasture and agricultural lands, road construction, and introduction of exotic species have disturbed many natural processes of Coeur d'Alene subbasin and their biotic systems.

The climate and hydrology the watersheds within the Coeur d'Alene subbasin are similar in that they are influenced by the maritime air masses from the Pacific coast, which are modified by continental air masses from Canada. Summers are mild and relatively dry, while fall, winter, and spring brings abundant moisture in the form of both rain and snow. A seasonal snowpack generally covers the landscape at elevations above 4,500 feet from late November to May. Snowpack between elevations of 3,000 and 4,500 feet falls within the “rain-on-snow zone” and may accumulate and deplete several times during a given winter due to mild storms (US Forest Service 1998). The precipitation that often accompanies these mild storms can cause significant flooding because the soils are either saturated or frozen and the rain and melting snow directly contributes to the runoff.

Morphology, aspect, and vegetative cover can influence the magnitude and frequency of these peak flow events. Large openings that permit free air movement over the snow pack can accelerate the rate of snow pack depletion. Openings from fires, insects and disease, and wind have always existed in the watersheds and have enhanced this rain-on-snow phenomenon. More recently, however, clearing of land for homesteads, logging, pasture, and agriculture have substantially enhanced this phenomenon. In Lake Creek for example, where nearly 40 percent of the basin area has been cleared for agriculture, peak discharges have increased by an estimated 55% for 100-year events when compared with the pre-settlement period (Peters et. al. 1999). Lesser amounts of forest clearing have occurred in the other Coeur d'Alene subbasin watersheds, suggesting measurable increases in peak discharges for these areas as well.

The runoff period and peak discharge from the lake generally occurs between April and June, but the highest peak flows recorded are from mid-winter rain-on-snow events. Peak flows from the St. Joe and Coeur d'Alene rivers have exceeded 50,000 cfs and 70,000 cfs, respectively. Average monthly discharges from both the St. Joe and Coeur d'Alene rivers range from September lows of between 400 cfs to 500 cfs to April-May highs of 7,000 to 8,000 cfs.

The Spokane River basin can be grouped into five key watersheds based on geographic features, known relatively unimpacted areas, other important habitat related to native species and known historic conditions (Table 1). The key watershed groupings are the St. Joe River and tributaries (excluding the St. Maries River), St. Maries River and tributaries, Coeur d'Alene River and tributaries, and Coeur d'Alene Lake and tributaries.

Table 1. Breakdown of vegetative cover per key watershed area in the Coeur d'Alene subbasin.

Cover Type	Watershed Coeur d'Alene River	St. Joe River	St. Maries River	Coeur d'Alene Lake and Tributaries	Spokane River	Total
Forest	834146	648633	287006	192244	68926	2030954
Agriculture	17731	8669	10615	53162	46508	136685
Rangeland	62924	46477	13281	23923	23093	169697
Water	6034	1257	35	31236	2411	40972
Wetland	4508	131	221	877	178	5915
Other	28479	87338	1188	5113	10905	133022
Total acres	**953821**	**792505**	**312345**	**306555**	**152021**	**2517246**

Twelve native fish species inhabit the Coeur d'Alene Lake basin: northern pikeminnow *Ptychocheilus oregonensis*, redside shiner *Richardsonius balteatus*, torrent sculpin *C. rhotheus*, shorthead sculpin *C. confusus*, speckled dace *Rhinichthys osculus*, longnose dace *R. cataractae*, longnose sucker *Catostomus catostomus*, largescale sucker *Catostomus macrocheilus*, bridgelip sucker *C. columbianus*, mountain whitefish *Prosopium williamsoni*, westslope cutthroat trout *Oncorhyncus clarki lewisi* and bull trout *Salvelinus confluentus*.

Fifteen introduced fish species currently inhabit the basin: smallmouth bass *Micropterus dolomieui*, largemouth bass *M. salmoides*, crappie *Pomoxis spp.*, sunfish *Lepomis spp.*, yellow perch *Perca flavescens*, lake superior whitefish *Coregonis clupeaformis*, brown bullhead *Ameiurus nebulosus*, channel catfish *Ictalurus punctata*, tench *Tinca tinca,* northern pike *Esox lucius*, tiger musky *E. lucius x E. masquinogy,* brook trout *Salvelinus fontinalis*, rainbow trout *Oncorhynchus mykiss*, chinook salmon *O. tshawytscha,* cutthroat-rainbow trout hybrids, and kokanee *O. nerka*.

Herptofauna known or suspected to inhabit the Coeur d'Alene subbasin include the long toed salamander *Ambystroma macrodactylum*, Coeur d'Alene salamander *Plethodon idahoensis*, Idaho giant salamander *Dicamptodon aterrimus*, tiger salamander *Ambystoma tigrinum*, garter snake *Thamnophis sirtalis*, western toad *Bufo boreas*, Pacific chorus frog *Pseudacris regilla*, Columbia spotted frog *Rana pretiosa*, and tailed frog *Ascaphus truei*.

Wide spread changes in land-use patterns have also contributed to the decline of many of the more sensitive native species. Bull trout have been listed as threatened under the Endangered Species Act by the USFWS and the status of westslope cutthroat trout is currently under review. Species of concern also include the Coeur d'Alene salamander and the Columbia spotted frog. These changes in land-use patterns are not always to the detriment of native species. Some species like the northern pikeminnow have flourished under the current conditions of the watersheds. Most of the introduced exotic species are also doing well under the current environmental conditions. Northern pike, largemouth and smallmouth bass, chinook salmon, kokanee salmon, as well as, yellow perch and black crappie are all doing well. Historically, cutthroat trout were the most abundant fish species. Today, kokanee salmon are the most abundant fish species in the subbasin.

Wildlife species are abundant within the Coeur d'Alene subbasin. Ungulates consist of two deer species, elk, and moose. Carnivores are widespread and diverse throughout the basin including the lynx, gray wolf, black bear, fishers, martens, and other species. Other important guilds include various waterfowl populations, neo-tropical migratory birds, small mammals, amphibians and reptiles. Mitigation activities are directed at a group of target species intended to represent cover types that were impacted by the development and operation of the Federal Columbia River Hydropower System.

5 CUTTHROAT TROUT BIOLOGY

5.1 Life History

Westslope cutthroat trout inhabit streams, rivers, and lakes on both sides of the Rocky Mountain Continental Divide. Distribution east of the divide is limited mostly to Montana but some also occur in some headwater systems in Wyoming and Southern Alberta. West of the divide they range from Southern BC to the Salmon River basin, Idaho and Oregon. Color is highly variable normally greenish-blue to steel gray on the back and yellowish-green to copper color on the bottom, sometimes silvery on the belly (Simpson and Wallace 1982). Black spots on the back and side are usually more concentrated behind the dorsal fin. Spots are also located on the dorsal, adipose and anal fins while all other fins usually have none. The most characteristic feature is a red slash on each side of the lower jaw.

These fish can be resident or migratory. Resident forms will spend their entire lives in the streams where migratory forms move downstream to a larger river or lake. These migratory forms will then move back to natal streams to spawn. Resident fish spawn predominantly in small tributaries with the migratory forms spawning in the lower reaches of the same streams. Spawning usually occurs from March to July at water temperatures near 10^{o}C. Westslope cutthroat trout are iteroparous with repeat spawners consistently up to 24% of the overall spawning population. This is important because repeat spawners are usually older larger fish. Most fry emerge from the gravel in late June to early July into the streams where the migratory forms may spend up to three years before moving downstream. Migratory fish usually spawn for the first time at five years of age.

Waters inhabited by westslope cutthroat trout are generally cold (optimum <60^{o}) and nutrient poor. Growth is quite variable with an average length of 13-22 inches. Fish can exceed 2 pounds and larger ones are not uncommon. Feeding habits are quite similar to other trout and diet consists primarily of aquatic and terrestrial insects. Fish form a sizable portion of the diet of larger fish. The quality of the flesh is excellent when taken from clear cold water. Westslope cutthroat trout are highly susceptible to angling thus, the popularity with the angling community is equal to that of the rainbow trout.

5.2 Status

Current distribution and abundance of westslope cutthroat trout appear to be severely restricted when compared to historical conditions. Westslope cutthroat trout are now believed to persist in only 27% of their historical range. Rieman and Apperson (1989) estimated that populations considered as "strong" (greater than or equal to 50% of historical potential) by Idaho Department of Fish and Game (IDFG) remained in only 11% of the historical range within the State of Idaho. Currently only 4% of the existing populations are not threatened by hybridization with non-native salmonids (Rieman and Apperson 1989).

Large and diverse cutthroat trout populations remain in heavily-forested upper elevation portions of the St. Joe and Coeur d'Alene River basins. However, cutthroat populations in low elevation tributaries of Coeur d'Alene Lake have been severely impacted by cumulative impacts of habitat ecological community changes.

Nineteen tributary streams totaling 110.3 stream miles located, wholly or partially, on the Coeur d'Alene Indian Reservation were identified based on aerial surveys as probable historic cutthroat trout bearing streams (Graves et. al. 1990). Total stream miles of available habitat is underestimated because this figure only includes mainstem reaches. We know that small intermittent tributaries serve as important spawning and rearing areas. For example, in Benewah creek the mainstem is 14.7 miles long but there are approximately 24.1 miles of fish bearing waters when intermittent tributaries are taken into account (Peters et. al. 1999).

Reproducing populations currently occur in nine of the nineteen streams historically thought to produce cutthroat trout within the Reservation (Lillengreen et. al. 1993). In eight of the nine populations, fish densities and individual growth rates were substantially less than in other Idaho streams. Significant populations were present in only four streams (Lake, Benewah, Evans and Alder creeks). Population status and life history patterns have been monitored in these four streams since 1993 using upstream and downstream fish traps.

Lake Creek supports a small and relatively stable population of several thousand fish that express resident and adfluvial life history forms. Recently, a total of 907 cutthroat trout were caught in the lower Lake Creek trap in 1996, 273 were caught in 1997 and 1277 were caught in 1998. Twenty-eight (3% of total catch) adult fish (age IV or older) were captured in 1996 and nine (3%) were captured in 1997 and sixty-three (5%) were captured in 1998. Although total numbers varied considerably among years, catch per unit effort was similar (12.4 fish/day and 7.8 fish/day, respectively). Mean annual population size of cutthroat trout (200 m and larger) was estimated at 4,946 from Lake Creek to 1996-1998 based on an electrofishing during summer (Vitale et al. 1999).

Benewah Creek also supports a significant resident and adfluvial population. Only one cutthroat trout was caught in 1996 (0.04 fish/day) while a total of 26 were caught in 1997 (0.7 fish/day) and 535 were caught in 1998. Adult fish (age IV or older) accounted for 27 percent of the catch (n=8) in 1997 and 14.5 percent (n=78) in 1998. Above normal precipitation and runoff greatly reduced the effectiveness of trapping efforts and, in part, account for the variation in catch numbers. Mean annual population size of cutthroat trout (200 mm and larger) was estimated at 5,553 for Benewah Creek from 1996 to 1998 based on electrofishing during summer (Vitale et al. 1999).

Evans Creek continues to support small populations of resident cutthroat but the adfluvial life history appears to have been extirpated. No adfluvial fish were caught in Evans since trapping began in 1993. Mean annual population size of cutthroat trout (200 mm and larger) was estimated at 2,675 for Evans Creek for 1996 to 1998 based on electrofishing during summer (Vitale et al. 1999).

No adfluvial fish have been trapped in Alder Creek but a migration barrier may have historically precluded use by adfluvial fish. The Idaho Fish and Game altered the barrier in 1965 to aid westslope cutthroat migrations. It should be noted that historical records indicate that migratory westslope cutthroat trout were speared by Coeur d’ Alene tribal members upstream from this identified barrier. Mean annual population size of cutthroat trout (200 m and larger) was estimated at 808 for Alder Creek from 1996 to 1998 based on electrofishing during summer (Vitale et al. 1999).

Hells Gulch Creek is a lower St. Joe River tributary that currently contains a population of resident, adfluvial/fluvial cutthroat as well as brook trout. Cherry Creek contains adfluvial/fluvial and resident cutthroat trout. Specific population sizes are unknown.

Goose Haven Lake is in the lower St. Joe River floodplain and does not currently support a significant cutthroat trout population. The lake is not directly connected to the river but may be periodically flooded.

General patterns of cutthroat trout abundance and distribution vary among the target watersheds and among years, but seem to be highly correlated with seasonal changes in water quality and quantity. Cutthroat trout were sporadically distributed in the Lake Creek, Benewah Creek, and Alder Creek watersheds during both the summer and fall seasons. Abundance in second order tributaries of Lake Creek and Benewah Creek was consistently much higher than in adjacent mainstem reaches, despite the effects of low flow conditions. During base flow conditions, for example, cutthroat trout have been known to crowd into small, isolated pools

(>15 fish/m2) located in cool tributaries, rather than face conditions of high water temperatures in mainstem reaches. In contrast, favorable water quality conditions in Evans Creek resulted in a relatively even longitudinal distribution of cutthroat trout.

Surveys conducted in 1997 showed that cutthroat trout abundance increased dramatically during the fall sample period. Fall surveys were conducted following fry emergence, which occurs in late June to early July, and young of the year fish accounted for most of the seasonal variation in abundance within sites. Young of the year fish were found principally in small tributaries, which supports the hypothesis that the majority of spawning activity takes place in second order streams in these watersheds.

Population viability analyses based on population size and demographic variability indicate that current populations are at risk of extinction within the foreseeable future (Vitale et al. 2002). Extinction risks are greatest for small populations in Evans and Alder creeks but still significant for Lake and Benewah creeks. Extinction events likely result for extended drought periods which reduce flows and increase temperatures to unsuitable levels. The adfluvial life history strategy historically contributed to population viability and persistence during poor production periods as fish found refuge in the lake. Young of the year fish thus are likely to have a greater chance of mortality due to random events than are older fish.

5.3 Genetic Stock Structure

Genetic stock structure of remaining cutthroat trout populations was evaluated by the Wild Trout and Salmon Genetics Lab at the University of Montana based on analysis of seven polymorphic microsatellite loci in 416 samples from 16 sites (Table 2). Remaining populations are largely unaffected by hybridization problems that have impacted many other cutthroat trout populations throughout their range. Six sites contained samples of westslope cutthroat trout with no evidence of hybridization with rainbow trout (Knudsen and Spruell 1999). Ten sites included at least one hybrid individual but hybridization levels were low. The maximum number of hybrid individuals (28%) found was observed in Cherry Creek. On average, hybrid individuals contained 37.5% of the rainbow trout markers. However, these same individuals also contained 100% of the markers diagnostic for westslope cutthroat. If this population had experienced high levels of hybridization for an extended period of time, loss of westslope markers should have been apparent. Thus, even in Cherry Creek it appears as though hybridization events occur episodically not continually.

Analyses noted high heterozygosity, no inbreeding depression, persistence of rare alleles, and low genetic distances among populations (Knudsen and Spruell 1999). Samples of westslope cutthroat from Coeur d'Alene Lake tributaries differ significantly in allele frequencies at one or two loci but genetic distances among samples were small. All seven microsatellite loci analyzed were polymorphic. Levels of heterozygosity appeared to be reasonably high, minimizing the possibility that inbreeding depression is currently a problem. Allelic distributions, estimators of pair-wise divergence, and significance measures indicated little correlation between geographic distance and genetic differentiation. These results are consistent with a system in which gene flow occurs but not at a sufficient rate to make these populations genetically homogeneous. The differences in allele frequencies are probably the result of genetic drift in small populations.

Table 2. Sample sites and sizes, collection dates and possible life history forms for westslope cutthroat trout captured in the Coeur d'Alene Lake basin by the Coeur d'Alene Tribe in 1998. Except as noted, only juvenile fish were collected.

Location*	Life History**	Collection Dates	Sample Size
Fighting Creek	Resident?	12 June, 1998	29
Cherry Creek	Resident?/Adfluvial?	18 June, 1998	29
Hells Gulch Creek	Resident?	11 June, 1998	29
Alder Creek	Resident	30 July, 1998	6
Evans Creek	Resident	29 July, 1998	33
South Fork Evans Creek	Resident	29 July, 1998	27
Benewah Creek 1	Adfluvial	April, 1998	24 (18 juvenile, 6 adult)
Benewah Creek 2	Adfluvial?	April, 1998	10 (adults)
South East Fork Benewah Creek	Resident?/Adfluvial?	26 June, 1998	22
Whitetail Creek	Resident?/Adfluvial?	30 June, 1998	17
Windfall Creek	Resident?/Adfluvial?	01 July, 1998	35
Bull Creek	Resident?/Adfluvial?	02 July, 1998	30
Lake Creek 1	Adfluvial	March-April, 1998	48 (41 juvenile, 7 adult)
Lake Creek 2	Resident?/Adfluvial?	04 August, 1998	18
Bozard Creek	Resident?/Adfluvial?	05 August, 1998	27
West Fork Lake Creek	Resident?/Adfluvial?	04 August, 1998	32
Totals			**416**

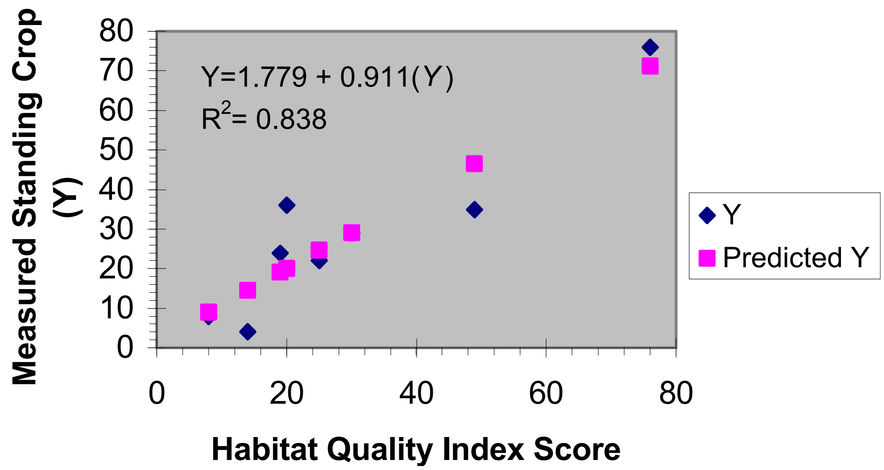


Figure 4. Relationship Between HQI and Trout Standing Crop (kg/hectare) at 8 Reservation Tributaries

5.4 Biological Requirements

Population sizes currently appear to be limited by summer rearing habitat availability. Unsuitable mainstem flows (too low) and temperatures (too high) in the lower reaches of tributaries currently restrict fish to headwater areas. Winter habitat conditions resulting from flooding and ice scour may also limit habitat suitability in lower tributary mainstems. Finally, changes in lake habitat and the introduction of predator and competitor species may also have reduced cutthroat survival rates and net productivity such that marginal habitats under historic conditions no longer sustain significant numbers of cutthroat.

Most (83%) of the variation in trout standing crop among eight Reservation streams was correlated to a Habitat Quality Index (HQI) score based on eleven habitat attributes (Figure 4, Table 3). Attributes included stream flow in late summer, annual stream flow variation, maximum summer water temperature, nitrate nitrogen, fish food abundance, fish food diversity, instream cover, eroding streambanks, submerged aquatic vegetation, water velocity, and stream width. This HQI model was initially developed to predict trout standing crop in Wyoming streams where it explained 96% of the variation in trout biomass for the 36 streams from which it was developed (Binns and Eiserman 1979) and 87% of the variation for 16 additional streams (Conder and Annear 1987). Our application of this model included modifications of maximum summer water temperature criteria to reflect specific tolerances of westslope cutthroat trout consistent with recommendations by Griffith (1993) and Binns and Eiserman (1979) that modifications are needed to provide more accurate evaluations of local habitat conditions consistent with life history requirements of different trout species.[1]

[1] The original model was applied to streams that supported multiple salmonid species (including brook, brown, rainbow, and cutthroat trout) and used temperature ranges that were, in some cases, higher than the upper incipient lethal temperature reported for cutthroat trout (Behnke 1979; Behnke and Zarn 1976; Bell 1973). We modified the temperature rating characteristics of the model according to 20-100% suitability index values from Hickman and Raleigh (1982). In addition, we changed the lower rating characteristic for the late summer stream flow attribute to reflect the fact that tributaries on the Reservation support juvenile trout to a much greater extent than resident adults. Therefore, in our model late summer stream flows =8% of average annual stream flow provide at least sporadic but limited support for juvenile rearing. Data published by Hickman and Raleigh (1982) indicating 100% suitability for juvenile cutthroat residing in small streams when the average thalweg depth reaches 30 cm, seem to support this assumption.

Table 3. Habitat Quality Index (HQI)/Current Conditions

Habitat Quality Index attribute measurement data, ratings and calculations for tributaries of the Coeur d'Alene Reservation, based on current conditions (1998).

Attribute	Model symbol	*Lake Creek below Elder Rd.*		*Lake Creek upper*		*Evans Creek*		*N.F.Alder Creek*		*Alder Creek*		*Benewah Creek below 9mile*		*S.E. Benewah*		*W.F. Benewah*		*Whitetail*		*Windfall*	
		Data	*Rating*	*Data*	*Rating*	*Data*	*Rating*	*Data*	*Rating*	*Data*	*Rating*	*Data*	*Rating*	*Data*	*Rating*	*Data*	*Rating*	*Data*	*Rating*	*Data*	*Rating*
Late summer stream flow	X1	CPF=6%ADF	0	CPF=10%ADF	1	CPF=16%ADF	2	CPF=8%ADF	1	CPF=8%ADF	1	CPF=10% ADF	1	CPF=10%ADF	1	CPF=9%ADF	1	CPF=4%ADF	0	CPF=7%ADF	0
Annual stream flow variation	X2		2		2		3		2		2		2		2		1		1		1
Maximum summer water temperature (°C)	X3	22.6	1	18.0	3	17.1	3	20.1	2	21.4	2	23.1	1	16.8	4	16.2	4	18.6	3	24.3	3
Nitrate nitrogen (mg/l)	X4	0.10	3	0.05	2	0.10	3	0.05	2	0.05	2	0.12	3	0.06	2	0.30	3	0.05	2	0.05	2
Fish food abundance (number/0.1 m2)	X5	534	4	129	2	535	4	530	4	437	3	499	3	594	4	594	4	594	4	594	4
Fish food diversity	X6	2.41	3	2.41	3	2.35	3	2.29	3	2.29	3	2.25	3	2.25	3	2.25	3	2.25	3	2.25	3
Cover (%)	X7	40	2	35	2	57	4	48	3	25	1	28	2	51	3	54	3	30	2	40	2
Eroding banks (%)	X8	22	3	7	4	8	4	25	2	40	2	45	2	8	4	7	4	9	4	15	3
Substrate	X9		3		3		2		3		3		3		3		3		3		3
Water velocity	X10		2		2		2		2		2		2		2		2		2		2
Stream width (m)	X11	3.6	3	1.5	1	3.6	3	3.7	3	3.6	3	5.0	3	2.7	2	1.6	1	2.0	1	2.1	2
Calculation of trout standing crop																					
X1 + 1			1		2		3		2		2		2		2		2		1		1
X2 + 1			3		3		4		3		3		3		3		2		2		2
X3 + 1			2		4		4		3		3		2		5		5		4		4
P + 1			1296		192		3456		864		216		648		1152		864		384		576
F + 1			18		36		36		24		24		18		48		72		36		36
S + 1			18		8		48		18		6		12		24		12		8		12
Model I - Predicted standing crop (kg/hectare)			10		33		194		34		22		17		79		37		10		11
Model II - Predicted standing crop (kg/hectare)			**8**		**49**		**122**		**30**		**25**		**14**		**95**		**76**		**19**		**20**
Measured standing crop (kg/hectare)																					
1996			5		21		18		34		26		8		25		37		51		23
1997			7		46		24		20		14		2		19		94		13		33
1998			11		36		14		34		26		1		33		98		9		51
Mean			**8**		**35**		**18**		**29**		**22**		**4**		**26**		**76**		**24**		**36**

Table 4. HQI Model/Habitat Restoration

Habitat Quality Index attribute measurement data, ratings and calculations for tributaries of the Coeur d'Alene Reservation, based on 25% expected improvements in habitat quality from restoration efforts (2007).

Attribute	Model symbol	Lake Creek below Elder Rd. Data	Rating	Lake Creek upper Data	Rating	Evans Creek Data	Rating	N.F.Alder Creek Data	Rating	Alder Creek Data	Rating	Benewah Creek below 9mile Data	Rating	S.E. Benewah Data	Rating	W.F. Benewah Data	Rating	Whitetail Data	Rating	Windfall Data	Rating
Late summer stream flow	X1	CPF=6%ADF	0	CPF=10%ADF	1	CPF=16%ADF	2	CPF=8%ADF	1	CPF=8%ADF	1	CPF=10% ADF	1	CPF=10%ADF	1	CPF=9%ADF	1	CPF=4%ADF	0	CPF=7%ADF	0
Annual stream flow variation	X2		2		2		3		2		2		2		2		1		1		1
Maximum summer water temperature (°C)	X3	22.6	1	18.0	3	17.1	3	20.1	2	21.4	2	23.1	1	16.8	4	16.2	4	18.6	3	18.6	3
Nitrate nitrogen (mg/l)	X4	0.10	3	0.05	2	0.10	3	0.05	2	0.05	2	0.12	3	0.06	2	0.30	3	0.05	2	0.05	2
Fish food abundance (number/0.1 m2)	X5	534	4	129	2	535	4	530	4	437	3	499	3	594	4	594	4	594	4	594	4
Fish food diversity	X6	2.41	3	2.41	3	2.35	3	2.29	3	2.29	3	2.25	3	2.25	3	2.25	3	2.25	3	2.25	3
Cover (%)	X7	45	3	40	2	57	4	53	3	30	2	33	2	56	4	59	4	35	2	45	3
Eroding banks (%)	X8	17	3	7	4	8	4	20	3	35	2	40	2	8	4	7	4	9	4	10	3
Substrate	X9		3		3		2		3		3		3		3		3		3		3
Water velocity	X10		2		2		2		2		2		2		2		2		2		2
Stream width (m)	X11	3.6	3	1.5	1	3.6	3	3.7	3	3.6	3	5.0	3	2.7	2	1.6	1	2.0	1	2.1	2
Calculation of trout standing crop																					
X1 + 1			1		2		3		2		2		2		2		2		1		1
X2 + 1			3		3		4		3		3		3		3		2		2		2
X3 + 1			2		4		4		3		3		2		5		5		4		4
P + 1			1944		192		3456		1296		432		648		1536		1152		384		864
F + 1			18		36		36		24		24		18		48		72		36		36
S + 1			27		8		48		27		12		12		32		16		8		18
Model II - Predicted standing crop (kg/hectare)			**9**		**49**		**122**		**33**		**28**		**14**		**100**		**80**		**19**		**22**

Habitat Quality Index attribute measurement data, ratings and calculations for tributaries of the Coeur d'Alene Reservation, based on 50% expected improvements in habitat quality from restoration efforts (2012).

Attribute	Model symbol	Lake Creek below Elder Rd. Data	Rating	Lake Creek upper Data	Rating	Evans Creek Data	Rating	N.F.Alder Creek Data	Rating	Alder Creek Data	Rating	Benewah Creek below 9mile Data	Rating	S.E. Benewah Data	Rating	W.F. Benewah Data	Rating	Whitetail Data	Rating	Windfall Data	Rating
Late summer stream flow	X1	CPF=6%ADF	0	CPF=10%ADF	1	CPF=16%ADF	2	CPF=8%ADF	1	CPF=8%ADF	1	CPF=10% ADF	1	CPF=10%ADF	1	CPF=9%ADF	1	CPF=4%ADF	0	CPF=7%ADF	0
Annual stream flow variation	X2		2		2		3		2		2		2		2		1		1		1
Maximum summer water temperature (°C)	X3	21.5	2	17.0	3	17.1	3	19.1	2	20.4	2	22.1	1	16.8	4	16.2	4	17.6	3	17.6	3
Nitrate nitrogen (mg/l)	X4	0.10	3	0.10	3	0.10	3	0.10	3	0.10	3	0.12	3	0.10	3	0.30	3	0.10	3	0.10	3
Fish food abundance (number/0.1 m2)	X5	534	4	250	3	535	4	530	4	437	3	499	3	594	4	594	4	594	4	594	4
Fish food diversity	X6	2.41	3	2.41	3	2.35	3	2.29	3	2.29	3	2.25	3	2.25	3	2.25	3	2.25	3	2.25	3
Cover (%)	X7	50	3	45	3	57	4	58	4	35	2	38	2	56	4	59	4	40	2	50	3
Eroding banks (%)	X8	12	3	7	4	8	4	15	3	30	2	35	2	8	4	7	4	9	4	9	4
Substrate	X9		3		3		3		3		3		3		3		3		3		3
Water velocity	X10		2		2		2		2		2		2		2		2		2		2
Stream width (m)	X11	3.6	3	1.5	1	3.6	3	3.7	3	3.6	3	5.0	3	2.7	2	1.6	1	2.0	1	2.1	2
Calculation of trout standing crop																					
X1 + 1			1		2		3		2		2		2		2		2		1		1
X2 + 1			3		3		4		3		3		3		3		2		2		2
X3 + 1			3		4		4		3		3		2		5		5		4		4
P + 1			1944		648		3456		2592		648		648		2304		1152		576		1728
F + 1			36		54		54		36		36		18		72		72		54		54
S + 1			27		12		48		36		12		12		32		16		8		24
Model II - Predicted standing crop (kg/hectare)			**24**		**68**		**158**		**45**		**37**		**14**		**130**		**80**		**25**		**30**

Habitat Quality Index attribute measurement data, ratings and calculations for tributaries of the Coeur d'Alene Reservation, based on 75% expected improvements in habitat quality from restoration efforts (2016).

Attribute	Model symbol	Lake Creek below Elder Rd. Data	Rating	Lake Creek upper Data	Rating	Evans Creek Data	Rating	N.F.Alder Creek Data	Rating	Alder Creek Data	Rating	Benewah Creek below 9mile Data	Rating	S.E. Benewah Data	Rating	W.F. Benewah Data	Rating	Whitetail Data	Rating	Windfall Data	Rating
Late summer stream flow	X1	CPF=6%ADF	0	CPF=10%ADF	1	CPF=16%ADF	2	CPF=8%ADF	1	CPF=8%ADF	1	CPF=10% ADF	1	CPF=10%ADF	1	CPF=9%ADF	1	CPF=4%ADF	0	CPF=7%ADF	0
Annual stream flow variation	X2		2		2		3		2		2		2		2		1		1		1
Maximum summer water temperature (°C)	X3	20.5	2	16.0	4	16.1	4	18.1	3	19.4	2	21.1	2	16.8	4	16.2	4	16.6	4	16.6	4
Nitrate nitrogen (mg/l)	X4	0.10	3	0.10	3	0.10	3	0.10	3	0.10	3	0.12	3	0.10	3	0.30	3	0.10	3	0.10	3
Fish food abundance (number/0.1 m2)	X5	534	4	500	4	535	4	530	4	500	4	525	4	594	4	594	4	594	4	594	4
Fish food diversity	X6	2.41	3	2.41	3	2.35	3	2.29	3	2.29	3	2.25	3	2.25	3	2.25	3	2.25	3	2.25	3
Cover (%)	X7	55	4	50	3	57	4	58	4	40	2	43	3	56	4	59	4	45	3	55	4
Eroding banks (%)	X8	9	4	7	4	8	4	10	3	25	2	30	2	8	4	7	4	9	4	9	4
Substrate	X9		3		3		3		3		3		3		3		3		3		3
Water velocity	X10		2		2		2		2		2		2		2		2		2		2
Stream width (m)	X11	3.6	3	1.5	1	3.6	3	3.7	3	3.6	3	5.0	3	2.7	2	1.6	1	2.0	1	2.1	2
Calculation of trout standing crop																					
X1 + 1			1		2		3		2		2		2		2		2		1		1
X2 + 1			3		3		4		3		3		3		3		2		2		2
X3 + 1			3		5		5		4		3		3		5		5		5		5
P + 1			3456		864		3456		2592		864		1296		2304		1152		864		2304
F + 1			36		72		72		54		36		36		72		72		72		72
S + 1			48		12		48		36		12		18		32		16		12		32
Model II - Predicted standing crop (kg/hectare)			**27**		**108**		**250**		**83**		**37**		**39**		**130**		**80**		**43**		**51**

Table 5.   HQI/Optimal Future Desired Conditions

Habitat Quality Index attribute measurement data, ratings and calculations for tributaries of the Coeur d'Alene Reservation, based on optimal future desired condition beyond 2016.

		Lake Creek below Elder Rd.		*Lake Creek upper*		*Evans Creek*		*N.F. Alder Creek*		*Alder Creek*		*Benewah Creek below 9mile*		*S.E. Benewah*		*W.F. Benewah*		*Whitetail*		*Windfall*	
Attribute	*Model symbol*	*Data*	*Rating*	*Data*	*Rating*	*Data*	*Rating*	*Data*	*Rating*	*Data*	*Rating*	*Data*	*Rating*	*Data*	*Rating*	*Data*	*Rating*	*Data*	*Rating*	*Data*	*Rating*
Late summer stream flow	X1	CPF=10%ADF	1	CPF=16%ADF	2	CPF=16%ADF	2	CPF=16%ADF	2	CPF=16%ADF	2	CPF=16% ADF	2	CPF=16%ADF	2	CPF=16%ADF	2	CPF=8%ADF	1	CPF=10%ADF	1
Annual stream flow variation	X2		2		2		3		2		2		2		2		1		1		1
Maximum summer water temperature (°C)	X3	18.0	3	16.0	4	16.1	4	16.1	4	17.4	3	19.1	2	16.8	4	16.2	4	16.6	4	16.6	4
Nitrate nitrogen (mg/l)	X4	0.10	3	0.10	3	0.10	3	0.10	3	0.10	3	0.12	3	0.10	3	0.30	3	0.10	3	0.10	3
Fish food abundance (number/0.1 m2)	X5	534	4	500	4	535	4	530	4	500	4	525	4	594	4	594	4	594	4	594	4
Fish food diversity	X6	2.41	3	2.41	3	2.35	3	2.29	3	2.29	3	2.25	3	2.25	3	2.25	3	2.25	3	2.25	3
Cover (%)	X7	55	4	50	3	57	4	58	4	40	2	43	3	61	4	64	4	45	3	55	4
Eroding banks (%)	X8	9	4	7	4	8	4	10	3	25	2	30	2	8	4	7	4	9	4	5	4
Substrate	X9		3		3		3		3		3		3		3		3		3		3
Water velocity	X10		2		2		2		2		2		2		2		2		2		2
Stream width (m)	X11	3.6	3	1.5	1	3.6	3	3.7	3	3.6	3	5.0	3	2.7	2	1.6	1	2.0	1	2.1	2
Calculation of trout standing crop																					
X1 + 1			2		3		3		3		3		3		3		3		2		2
X2 + 1			3		3		4		3		3		3		3		2		2		2
X3 + 1			4		5		5		5		4		3		5		5		5		5
P + 1			3456		864		3456		2592		864		1296		2304		1152		864		2304
F + 1			54		72		72		72		54		36		72		72		72		72
S + 1			48		12		48		36		12		18		32		16		12		32
Model II - Predicted standing crop (kg/hectare)			**88**		**150**		**250**		**184**		**95**		**55**		**180**		**111**		**76**		**90**

For two tributaries (Evans Creek and SE Benewah Creek), there was considerable deviation between measured and predicted values. It is unclear whether this discrepancy resulted from anthropomorphic influences, underseeding of spawning habitat, or a local habitat effect not captured by the HQI model.

Effects of habitat restoration efforts on trout carrying capacity can be projected with the HQI model based on expected improvements in late summer stream flow, streambank stability, instream cover, fish food abundance and maximum summer water temperature. Projections were made based on 25%, 50%, 75%, and 100% improvements targeted for 2007, 2012, 2016 and "beyond", respectively (Table 4 and Table 5). "Beyond" describes the desired future condition for Reservation tributaries which is assumed to be equivalent to the potential natural community. Expected increases in carrying capacity were 2%, 35%, 117%, and 219% compared with 1998 values (Table 6).

Table 6. Carrying Capacity Predictions

Carrying capacity predictions for juvenile cutthroat trout in tributaries of the Coeur d'Alene Reservation.

	Standing Crop (kg/hectare)					Number of Juveniles				
Tributary	**1998**	**2007**	**2012**	**2016**	**Beyond**	**1998**	**2007**	**2012**	**2016**	**Beyond**
Lake Creek (Lower)	8	9	24	27	88	1036	1165	3108	3496	11396
Lake Creek (Upper)	49	49	68	108	150	7322	7322	10161	16138	22414
Evans Creek	122	122	158	250	250	18129	18129	23478	37149	37149
N.F. Alder Creek	30	33	45	83	184	1132	1245	1698	3333	7390
Alder Creek	25	28	37	37	95	4211	4716	6232	9510	24418
Benewah Creek (mainstem)	14	14	14	39	55	4577	4577	4577	13313	18775
S.E. Fork Benewah	95	100	130	130	180	2401	2527	3285	3655	5060
West Fork Benewah	76	80	80	80	111	1200	1263	1263	964	1337
Whitetail Creek	19	19	25	43	76	461	461	607	863	1526
Windfall Creek	20	22	30	51	90	828	910	1241	1229	2169
Totals	458	476	611	848	1279	41295	42316	55650	89650	131633

5.5 Factors for Decline

Range-wide causes of westslope cutthroat trout population declines include competition with and predation by non-native species, genetic introgression, overfishing, habitat loss and fragmentation, and habitat degradation (Liknes 1984; Liknes and Graham 1988; Rieman and Apperson 1989; McIntyre and Rieman 1995). In Idaho, habitat loss was identified as the primary cause of decline in streams supporting depressed populations (Rieman and Apperson 1989). In the Coeur d'Alene system, significant factors for decline include agricultural and urban development, forest management, mining, dam construction, and introduction of exotic fish species. The following information is summarized from the following documents: *Forest Service Biological Assessment of the St. Joe River and North Fork Clearwater River Basin* (1998), *Draft Coeur d'Alene Basin Problem Assessment* prepared by the Panhandle Bull Trout Technical Advisory Team (1998*), Conservation Assessment for inland cutthroat trout* prepared by the Forest Service (1995), and the *Stock Assessment of westslope cutthroat trout on the Coeur d'Alene Indian Reservation* prepared by Peters and Vitale (1999).

5.5.1 Agricultural & Urban Development

Low elevation watersheds in the Coeur d'Alene Lake basin have been largely transformed from forest to agriculture or urban uses with substantial effects on stream hydrography, riparian conditions, bank stability, nutrient levels, and sediment inputs. Row crop agriculture is most common in the Palouse area, where streams drain into Coeur d'Alene Lake, and along the lower river valleys.

Development has generally increased peak flow volumes and reduced summer base flows and increased the frequency of stochastic events that cause mortality of embryo, fry, and juvenile lifestages. Peak flows have been identified in previous reports as a potential limiting factor for trout production (Lillengreen 1996). Spikes in stream discharge during the early spring may cause redd scouring and poor egg survival. Low base flows reduce the amount of available rearing habitat. Juvenile trout are concentrated into small pools where high densities may lead to dispersal, downstream displacement or mortality in salmonids (Chapman 1962; Mason and Chapman 1965; Everest 1971; Erman and Leidy 1975; LeCren 1973). In water quality limited systems, such as Lake Creek, Benewah Creek, and Alder Creek, dispersal to downstream areas exposes juvenile cutthroat to suboptimal temperature conditions that increase stress, weaken individuals and may result in mortality.

Large amounts of fine sediment are also delivered to streams from row crop agriculture. Changing practices, implementation of BMPs, and changes in crops and field cover have helped to reduce fine sediment delivery. However, sedimentation remains a major problem in the Lower Coeur d'Alene River and smaller west side tributaries of Coeur d'Alene Lake. High percentages of fine sediment in spawning reaches resulting from agriculture activities probably greatly reduce spawning success of native trout in tributary streams located on the Reservation.

5.5.2 Forest Management

Timber harvesting activities in the Coeur d'Alene Lake basin have included clear cutting, partial cutting, thinning, fertilization and prescribed burning. The yarding or skidding of trees varies from ground-based operations and cable systems to aerial approaches with helicopters. Impacts from timber harvest include streams with decreased large woody debris (from log skidding directly in streams and riparian harvest), and lack of recruitable large woody debris and increased temperatures (from harvest of riparian forests). Splash dams were used in several streams (most notably Marble Creek in the St. Joe watershed) and created significant changes to stream channels and fish habitat by creating migration barriers and scouring channels with regular releases of large flows of water and logs. Current impacts of timber harvest on native trout have been reduced with implementation of forest practice rules requiring leave trees in riparian areas, prohibiting equipment in or near streams, and controlling erosion from roads, trails and landings. However, the current leave tree requirement does not adequately protect temperature in all cases (Zaroban 1996).

Road development in the basin includes an extensive road network constructed for forest product removal. Those areas with the highest density of roads occur in areas managed primarily for timber production. Roads and railroads have had significant impacts on stream habitats in the Coeur d'Alene Basin through channelization of streams, encroachment on floodplains, destruction of riparian zones, creation of fish migration barriers for fish, through sediment delivery associated with construction and failures, and altered runoff patterns. Roads paralleling tributary stream artifically constrain channel meanders, reduce floodplain capacity, reduce or eliminate riparian areas and limit large woody debris recruitment. On slopes, roads intercept the downward movement of subsurface water and cause it to flow rapidly on the surface. Road location and construction contribute to erosion rates far beyond those under which the watersheds and stream inhabitants adapted and evolved. Furthermore, this road system exists in many of the most sensitive locations (floodplains, and unstable land types) within the watersheds. The density of adunimproved roads exceeds 2.5-miles/mile^2 in most of the subbasin watersheds (Angelo Vitale, Coeur d'Alene Tribe Fisheries Program personal comm.).

Migration barriers created by culverts are common in the Coeur d'Alene Lake basin. These culverts negatively affected native trout by limiting distribution or preventing access to high quality spawning and rearing areas. Where culverts prevent invasion of exotic fishes, they may have a positive effect on native trout populations. Barriers should be evaluated to determine their effect on native fishes and amphibians in the drainage before they are placed or removed.

Recent evidence suggests that successful fire suppression since the 1930's may be currently resulting in more intense, catastrophic fires. Past management activities and successful wildfire control have caused a shift in forest species composition and stocking levels, predisposing forests to large scale mortality. Drought conditions can further dispose these forests to increased wildfire incidence and intensity, with the potential for significant negative impacts on water quality and fish habitat. Large wildfires (during 1910 and the 1930's), and numerous smaller fires, have burned in the Coeur d'Alene Lake basin in this century. Large fires have often left riparian vegetation intact along larger streams, but accounts of the 1910 fire from the St. Joe watershed documented significant burning of riparian areas along some streams. Intense fires may increase natural sediment delivery to streams, when hydrophobic soils are created. At the same time, fires can significantly increase recruitment of large woody debris to stream channels. Where post-fire salvage operations have removed woody debris from streamside areas, or created other disturbances such as roads and fire breaks impacts to fish may be increased (Rieman and Clayton 1997). Large stand replacing fires burned through a considerable portion of the upper St. Joe watershed, including riparian areas, yet this area remains the largest remaining stronghold for native trout in the Coeur d'Alene Lake basin.

5.5.3 Mining

Placer mining in streams and valley bottoms has had serious negative effects on native trout in portions of the Coeur d'Alene Basin. This type of mining is associated with increased sediment load, substrate disturbances, resuspension of fine sediments, channelization, bank destabilization, and removal of large woody debris. Streams that have been mined usually lack habitat complexity, large woody debris, and suitable spawning and wintering habitat (Nelson et al. 1991). Revegetation of dredge piles may be slow and sparse, creating a long-term potential for sedimentation (Levell et al. 1987, Nelson et al. 1991). Placer mining has significantly impacted streams in the Beaver and Pritchard Creek drainages in the North Fork Coeur d'Alene watershed, and the Emerald and Carpenter in the St. Maries watershed. Some placer mining has occurred in upper St. Joe tributaries, including Heller and Sherlock creeks, but impacts appear to be less severe in those streams.

Mine tailing dams, waste dumps and diversions can provide barriers to native trout migratory corridors and spawning sites. Toxic constituents (such as heavy metals) arising from historical activities can block migratory corridors or kill life stages of native trout. Prior to establishment of the Clean Water Act, the entire South Fork of the Coeur d'Alene River from Wallace downstream to the mainstem Coeur d'Alene River, and the mainstem downstream to Coeur d'Alene Lake, were so polluted from mining and other wastes that resident fish were unable to survive (Ellis 1932). Portions of the South Fork still do not support coldwater biota due to metals contamination, and the Bunker Hill Superfund Site centered at Kellogg is one of the largest in the nation. Clean-up projects and the cessation of much of the mining and all of the smelting operations have allowed some recovery in several stream reaches to the point where at least some fish and other coldwater biota are supported.

5.5.4 Dam Construction,

Construction of Post Falls Dam in 1906 increased the surface elevation of Coeur d'Alene Lake and created a series of shallow, weedy zones at the southern end of the lake. Water temperatures in these areas exceed optimums for cutthroat trout during much of the year. These areas provide favorable conditions for introduced species including fish predators.

5.5.5 Introduced Fishes

Species introductions have drastically altered the fish community composition of the Coeur d'Alene system, likely to the detriment of cutthroat trout. Significant introductions into rivers and streams include rainbow trout and brook trout. Significant introductions into the Lake include kokanee, chinook salmon, yellow perch, and northern pike. Detrimental interactions might include hybridization, competition, and predation.

Westslope cutthroat trout hybridize with rainbow trout producing inferior progeny that can significantly alter the genetic composition of the population. Hybridization has been documented in Reservation streams although at low levels. (See Appendix C)

Competition with brook trout may reduce cutthroat populations in tributaries where both are present. Griffith (1972) demonstrated that cutthroat trout fry emerge from the gravel later in the year than brook trout and, thus, age-0 cutthroat trout are at a size disadvantage that may negatively affect survival. Competitive exclusion is a likely cause of decline for cutthroat trout in some subbasin watersheds. In Yellowstone National Park, where the introduction of brook trout has nearly always resulted in the disappearance of the sympatric cutthroat trout (Varley and Gresswell 1988). Brook trout also tolerate slightly warmer conditions than cutthroat, thus may be less affected by increased thermal regimes resulting from habitat degradation. Implications are that cutthroat trout may have a difficult time naturally recovering given continued water quality degradation and the persistence of brook trout.

Competition may also negatively affect cutthroat trout in Coeur d'Alene Lake. Historically, cutthroat trout probably utilized the littoral zone of the lake until they were large enough to move offshore and feed, most likely, on mid-water prey and fish when available. Nilsson and Northcote (1981) noted that cutthroat trout in allopatry with other salmonids were found throughout the lake and when in sympatry, were located primarily in the littoral zone. It has been shown that introduction of kokanee salmon will also have detrimental effects on the cutthroat trout population (Gerstung, 1988; Marnell, 1988). Marnell (1988) determined that declines in westslope cutthroat trout populations in lakes in Glacier National Park where kokanee were introduced were caused by interspecific competition for planktivorous food. Thus, the introduction of non-native species into Coeur d'Alene Lake, at the minimum, likely, altered the normal behavioral pattern of the cutthroat trout in both the littoral and limnetic zones of Coeur d'Alene Lake.

Increases in predation by introduced fishes may also reduce survival in the lake. Northern pike have been in the Coeur d'Alene system since at least the 1970's and are known to consume large numbers of migratory cutthroat trout. Chinook salmon likely feed on westslope cutthroat trout as well. Other introduced predators include largemouth bass and smallmouth bass. Historically, bull trout and northern squawfish were the only predators of cutthroat trout in the lake. Electrofishing data revealed that these predators are associated primarily with the shoreline littoral zone which is the same area favored by cutthroat trout.

5.5.6 Fishing and Fish Management

Harvest of cutthroat trout in the St. Joe and Coeur d'Alene systems has been limited since 2000 by state regulation to two fish per day, none between 8 and 16 inches. Biologically, this allows virtually all cutthroat to spawn at least once before being legally harvested, and protects the vast majority of the catchable sized population from harvest (V. Moore, Idaho Department of Fish and Game, 9/6/02 letter to R. Peters, Coeur d'Alene Tribe). Fisheries in reservation waters are regulated by the Coeur d'Alene Tribe. Benewah and Lake creeks have been closed to all fishing since 1994. Evans and Alder creeks are currently managed consistent with state regulations.

Historically, adfluvial cutthroat were collected from Evans Creek in 1973 and 1974 for use as hatchery broodstock. Fewer than 100 fish were collected (V. Moore, Idaho Department of Fish and Game 9/6/02 letter to R. Peters, Coeur d'Alene Tribe).

6 HATCHERY OPERATION AND DESIGN

J-U-B ENGINEERS INC. was contracted by the Coeur d'Alene Tribe to initiate the conceptual design phase for the proposed hatchery in 1999. An area known as the "Pow Wow site" was selected and analyzed for the development of the conceptual hatchery planning document submitted to the Northwest Power Planning Council as part of the three-step process. This site was evaluated extensively for the water quantity needs of the hatchery. As groundwater quantity issues were challenging for this area, numerous wells were drilled, pump tested and recovery rates analyzed to determine whether sufficient long-term targets would be met. Results indicated that groundwater yields were a limiting factor for this particular site. Acceptable groundwater sources were identified, however, extensive water pipelines for transport would be required. Based on this information, the NWPPC, BPA, and the Tribe agreed to explore the potential for a hatchery location in close proximity to Coeur d' Alene Lake as the hatchery water source.

A second feasibility investigation was conducted using an interdisciplinary team (IDT) including eleven recognized scientists in the fields of hatchery life support systems, aquatic habitats, fishery ecology, fisheries science, and hydrogeology. The full alternate site feasibility report can be found in Appendix B. Several team members researched seven sites on Coeur d' Alene Lake and ultimately narrowed the review to two optimal lake site locations. The original Pow Wow site was also considered for the evaluation, based on information gathered from the earlier design process. The report describes each site and the various analyses that contributed to final site recommendations. The final review of the recommended sites focused on water quantity, equipment requirements, energy costs, land availability, impacts to existing home-sites, proximity to Tribal waters, and capital construction costs. The final preferred site was reviewed, and recommended, by the entire team to ensure consistency with program objectives.

Finally, the IDT convened a Project Review Team (PRT) to review both the results of the feasibility study and to update this Master Plan as part of the NWPPC's three-step process. The PRT assisted in the development of an updated conceptual cutthroat hatchery design, which includes production numbers, facility infrastructure, and updated engineering cost opinions (Appendix A). Sections 6.1 through 6.6 highlight critical important aspects of the updated design plan within the areas of release objectives, production objectives, broodstock selection and acquisition, and hatchery facilities descriptions.

6.1 Release Objectives

Based on the production objectives identified, the facility will contribute 65,000 fingerlings (1.5 inches), 27,000 juveniles (4.0 inches), and either 20,000 adults (8-10 inches) or 17,000 adults (13 inches) at full capacity. Thirteen inches is the desired size for fisheries but a combination of 8-10 inch and 13 inch fish may be used depending on capacity in the grow-out pond. Releases are apportioned as described in Table 7. Release numbers are based on interim fishery, research, and evaluation objectives. Future release numbers will be revised based on results of initial investigations. For instance, the facility was designed to provide the flexibility for future exclusive production of 42,000 adults (13 inches) if desired.

Table 7. Release groups of adfluvial cutthroat trout produced by the Coeur d'Alene Trout Facility.

			Fingerling		
Release site	Purpose	Fry	Acclimated	Direct	Adults
Squaw Creek	Fishery, reintroduction	32,500	0	0	2,300
Plummer Creek	Fishery	0	0	0	2,300
Hatchery direct	Fishery, research	32,500	0	0	2,300
Goose Haven Lake	Fishery	0	0	0	10,000
Benewah Creek	Pair 1 - Acclimation experiment	0	12,500	0	0
Lake Creek	Pair 1 – control	0	0	0	0
Evan Creek	Pair 2 – Out-planting experiment	0	0	14,500	0
Cherry Creek	Pair 2 – control	0	0	0	0
Alder Creek	Pair 3 – Brook trout removal experiment	0	0	0	0
Hells Gulch Creek	Pair 3 – Control	0	0	0	0
Total		***65,000***	***12,500***	***14,500***	***27,000***

6.2 Production Capacity

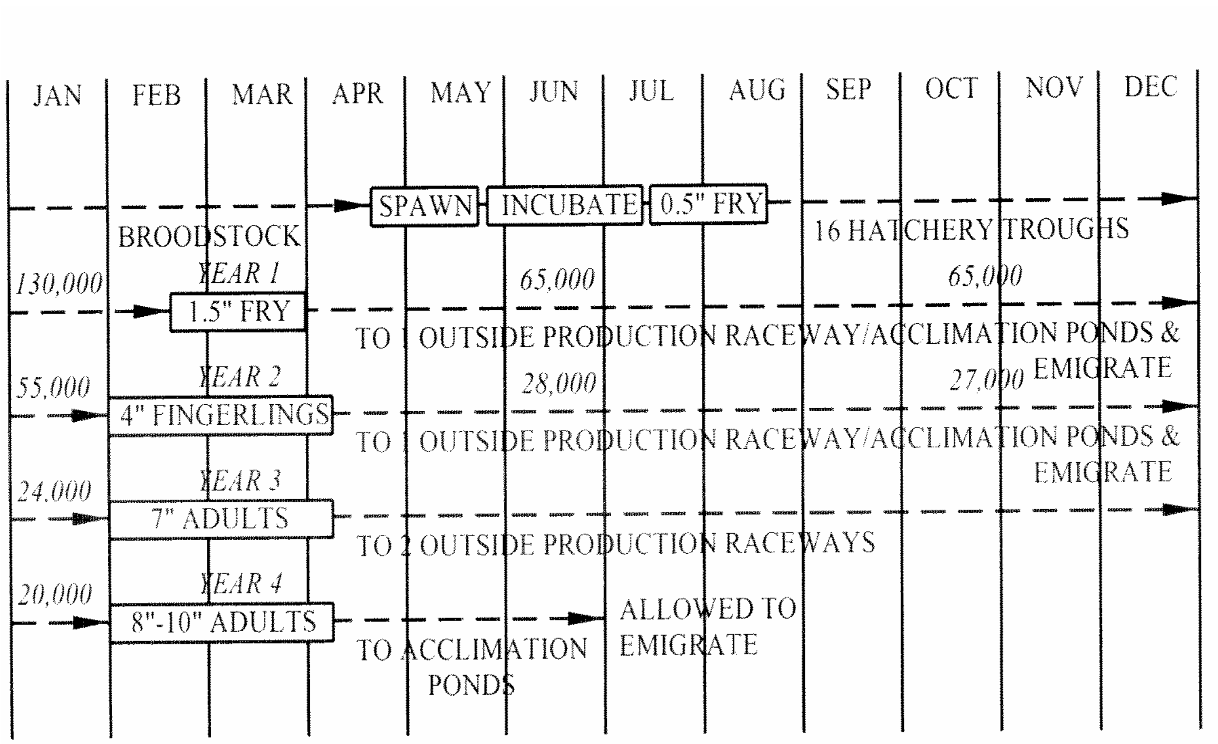
At full production, the Coeur d'Alene trout facility is conservatively designed to hold a maximum of approximately 247,600 cutthroat (23,780 pounds) at various sizes and ages as outlined in Table 8. It is anticipated that 6 to 8 years will be required to fully develop a cutthroat broodstock and achieve full cutthroat trout production. (Table 9)

Table 8. Maximum annual production capacity of Coeur d'Alene Tribal Trout Facility

Number of Fish	*Size/Weight*	*Species/Life Stage*	*Pounds Produced*
1,600	12 inch/0.75 lbs	CTT/Broodstock	1,200
130,000	1.5 inch/1.2 lbs per 1,000	CTT/Fry	156
55,000	4 inch/22.6 per 1,000	CTT/Fingerling	1,243
24,000	7 inch/111 per 1,000	CTT/Adults	2,664
20,000	8-10 inch/272 per 1,000	CTT/Adults	5,440
17,000	13 inch	CTT/adults	13,080[1]
247,600			***23,780***

[1]*Produced using grow-out ponds.*

Table 9. Cutthroat trout production schedule.



(Year 4 production transferred to grow-out ponds for subsequent fishery releases in year 5 rather than acclimation ponds for release.)

6.3 Broodstock Selection and Acquisition

Sources of hatchery broodstock will be developed consistent with program fishery and conservation goals based on fish availability and a careful benefit risk analysis. Potential alternatives include: 1) natural-origin fish that preserve attributes of the wild populations and minimize risks associated with straying, 2) sterile triploids that pose little risk of introgression, and/or 3) a hatchery stock selected to minimize overlap with natural spawners. Initial efforts will use a natural-origin broodstock to minimize genetic hazards to existing populations. Triploid fish will be considered for fishery use at such time as effective methods for triploid production are determined for cutthroat trout. Use of a discrete hatchery stock will not be considered except where efforts to use wild broodstock fail and hatchery fish can be concentrated in areas where they pose no risk to natural populations such as tributaries where natural populations have been extirpated.

Initial hatchery designs provide the flexibility for separate groups but adaptive implementation of the program may ultimately require use of a pooled broodstock to maximize diversity. The ideal option would be to use broodstock from each of the four tributaries with significant unhybridized populations and to raise and release the progeny only into their ancestral drainages. This approach would minimize risks of outbreeding depression if differences among populations represent specific adaptations. However, if this ideal option is unattainable or unrealistic based on reduce population sizes, the ISRP suggested that a pooled native broodstock would provide adequate protection for existing populations. If only one brood stock is create under this scenario, the best alternative may be to collect fish from multiple source populations and use this mixture as the brood stock. Genetic characteristics of cutthroat trout populations in remaining populations appear quite similar and use of a pooled broodstock may counter the apparent effects of genetic drift that may account for observed differences.

Risks of inadvertent introgression with rainbow trout will be minimized by avoiding tributaries where genetic studies have detected hybridization. Routine genetic monitoring will be initiated to identify and eliminate any hybrid individuals that may be included in the brood stock. Risks of domestication will be avoiding by limiting use of hatchery-origin fish to 50% of any given brood. Some use of hatchery-origin fish is appropriate to ensure that genetic characteristics of source parents contribute to subsequent generations. Risks of inbreeding depression by maximizing the number of breeders and avoiding effective spawning population sizes of less than 50 fish.

Broodstock will be initially established using wild-caught juveniles (2” to 4” fingerlings) reared to maturation in the hatchery. Fish will be collected, and held until adults in order to minimize effects of broodstock removal on the natural populations. Two separate broodstocks will initially be developed. An “adfluvial” stock will be established by collecting 50 migrants per year each from Benewah and Lake creeks. A “resident” broodstock will be established by collecting 50 juveniles each from Evans and Alder creeks.

6.4 Hatchery Facilities

A new 5,100 square-foot hatchery building and facilities, (see Figure 5) will be constructed to enable the efficient production of approximately 130,000 cutthroat trout fry. Water from a new well will be aerated, filtered and chilled to 45-50° F for incubating cutthroat trout eggs (to match natural fry-emergence temperatures) during the period of mid-April through early July. Approximately 20 gpm of such treated water will be required for the hatching operation. Cutthroat trout fry will be overwintered in the hatchery building until ready to be released in the outdoor acclimation ponds or concrete raceway production facilities. Table 9 presents a production program timetable for the cutthroat trout at the new facility.

Newly hatched fry will be placed in fiberglass troughs of the following approximate dimensions: 3 ft. wide by 1.33 ft. deep and 7 ft. long. The usable space in each trough is 18 ft^3, based on a maximum freeboard of 4-inches (0.33 ft). The downstream 12-inch length of each trough is blocked off by an overflow weir, and thus does not contribute to usable space. A total of 20 such troughs will be provided for fry rearing — 16 troughs for the production of 130,000 cutthroat fry, plus 4 spare troughs.

Each of the 16 cutthroat fry troughs will be supplied with 8 gpm of filtered, U.V. sterilized and oxygen enriched water at a temperature of 48 to 52° F. Each trough will be capable of holding 8,100 l.5-inch fry at a density index (D.I.) of 0.37. The resultant flow index (F.I.) at this density is an acceptable 0.75. The total hatchery building water requirement for this scheme is 200 gpm.

For potential future production of 42,000 13-inch cutthroat adults for supplementation efforts, the hatchery will require an additional ten fiberglass troughs to produce the required 76,000 1.5-inch fry. The additional space within the hatchery building will be used to accommodate fourteen larger troughs for the production of 64,000 4.0-inch (year 2) fingerlings. These fiberglass troughs will have dimension of 3 ft. wide by 3 ft. deep and 7 ft. long. The usable space of these larger troughs will be 45 ft^3 each, based on a freeboard of 6 inches. Each of the 14 troughs (12 for production, plus 2 spares) will receive up to 40 gpm of filtered, U.V. sterilized and oxygen enriched water at ambient temperature. The anticipated hatchery building water requirement for this supplementation scheme is 620 gpm. The larger troughs will be plumbed just like the small ones – with a cleaning waste drain and a separate overflow drain for grow-out pond reuse. The downstream 12-inch length of each trough is blocked off by an overflow weir, and thus does not contribute to useable space.

A 120 square-foot incubation room, complete with four 8 tray vertical incubators, a large stainless steel sink, a floor drain and a small floor trench will be located adjacent to the fry rearing area. Waste from all 3 drains will be treated, but not reused. A formalin drip system will be provided for this room.

An outdoor isolation/early rearing covered area, containing five 4-ft. diameter round tanks, will be used to hold and observe newly recruited wild cutthroat fingerling prior to releasing them into the broodstock raceways. This area will be adjacent to the hatchery building and will be covered by extending the roof line of the building.

Other spaces, will include a small diagnostic lab with counter tops, double sinks and chest freezers for moist feed, as well as office space, a public interpretive area for outreach and educational functions, kitchen/dining/bunkroom area, and two restrooms. There will also be a loft area above the restrooms for light materials storage.

6.5 Acclimation Sites

Off-station acclimation facilities will be developed at tributaries where supplementation feasibility is being evaluated (e.g. Benewah, Alder, and Evans creeks). A combination of temporary and fixed facilities will be utilized as the project is developed. In some cases, temporary tanks or pools may be an effective and less costly alternative in some cases to ponds during the experimental phase of supplementation feasibility evaluations.

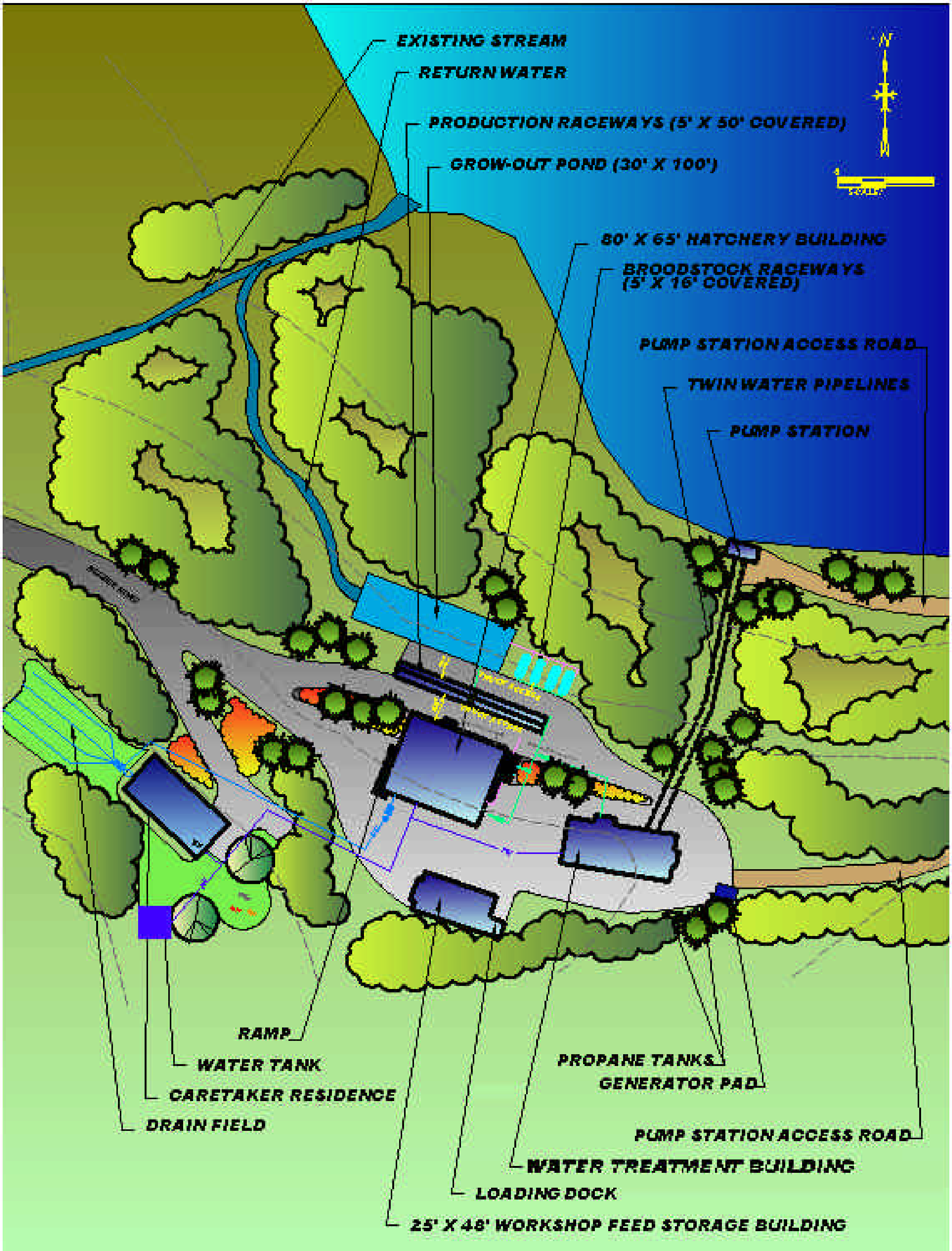


Figure 5. Proposed Hatchery Facility

Table 10. Hatchery Building Facility Requirements

	Gross SF	Lighting	HVAC	Water: Peak Flow	Water: Treatment	Water: Aeration or Degassing	Electrical	Plumbing
PRODUCTION AREA								
Incubation	120	Yes	HV only	20 gpm @ 45-50°	Micro Filter Chiller UV	Yes	110 v GFIC outlets	Double Sink Trench Drains Supply Piping
Isolation/Early Rearing (Outdoors)	240	No	______	20 gpm	(same as outdoor production)	Yes	110 v GFIC outlets	Supply Piping
Fry Rearing 20 troughs 7' long	3,300	Yes (pink-filtered)	HV only	160 gpm @ 48-52° 580 gpm*	Micro Filter Chiller UV	Yes	110 v GFIC outlets	Trench Drains Supply Piping
Diagnostic Lab	200	Yes	Yes	________	________	Yes	Strip outlets	Double Sink Floor Drain
Office Space/Interpretive	870	Yes	Yes	________	________	________	110 v outlets	________
Kitchen/Dining/ Bunkroom	440	Yes	Yes	________	________	________	110 v outlets	Potable & Sewer
Restrooms	170	Yes	Yes	________	________	________	110 v outlets	Floor Drain Potable & Sewer
Electrical (E-Gen Set on outside pad)	40	Yes	_______	________	________	________	________	________
Subtotal	5,100 SF			200 gpm/ 620 gpm *				

* during production of 13-inch CTT

6.6 Hatchery Water Supply

Water will be supplied by withdrawal from Coeur d'Alene Lake. Selective withdrawal of the Coeur d'Alene Lake water for temperature control will be accomplished by means of a double intake pipe system that features both a near surface intake and a deep (35 ft.+) intake. The intakes will be screened, and will be designed to minimize disturbance of bottom sediment both during construction and during operation. The shallow intake will likely be suspended from a float that is accessible from the shore. The deeper intake will likely be attached to four pilings. These pilings will terminate about 25 feet below normal lake level, and the intake will be located about 10 feet above the lake bottom. The intakes will likely consist of 14-inch diameter high density polyethylene pipe, which is nearly indestructible and is easily floated into position by small boats and then sunk by filling it with water.

The on-shore pump station will consist of a platform located a few feet above the high water mark. On the platform will be a pipe manifold and valves for selective withdrawal, and space for the addition of future pumps. Initially, two 40 H.P. pumps will provide operating flows of 1,700 gpm from 1 pump or 3,000 gpm from 2 pumps. For the production of cutthroat trout up to 8-10 inch sizes as described in this report, one pump will suffice and the second pump will be on stand-by. For the production of 42,000 13-inch cutthroat trout, both pumps will need to be in operation, and a third similar pump should be installed (future).

Water will be treated to remove suspended materials and biological agents. Water from the lake pump station will be piped a short distance to two drum filters located on an elevated platform. These filters (30 microns) will remove some, but not all turbidity that may periodically appear in the lake. Clean water will discharge from the filters into three large aeration columns or these could be bypassed for temperature considerations. Adjacent to the aeration columns will be three 40 lamp UV sterilization units, each capable of handling 1,000 gpm. Sterilized water will be piped to a headbox, from where it will be distributed to the various production facilities. Water destined for the hatchery building fry rearing (160 gpm) will receive further treatment consisting of micron filtration and heating/chilling via heat pumps.

7 RESEARCH, MONITORING AND EVALUATION

An effective research, monitoring, and evaluation program will be critical to the effective and efficient adaptive management of this phased natural and captive production enhancement program for cutthroat trout. Hatchery evaluations are one component of an integrated program that also addresses management of resident and adfluvial forms of cutthroat trout and evaluations of the habitat restoration program. This section describes core elements common to several program objectives. It also provides methods and rationale for specific evaluations focused on limiting factor and critical uncertainty research, hatchery suitability evaluations, and interim fisheries evaluations.

7.1 Core Monitoring Program

7.1.1 <u>Tributary habitat conditions</u>

Habitat monitoring will identify effects of habitat improvement measures and will help distinguish the relative effects of habitat vs. hatchery actions. Baseline information already exists from past habitat surveys. Changes in conditions associated with habitat restoration activities will be documented using standard habitat measurement methods (habitat types including pools, riffles, glides; channel morphology including sinuosity, depth, width, gradient; substrate composition, bank stability, riparian conditions, etc.) Flow and temperature conditions will be monitored to help evaluate season and annual patterns. Other activities that could potentially affect habitat conditions or fish production will also be identified and documented.

7.1.2 <u>Tributary populations and habitat use</u>

Periodic fish population assessments will be completed to document the status of resident fish populations including all species. Assessments will be completed using a combination of standardized electrofishing and snorkel surveys in index areas. Data will include fish distribution, numbers, size and age composition, condition, and habitat use. Cutthroat trout redd count surveys will also be conducted in spawning areas to determine spawner distribution and relative abundance.

7.1.3 <u>Juvenile Migrants</u>

Outmigrant traps will be operated to monitor outmigration timing, numbers, and composition. Data will include length, weight and origin (hatchery or natural). Trap efficiency will be determined through mark and recapture of known numbers of juvenile trout.

7.1.4 <u>Adult Returns</u>

Upstream traps will be installed and monitored to enumerate returns. Fish will be counted and measured. Several adult fish will be radiotagged and tracked to determine movement pattern and length of time prior to spawning.

Table 11. Locations of research, monitoring, and evaluation activities.

	Hatch-ery	Bene-wah	Lake	Evans	Cherry	Alder	Hells Gulch	Plum-mer	Squaw
Core monitoring									
Habitat	--	X	X	X	--	X	--	--	--
Population assessments	--	X	X	X	X	X	X	--	X
Juvenile migrants	--	X	X	X	X	X	X	--	--
Adult returns	--	X	X	X	X	X	X	--	X
Specific evaluations									
1. Hatchery practices	X	--	--	--	--	--	--	--	--
2. Fishery benefits	X	--	--	--	--	--	--	X	X
3. Resident-adfluvial interactions	--	X	--	--	--	--	--	--	--
4. Limiting stage and factors	X	X	X	X	X	X	X	--	X
5. Tributary habitat constraints	--	X	X	X	--	X	--	--	--
6. Tributary species interactions	--	--	--			X	X	--	--
7. Hatchery-wild interactions	--	X	--	--	--	--	--	--	--
8. Lake fish interactions	--	--	--	--	--	--	--	--	--
9. Reintroduction feasibility	--	--	--	--	--	--	--	--	X
10. Supplementation feasibility	--	Tr 1	Cn 1	Tr 2	Cn 2	Tr 3	Cn 3	--	--

Tr = treatment, Cn = control

7.2 Limiting Factor and Critical Uncertainty Evaluations

Ten limiting factors and critical uncertainties have been identified (Box 1). Evaluation of these uncertainties will result in specific directions for management actions regarding hatchery operations, fishery management , and the efficacy of supplementation. In particular, much of the scientific research will focus on evaluation of cutthroat supplementation on lake and tributary populations. It is anticipated that specific management directives will result from the research component of this project. Research will assist in evaluating whether acclimation ponds, stream out planting, or non-native species control will result in increased populations of adfluvial cutthroat trout. Moreover, the research will also reveal if none of the proposed supplementation techniques will have the desired impact on adfluvial cutthroat trout populations. Table 12 describes some of the potential responses of resident and adfluvial forms of cutthroat the three primary treatments: acclimation, direct out planting, and brook trout management. Each critical uncertainty is described below.

7.2.1 Hatchery Practices

Determine best practices for producing adfluvial cutthroat trout in the hatchery. What is the best way to produce cutthroat in the hatchery? Effective practices for spawning and rearing these fish in the hatchery and for size and time of release remain to be established. For instance, fingerlings are least costly to produce but greater survival and catchability of larger fish may be more cost-effective. Initial evaluations will compare the relative costs and contributions of fingerling and catchable release groups. Similarly release site and protocol will also be examined based on comparison of a series of treatments including direct stream releases, acclimated stream releases, and possibly lake releases. These experiments may be conducted directly from the hatchery if suitable attraction and collection conditions are established or in treatment streams where potential impacts on native populations can be carefully regulated.

This task also involves quality control in the hatchery involving systems, procedures, and the fish (e.g. Quality Assurance, Quality Control programs). Work includes review of existing literature/empirical program data and in-hatchery monitoring of fish performance in hatchery (health, growth, morphology, behavior, and survival) with different rearing densities, thermal regimes, feed and feeding strategies.

7.2.2 Fishery Benefits

Evaluate accessibility, use, and benefits of fisheries established using hatchery-reared progeny of native wild fish. As the hatchery produces significant returns, do people fish for them, can they catch them, and does the fishery provide desired benefit relative to identified mitigation needs? Systematic angler surveys will be completed in areas where captively-reared fish provide harvest opportunities. Surveys will be concentrated in streams and stream mouths where significant effort is likely to occur. Surveys will also be conducted at rainbow trout ponds. Surveys of lake anglers will not be considered until such time as hatchery numbers can be expected to provide significant lake fishing catches. Fishery benefits will be compared among several alternatives including hatchery and stream release sites. Exploitation rates will be estimated based on estimated catches and total returns. These activities will be focused on Squaw and Plummer creeks where fish are planted primarily for harvest and sport fishery purposes.

7.2.3 Resident-Adfluvial Interactions

Evaluate interactions of resident and adfluvial life history traits of cutthroat trout. Understanding mechanisms of life history trait expression, together with existing empirical ecological, biological, and genetic data in these systems is required to develop and implement informed management decisions for appropriately enhancing wild populations.

This investigation has implications for conservation of life history diversity of existing cutthroat populations and how hatchery broodstock are established. Can you produce adfluvial fish from resident parents, juvenile migrants raised in the hatchery, or returning adults? Work involves raising and releasing fish from the hatchery from wild resident parents and wild juvenile migrant broodstock to see how many return to spawn. Development of hatchery broodstock from wild juvenile resident fish collected from streams and migrants collected in downstream traps will provide the basis for this evaluation.

This task examines current fish production goals and assumptions of unused habitat capacity which precipitated proposals to supplement natural production with captively-reared progeny of wild fish. This unused habitat assumption can be directly tested by correlating population size with spawner number and by evaluating the population response to experimentally increased densities at various life stages using captively-reared progeny. These results can be used to identify an adaptive management approach for determining realistic production/subsistence goal. The key is to establish interim goals and measures then adapt from there.

M&E will also focus on experimentation on the effects of density on life history strategy, inheritance of life history trait expression (resident vs. adfluvial), and the influence of habitat improvement on rearing density (Box 3, Table 12). Annual estimates of population abundance in study streams will direct hatchery release numbers, provide information on the role of habitat on life history selection, and ultimately provide programmatic direction for the hatchery regarding stock selection and breeding matrices. These activities will provide a framework to assess the impact of management actions on the abundance, distribution, and ultimately harvest of cutthroat trout in the Coeur d'Alene Lake basin. To measure the impact of management actions, the change in abundance of cutthroat trout will be monitored over the next four generations, or approximately 15 years.

Primary response variables include juvenile density and numbers of out emigrating juveniles, and returning adults. Knowledge of outmigration levels will allow adjustment of captive fish production numbers, provide insight on the mechanisms driving selection of life history strategies, and estimate the contribution of ongoing habitat restoration. Counting returning adults will provide specific information on the contribution of captive, versus natural production, and will ultimately contribute to establishment of harvest rates.

Box 3 Resident-Adfluvial Interaction Approach

This investigation will experimentally determine effects of population density on expression of resident and adfluvial life history traits of cutthroat trout on the Coeur d'Alene Reservation. This experiment will document juvenile rearing densities and outmigration patterns during three baseline years and during the next 3 years when rearing densities, at a minimum, will be doubled annually. Work will focus in one pair of test streams: Evans/Cherry. Work is divided into Part 1 (Pre-treatment research, Years 1-3) and Part 2 (Treatment, monitoring, and evaluation, Years 4-6). Part 1 involves annually replicated characterization of baseline population and life history attributes of cutthroat trout in all 4 streams. Juvenile rearing densities and outmigration will be annually quantified and analyzed during years 1-3 (pre-treatment) and years 4-6 (post-treatment). The experimental treatment involves annually artificially increasing juvenile rearing densities in Evans Creek with hatchery reared, stream-specific progeny during years 4, 5, and 6. Cherry Creek will provide a set of controls. Research will also document whether the magnitude of expressed resident and adfluvial life history forms change as a function of increased juvenile rearing densities.

Analysis of data generated by this research in Phase 1 tests the following three null hypotheses:

Ho1: Expression of life history forms is not density dependent (not correlated with density)

Ho2: Resident broodstock do not give rise to adfluvial progeny

Ho3: Adfluvial broodstock do not give rise to resident progeny

Understanding of the relationships tested in these hypotheses, along with accompanying stream-specific empirical data on cutthroat trout population genetics, ecology, and biology forms the foundation for effective future management.

7.2.4 Limiting Life Stages and Factors

Identify life stages and limiting factors that currently regulate cutthroat trout population sizes. Do released hatchery-produced progeny return to spawn, and if not, what happens to them? Stage-specific survival rates derived from comparisons of release and return numbers collected in conjunction with core monitoring and other research and evaluation activities will help identify critical life stages and bottlenecks. These findings can then be used to formulate improved future management policies and practices.

7.2.5 Tributary Habitat Constraints

Determine the extent to which habitat and densities currently limit cutthroat trout production and habitat improvements may be expected to increase numbers. The effects of stream habitat restoration on native cutthroat trout populations will be evaluated based on long-term monitoring of fish distribution, numbers, and productivity in treated sections. The importance of this project is based on a previously untested but likely assumption that juvenile rearing habitat is limiting productivity and size of native cutthroat populations in streams on the Coeur d'Alene Reservation. Relevant null hypotheses to test include:

Ho4: Incremental increases in habitat quality and quantity are not correlated with increases in juvenile rearing densities

Ho5: Incremental increases in habitat quality and quantity are not correlated with increases in natural production

Ho6: Incremental increases in habitat quality and quantity are not correlated with increases in population size.

Analysis of the relationships tested by these null hypotheses will evaluate the relative success of habitat improvements in terms of increased rearing densities, natural production, and population sizes. This evaluation is fundamental to efforts to increase abundance of native cutthroat populations, because such increases likely cannot be met by simply adding captive-reared progeny of wild fish to streams if rearing habitat is limited and those limitations are not reduced.

7.2.6 Tributary Species Interactions

Evaluate constraints in tributaries associated with the presence of other species, especially brook trout. It is unclear whether brook trout significantly constrain cutthroat trout production or merely capitalize on a tolerance for more marginal habitat conditions. Brook trout are prevalent in Alder Creek and Hells Gulch Creek, and will serve as paired streams to test for imports associated with brook trout removal. Pre- and post-removal cutthroat densities will be compared. Removal will occur by electrofishing at the same time cutthroat populations are being assessed. This evaluation will help identify whether brook trout removal is a feasible alternative to improve cutthroat production.

7.2.7 Hatchery-Wild Interactions in Tributaries

Evaluate interactions in stream habitats of hatchery and naturally produced fish. Potential displacement of wild fish by hatchery fish was identified as a source of concern by the ISRP (2000). Interactions between resident trout and out- planted fish can be monitored using snorkel surveys, electrofishing, and trap data. Weight, length, and migration numbers of hatchery and natural fish would be collected at outmigration traps. Agtagonistic interactions between hatchery and natural fish in streams can also be monitored. It is important to note that the hatchery in this program will captively rear progeny of adapted, local wild fish, and will not involve stock transfers from distant and possibly less adapted source populations to enhance harvest. While recognizing negative connotations and potential risks associated with hatchery fish in wild vs. hatchery fish "comparisons", the Tribe endorses understanding of this important distinction.

7.2.8 Lake Fish Interactions

Consider interactions in the lake between wild cutthroat, hatchery- reared cutthroat, and potential fish predators. Habitat changes in Coeur d' Alene Lake have improved conditions for native predators such as northern pikeminnow (*Ptychocheilus oregonensis*), and introductions of non-native species such as northern pike (*Esox lucius*) have occurred. The overall impact of these species on westslope cutthroat is unknown. However, it has been suggested that piscivorous fish in the lake may be limiting the population of westslope cutthroat (ISRP 2001). Potential displacement of wild-spawned and facility-produced trout in Coeur d'Alene Lake was also identified as a concern by the ISRP (2000).

This work implemented a sampling program stratified by time, area, and habitat type using a combination of net, snorkel, and electrofishing methods. Predator-prey analysis in areas where significant temporal distribution of cutthroat and fish predators overlap (such as tributary mouths during migration periods) have been performed. This program's predation evaluation methods are presented in Box 4.

Appendix D presents results of the predation study in detail. Below is a summarization of these results. Nine cutthroat trout were identified in a total of 493 stomachs examined. Six of the nine cutthroat trout were found in northern pike stomachs, two in chinook salmon stomachs, and one in a smallmouth bass stomach. Cutthroat trout identified in stomach contents were adults, typically age three and four. Northern pike and chinook salmon had the smallest sample sizes of all piscivores examined, but contained the largest number of cutthroat trout in their diets.

Ivelev's selection index (Ivlev 1961) was used for all predators to determine if they were selecting for or against individual prey fish species. Values range from –1 to +1, with those greater than or equal to 0.7 indicating selection for a prey item. The annual selection value of westslope cutthroat trout by northern pike was 0.71. This indicated that northern pike selected for cutthroat trout in their diets. The annual selection value of westslope cutthroat trout by chinook salmon was 0.35, which did not indicate selection for or against cutthroat trout. Cutthroat trout were more than twice as important in northern pike diets than any other prey item. The annual relative importance for cutthroat trout in northern pike and chinook salmon diets was 23.4 % and 2.6 %, respectively. Eleven unidentified Salmonidae were found in chinook salmon stomachs; some of which could have been cutthroat trout, but more likely were kokanee salmon based on their abundance in the environment and identifiable salmonids in chinook salmon diets. Results from this study indicated that at most, 10 % of chinook salmon may have a cutthroat trout in its stomach at any given time.

Results of the predation study indicated that northern pike are likely the largest threat to migrating cutthroat trout and chinook salmon also pose a potential threat. However, based on the limited duration of this study and small sample sizes, it was not possible to determine the actual impacts these predators had on migrating cutthroat trout. It is recommended that a similar sampling protocol be continued for 10 to 15 years and be incorporated into the hatchery research efforts. Predation results can be compared before and after hatchery supplementation of adfluvial cutthroat trout and analyzed to determine predator responses to increases in cutthroat trout.

Box 4 Predation Evaluation Approach

Predation evaluations are already in progress to estimate the seasonal and annual relative importance of cutthroat in the predator species diet and estimate the annual and seasonal selectivity of predator fish prior to supplementation. Field work has been completed to represent an annual cycle by sampling in each season beginning in July 2001 and ending in June 2002. Currently field data is being analyzed and final results are expected by the end of December 2002. The sampling collected 3,938 total fish, and 450 stomach samples via the gastric lavage technique. Effort consisted of 37.8 hours of electrofishing, 350.3 hours of experimental horizontal gill net sets (4-6 hour sets), and 237 hours of vertical gill net sets (4-6 hour sets). Evaluation of the raw data is currently in progress. Stomach contents are being identified and quantified. These results will be presented by calculating the relative importance of each prey species or guild in each predator species diet and the prey selectivity by each of the predator species.

Stomach contents data of individual fish are being analyzed to estimate the importance of cutthroat trout and all other prey items to the diet of the piscivorous fish. For each prey item collected, frequency of occurrence will be calculated by dividing the number of stomachs containing a particular prey item by the total number of stomachs analyzed (Bowen 1996). Frequency of occurrence data illustrates the uniformity in which fish select their diet, but does not indicate selection or importance of prey items (Bowen 1996). Percent composition of prey items by number will be calculated by dividing the number of individuals of a certain prey item in one stomach by the total number of all prey items in the same stomach (Bowen 1996). This index can be biased toward small prey. For example, if a predator eats several hundred invertebrates and only two prey fish, higher importance may be wrongly placed on the smaller prey when in fact they do not provide as much energy as the fish consumed. Percent composition by weight will be calculated for both wet and dry weights by dividing the total weight of a certain prey item in one stomach by the total weight of all prey items in the same stomach (Bowen 1996). In cases where prey weight is too small to be measured on the analytical balance, the items will be pooled from several fish of the same species in the same age/length interval, weighed and divided by the total number of predator fish contributing to the sample. This index tends to be biased toward large prey items. More importance will be placed on one fish than several hundred invertebrates. To account for the biases in the previous analyses, a relative importance index will be calculated (George and Hadley 1979) as follows:

$$Ri_a = \frac{100Ai_a}{\sum_{a=1}^{n} Ai_a}$$

where: Ri_a = relative importance of food item a

Ai_a = % frequency of occurrence + % total numbers + % total weight; and

n = number of food types.

Each of the three previous indices are included in this index. Values for the relative importance index range from 0-100%; larger numbers will be considered more important prey items.

An electivity index (Ivlev 1961; Strauss 1979) is being used to determine if predators actively target cutthroat trout or other prey using the following formula:

$$E = \frac{r_i - p_i}{r_i + p_i}$$

where: *E* = Ivlev's (1961) measure of food selection

r_i = relative abundance of prey *i* in the gut; and

p_i = relative abundance of same prey *i* in the environment.

7.2.9 Reintroduction Feasibility

Experimentally evaluate the feasibility of using the hatchery to reintroduce resident and adfluvial cutthroat into streams where they do not currently exist. The Master Plan identifies nine streams on the Coeur d'Alene Reservation that currently do not contain cutthroat trout populations. It is currently unclear whether experimental introductions of captively-reared progeny of local wild fish will provide the opportunity to assess availability of suitable habitat. Experimental introductions can also provide valuable empirical data concerning which useful stream attributes are consistent with population viability and what mechanisms explain or are correlated with cutthroat trout presence and absence.

Prior to reintroduction key ecological attributes of streams will be evaluated and compared to predict suitability for and presence of wild cutthroat trout populations. This analysis will be used to identify the most promising candidate streams for reintroduction. Currently, Squaw Creek and Plummer Creek are believed to contain habitat suitable for adfluvial cutthroat trout but do not contain cutthroat trout. Squaw Creek will be used to initially evaluate the influence of reintroduction on adfluvial populations. Plummer Creek will serve as a put and take cutthroat fishery and treatment stream to evaluate reintroduction feasibility. The remaining streams will be used to document environmental conditions that result in low or nonexistent adfluvial cutthroat trout populations. Comparative habitat models will be explored to identify explanatory attributes and parameter values. Key ecological datasets from streams with and without cutthroat trout populations will be documented. The suite of environmental conditions that best predict the presence of cutthroat trout populations will be compared to identify limiting factors in barren streams.

7.2.10 Supplementation Feasibility

Evaluate the feasibility of hatchery supplementation to increase subsequent natural production of adfluvial fish in an existing population. Contingent upon the results of previously described research and limiting factor evaluations, a supplementation experiment will be conducted in three streams that currently contain resident cutthroat trout with three additional streams serving as controls. Additional planning is required to establish the conditions under which this experiment would be appropriate. The evaluation would monitor stock status including run size and escapement to track long-term performance and fitness of the fish population. Research monitoring activities include measurements of performance including: a) post-release survival (survival from time of release until the time the fish returns to spawn); b) reproductive success (number of offspring produced per spawner); c) long-term fitness (genetic diversity and long-term stock productivity), and d) ecological interactions (population abundance and distribution, growth rates, carrying capacity, survival rates, transfer of disease, and gene flow).

Table 12. Array of theoretical outcomes from increasing juvenile cutthroat trout densities in streams using adfluvial and resident broodstocks. Experimental treatment involves annually doubling juvenile rearing densities in all four streams during years 4-6 of this study.

Creek	Treatment	Treatment response (wild fish)		Management Implications
Benewah[1] and Lake[2]	Acclimation	R ↑	A ↑	Both resident and adfluvial forms increase which may indicate that acclimation increases overall population levels, adfluvial form can be enhanced through hatchery operations, and rearing habitat is not limiting adfluvial and resident forms. Continue to use acclimation ponds.
		R ↑	A ↓	Returning adults spawn resulting in increased rearing densities and depressing adfluvial form. Acclimation ponds are not increasing naturally spawning adfluvial forms, use other enhancement techniques. Rearing habitat is not limiting.
		R ↓	A ↑	Adfluvial populations increase indicating that acclimation is resulting in increased natural adfluvial production. Adfluvial fish, prior to lake ward migration, are displacing resident fish resulting in lower overall resident fish numbers. Continue to use acclimation ponds, improve rearing habitat as needed to increase resident populations.
		R ↓	*A* ↓	Both forms of cutthroat decline indicating that acclimation ponds are inadequate to overcome habitat, water quality, and predation issues. Consider other management options.
Evans[1] and Cherry [2]	stream out planting	R ↑	A ↑	Both resident and adfluvial forms increase which may indicate that stream out planting increases overall population levels, adfluvial form can be enhanced through hatchery operations, and rearing habitat is not limiting for adfluvial or resident forms. Continue to out plant.
		R ↑	A ↓	Out planted fish fail to out migrate resulting in increased resident populations. Adfluvial fish are not resulting from out plants, and rearing habitat is not limiting. Consider different management options.
		R ↓	A ↑	Adfluvial populations increase indicating that out planting is resulting in increased natural adfluvial production. Adfluvial fish, prior to lake ward migration, are displacing resident fish resulting in lower overall resident fish numbers. Continue to use out planting, and improve rearing habitat to increase resident population.
		R ↓	*A* ↓	Both forms of cutthroat decline indicating that out planting is inadequate to overcome habitat, water quality, and predation issues. Consider other management options.

Alder[1] and Hells Gulch[2]	brook trout removal	R ↑	A ↑	Both resident and adfluvial forms increase indicating that brook trout were limiting both adfluvial and resident forms. Since adfluvial type was not present prior to brook trout removal this outcome indicates that adfluvial life history may occur in a resident population. Continue to aggressively manage brook trout, and improve rearing habitat to encourage increasing population size.
		R ↑	A ↓	Returning adults spawn resulting in increased rearing densities and depressed adfluvial form. Brook trout were affecting resident populations but hatchery operations are not increasing adfluvial life forms. Continue to aggressively suppress brook trout and consider other management options.
		R ↓	A ↑	Adfluvial populations increase indicating that brook trout were depressing influencing adfluvial numbers. Resident population declines due to larger proportion of overall population expressing adfluviality. Improve instream habitat to encourage resident life history component and continue suppression of brook trout numbers.
		R ↓	*A* ↓	Both forms of cutthroat decline indicating that brook trout are not limiting cutthroat populations and other factors such as habitat, water quality, and predation are dominant. Consider other management options.

[1] stream where treatment will occur
[2] control strea

8 HARVEST PLAN

The Coeur d' Alene Tribe has made the difficult decision to maintain a strict wild fish management policy for traditional fishing areas, primarily on important cutthroat trout streams within the Reservation. The emphasis is to restore these areas in order to optimize conditions for expansion of wild stocks with habitat restoration. However, substantial increases to these populations to support any sizable harvest goals are not expected for some time.

Fisheries will be allowed in selected areas concurrent with restoration of hatchery-reared fish runs. As previously mentioned, initial efforts will be concentrated in readily-accessible tributaries that do not currently contain significant wild populations of cutthroat trout. All hatchery-reared fish will be marked. Liberal bag limits will be established for hatchery-reared fish to encourage harvest.

9 MANAGEMENT CONTEXT

9.1 Relation to Council Program

The NWPPC receives and reviews proposals to mitigate for fish and wildlife losses and refers approved measures to Bonneville Power Administration (BPA) for funding. The Northwest Power Act (Act) calls on the Council to include measures in its Columbia River Basin Fish and Wildlife Program (Program) to address system-wide fish and wildlife losses. The Act further states that the Council may include in its Program measures that provide off-site mitigation – mitigation physically removed from the hydro project(s) that caused the need to mitigate. The Program includes a goal "to recover and preserve the health of native resident fish injured by the hydropower system, where feasible, and, where appropriate, to use resident fish to mitigate for anadromous fish losses in the system." This project will address partial mitigation (out-of-place, out-of-kind) for anadromous fish losses in the Upper Columbia River basin through a resident fish substitution program.

Among those recommended measures are off-site mitigation for losses of anadromous fisheries including the measure under analysis in this Coeur d'Alene Tribe Trout Production Facility Master Plan, proposed by the Coeur d'Alene Tribe. To meet the need for off-site mitigation for anadromous fish losses in the Columbia River Basin in a manner consistent with the objectives of the Council's Fish and Wildlife Program, the Coeur d'Alene Tribe is proposing that the BPA fund the design, construction, operations and maintenance of a trout production facility on the Coeur d'Alene Indian Reservation. Measures for establishing a Coeur d'Alene fish production facility have been part of the Council's Program since 1987. The Coeur d'Alene Tribe Trout Production Facility construction project is one of many ongoing efforts directed at mitigating losses attributed to construction of Grand Coulee and Chief Joseph Dams. The project is also an integral part of the Columbia Basin Fish and Wildlife Authority multi-year plan.

In 1987, the Council amended the Columbia River Basin Fish and Wildlife Program to include baseline stream survey of tributaries located on the Coeur d'Alene Indian Reservation [Section 903 (g)(1)(B)]. Initial work rated reservation streams according to their potential for habitat development for westslope cutthroat trout and bull trout. Ten streams were selected for further study based on geographic location, potential for habitat improvement, road access, and stream gradient. Physical and biological surveys were conducted on the 10 selected streams. These surveys incorporated stream bank and bed stability, riparian condition, land use, urbanization, migration barriers, water quality, stream flow, substrate suitability, channel modification, relative abundance estimates, and macroinvertebrate densities. These physical and biological data were then combined to choose the four streams (Alder, Benewah, Evans, and Lake Creeks currently referred to as target tributaries) that offered the best potential habitat and highest fish populations for further study. Since no reproducing bull trout populations have been found in any of the target tributaries, the focus of the Tribe's efforts are on westslope cutthroat trout. It should be noted, however, that bull trout were sampled in Coeur d' Alene Lake during sampling efforts in 1995, 1998, and most recently during the winter of 2001.

In 1994, the Council adopted the recommendations set forth by the Coeur d'Alene Tribe to improve the reservation fishery. These actions included: 1) Implement habitat restoration and enhancement measures in Lake, Benewah, Evans, and Alder Creeks; 2) Purchase critical watershed areas for protection of fisheries habitat; 3) Conduct an educational/outreach program for the general public within the Coeur d'Alene Indian Reservation to facilitate a "holistic" watershed protection process; 4) Develop an interim fishery for tribal and non-tribal members of the reservation through construction, operation and maintenance of five trout ponds; 5) Design, construct, operate and maintain a trout production facility; and 6) Implement a five-year monitoring program to evaluate the effectiveness of the hatchery and habitat improvement projects. The principles, priorities, and objectives for this mitigation are described in the 1995 Program, Section 10, Resident Fish, specifically Sections: 10.8B; 10.8B.1; and 10.8B.20. Most recently the hatchery program was one of the highest priorities in the Coeur d' Alene subbasin summary provided to the NWPPC in 2000.

Consistent with the Northwest Power Planning Councils Fish and Wildlife Program and September 15th draft of the *Artificial Production Review*, artificial production will be used as a tool to address specific biological, ecological and management issues.

9.2 Consistency with Endangered Species Management

Significant numbers of bull trout occur in the Coeur d'Alene Basin, although these fish are rare in Reservation tributaries. Bull trout and cutthroat trout coevolved in the system and cutthroat trout were likely an important food source for bull trout. Based on suggested allopatry supported by empirical data cutthroat trout restoration activities are expected to be neutral or beneficial to bull trout.

9.3 Related Tribal Management Programs

The proposed hatchery program is an integral component in the strategy to address fish population enhancement and fishery restoration goals of the Coeur d'Alene Tribe.

9.3.1 Habitat Improvement

Habitat restoration and enhancement measures are being implemented in four target watersheds. The Tribe is also involved in purchasing critical watershed areas for protection of fisheries habitat. Existing information is analyzed to prioritize potential projects consistent with management guidelines. Landowner contracts are negotiated and signed. Site specific plans are developed and used to obtain permits and submit project descriptions to BPA and participating agencies for supplemental analysis and review. Projects are prioritized based on demonstrable improvements in watershed conditions by reductions in sediment delivery and transport, improvements in water quality and quantity, and increases riparian and instream habitat diversity. Maintenance activities are conducted at existing project sites as necessary. For instance, BPA is providing funding to the Coeur d'Alene Tribe to acquire 2,100 acres of high quality riparian wetlands and adjacent upland habitat in the Lake Creek watershed (9004401). This acquisition will secure critical habitat for protection of fish, water and wildlife, allow for enhancement of degraded areas. Expected benefits are reduced sediment loading, improved water quality and quantity, and improved riparian and instream habitat diversity in target watersheds.

A conceptual approach to the restoration of fish habitat has been adapted from various sources as a guide for management efforts on the Reservation (Lillengreen 1998; National Research Council 1992; Kauffman et al. 1993). The conceptual model is based on the ecological processes that shape riparian/stream ecosystems and focuses on 1) removing or modifying those land use impacts that are causing habitat degradation, 2) re-establishing riparian/stream linkages, and 3) restoring natural ecosystem processes. The desired future condition for target watersheds has been defined as being functionally equivalent to the potential natural community. In other words, the goal is to restore those essential ecological conditions and processes necessary to maintain diverse and productive resident and/or adfluvial trout populations. This concept recognizes that a number of human-caused factors will preclude a complete return to the historical condition. However, under this scenario ecological processes (succession, natural disturbances, competition, evolution, population dynamics, etc.) and hydrological processes (sediment transport and deposition, flood plain storage and subsurface recharge, nutrient cycling, etc.) function in such a manner as to ensure a sustainable intact ecosystem. Such a system has the potential to support a healthy resident trout fishery.

The EPA is working with the Water Resources Division of the Coeur d'Alene Tribe's Department of Natural Resources under sections 319 and 106 of the Clean Water Act to reduce non-point source pollution and to gather baseline water quality data in the four target watersheds. Implementation priorities for this program are 1) the reduction of sediment outputs from agricultural sheet and rill erosion; 2) the restoration of riparian zones and increasing of streambank canopy cover; 3) the augmentation of base flows; and 4) the mitigation of flow disturbances and sedimentation due to forest roads.

Additionally, local soil conservation districts have received State Agricultural Water Quality Program (SAWQP) grants to fund projects that reduce non-point source pollution from cropland erosion. The Kootenai-Shoshone Soil Conservation District recently enrolled 55% of the Lake Creek agricultural acreage within Idaho into the State Agricultural Water Quality Program (SAWQP). This commits watershed producers to a variety of agricultural BMP's including conversion to bluegrass. The majority of the contracts written are in their first two years of a five-year implementation plan. As the contracts are completed, the Lake Creek watershed should receive reduced sediment loads. Tribal staff are coordinating fish and wildlife habitat restoration efforts with this agency so that critical areas receive priority treatment. This project is also consistent with the IDFG management goal of conserving and enhancing native fish stocks throughout the region.

9.3.2 Educational/Outreach

In order to increase the public's awareness of the Coeur d'Alene Tribe's Fisheries Restoration Program and to involve the Reservation community and affected parties in a meaningful public involvement and education process, the following goals and objectives were identified:

- Encourage landowner and public support and guidance in the identification of creative solutions to land use problems impacting fisheries habitat in the study drainages.
- Develop and coordinate landowner, community and agency coalitions that would address issues related to habitat restoration efforts.
- Develop and distribute educational literature on fish habitat restoration.
- Develop and implement an outreach effort for all interested parties, including special interest groups, schools, and agencies.

- Develop educational components to be utilized by the local schools, clubs (i.e.4-H), community groups, etc.

Two parallel processes have been designed to achieve these goals. One focuses on addressing methods of fostering landowner cooperation and modifying land use practices that negatively affect impact fisheries habitat. The second process focuses on promoting the general public's awareness of fish, habitat and watershed health issues and increasing the public's awareness of the Coeur d'Alene Tribes compensatory harvest program.

The first process involves formulation of watershed working groups comprised of local land-owners, special interest groups (primarily active sportsman groups in the local watersheds), and interested agencies. The watershed working groups are responsible for assisting in the identification of problems in the watershed and developing long-term methods of improving fisheries habitat. These working groups are also responsible for gaining public support and cooperation with the restoration program. The watershed groups help identify and solicit other sources of revenue to expand the restoration effort.

The second process involves a "public relations" campaign or "marketing program". This process focuses on educating the general public about the importance of fish habitat and watershed health issues. This campaign targets civic organizations, local schools, the general public and other interested parties. The educational campaign also prepares and gives presentations pertaining to the needs of and protection of fisheries habitat. Field trips to showcase restoration projects are offered as well as publication and distribution of quarterly news letters.

9.3.3 Fishery Development

An interim fishery has been developed for tribal and non-tribal members of the reservation through construction, operation and maintenance of trout ponds. Since harvest of fish remains an ongoing subsistence activity for many Tribal members, there is a need to reduce fishing pressure on wild fish stocks while giving restoration efforts a chance to benefit the ecosystem. Over the last several years, poor fishing conditions have severely limited the ability of the Tribal Community to harvest desirable fish species in any acceptable numbers.

Since the Coeur d'Alene Tribe decided to close streams to harvest of wild fish in sensitive drainages on the Reservation as the principal method of protecting and promoting wild stock expansion, a hatchery oriented "put and take" fisheries program using rainbow trout was implemented. To provide for reasonable harvest of desired species in the near future it was decided that a series of trout fishing ponds located in strategic areas would best serve the need for an alternative fishery on an interim basis. To protect the integrity of the wild fish restoration projects none of these ponds are to be placed in drainages where restoration is occurring. This will minimize the chance of interaction between hatchery and native fish species. Additionally, all ponds will be "closed basin fisheries" to prevent genetic introgression as well as any potential spread of disease.

10 ALTERNATIVES TO THE PROPOSED ACTION

The selected alternative involves purchase of land immediately adjacent to Coeur d' Alene Lake and constructing a trout production facility. Detailed descriptions of other facility options may be found in Appendix B.

A combined rainbow and cutthroat trout production facility was also considered but purchase of rainbow trout from existing private hatcheries was estimated to be a more cost effective alternative. Purchase or acquisition of cutthroat trout from other facilities was rejected because of risks to local stocks, contrary to Artificial Production Review Policies.

Chinook-kokanee hatchery facility was also considered and rejected because native fish recovery is the Tribal management priority.

Another alternative considered is the no action alternative. No action means not constructing the facility and relying on habitat restoration to satisfy production needs. This alternative would not allow the furtherance of research measures aimed at answering critical uncertainties.

The range of alternatives will be evaluated in detail during the final NEPA process.

Alternatives beyond the scope of this plan include restoration of anadromous fish runs in previously-occupied portions of aboriginal territories, acquisition of management rights in key watersheds through conservation easements and fee title acquisition, or exercise of exclusive ceremonial, subsistence, or commercial fishing rights.

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12 APPENDIX A UPDATED CONCEPTUAL HATCHERY DESIGN

Production Goals

The Coeur d'Alene trout production facility will support about 1,600 adult cutthroat trout for use as broodstock. These fish will be collected as 2" to 4" fingerlings and held until adults in order to minimize effects on the natural populations. It is anticipated that four years will be required to fully develop a cutthroat broodstock at the new production facility. Four years thereafter, the facility will be expected to achieve full cutthroat trout production. Table 1 presents a summary of annual production goals for the new facility.

Table 1 - Maximum Annual Production Capacity of Coeur d'Alene Tribal Trout Facility

Number of Fish	*Size/Weight*	*Species/Life Stage*	*Pounds Produced*
1,600	12 inch/0.75 lbs	CTT/Broodstock	1,200
130,000	1.5 inch/1.2 lbs per 1,000	CTT/Fry	156
55,000	4 inch/22.6 per 1,000	CTT/Fingerling	1,243
24,000	7 inch/111 per 1,000	CTT/Adults	2,664
20,000	8-10 inch/272 per 1,000	CTT/Adults	5,440
17,000	13 inch	CTT/Adults	13,080
Total 247,600			23,780 lbs

Cutthroat trout will be stocked for supplementation efforts in the target tributaries. They will be placed in individual acclimation ponds—each one adjacent to the individual target tributary (see Figure 5). The acclimation pond will be fed with water from the stream. Fish when ready will be released and allowed to leave the pond on their own volition. The following annual CTT stocking strategy is planned: 65,000 at 1.5 inch; 27,000 at 4.0 inch; 20,000 at 8-10 inch, and experimentation with 17,000 13-inch adults.

Hatchery Building

A new 5,100 square-foot hatchery building (see Figure 1) will be constructed to enable the efficient production of 130,000 trout fry. Water from a new well will be aerated, filtered and chilled to 45-50° F for incubating cutthroat trout eggs (to match natural fry-emergence temperatures) during the period of mid-April through early July. Approximately 20 gpm of such treated water will be required for the hatching operation. CTT fry will be overwintered in the hatchery building until ready to be released in the outdoor acclimation ponds or concrete raceway production facilities. Table 2, found on the next page, presents a production program timetable for the cutthroat trout at the new facility.

Newly hatched fry will be placed in fiberglass troughs of the following approximate dimensions: 3 ft. wide by 1.33 ft. deep and 7 ft. long. The usable space in each trough is 18 $ft.^3$, based on a maximum freeboard of 4-inches (0.33 ft). The downstream 12-inch length of each trough is blocked off by an overflow weir, and thus does not contribute to usable space. A total of 20 such troughs will be provided for fry rearing — 16 troughs for the production of 130,000 cutthroat fry, plus 4 spare troughs.

Each of the 16 cutthroat fry troughs will be supplied with 8 gpm of filtered, U.V. sterilized and oxygen enriched water at a temperature of 48 to 52° F. Each trough will be capable of holding 8,100 l.5-inch fry at a density index (D.I.) of 0.37. The resultant flow index (F.I.) at this density is an acceptable 0.75. The total hatchery building water requirement for this scheme is 200 gpm.

For the exclusive future production of 42,000 13-inch cutthroat adults for supplementation efforts, the hatchery will only need ten fiberglass troughs to produce the required 76,000 1.5-inch fry. The additional space within the hatchery building will be used to accommodate fourteen larger troughs for the production of 64,000 4.0-inch (year 2) fingerlings. These fiberglass troughs will have dimension of 3 ft. wide by 3 ft. deep and 7 ft. long. The usable space of these larger troughs will be 45 ft^3 each, based on a freeboard of 6 inches. Each of the 14 troughs (12 for production, plus 2 spares) will receive up to 40 gpm of filtered, U.V. sterilized and oxygen enriched water at ambient temperature. The anticipated hatchery building water requirement for this supplementation scheme is 620 gpm. The larger troughs will be plumbed just like the small ones – with a cleaning waste drain and a separate overflow drain for grow-out pond reuse. The downstream 12-inch length of each trough is blocked off by an overflow weir, and thus does not contribute to useable space.

A 120 square-foot incubation room, complete with four 8 tray vertical incubators, a large stainless steel sink, a floor drain and a small floor trench will be located adjacent to the fry rearing area. Waste from all 3 drains will be treated, but not reused. A formalin drip system will be provided for this room.

An outdoor isolation/early rearing covered area, containing five 4-ft. diameter round tanks, will be used to hold and observe newly recruited wild cutthroat fingerling prior to releasing them into the broodstock raceways. This area will be adjacent to the hatchery building and will be covered by extending the roof line of the building.

Other spaces, as outlined on Table 3 and illustrated on Figure 1 will include a small diagnostic lab with counter tops, double sinks and chest freezers for moist feed, as well as office space, interpretive area, kitchen/dining/bunkroom area, and two restrooms. There will also be a loft area above the restrooms for light materials storage.

TABLE 2 - PRODUCTION PROGRAM

COEUR D'ALENE TRIBAL TROUT FACILITY

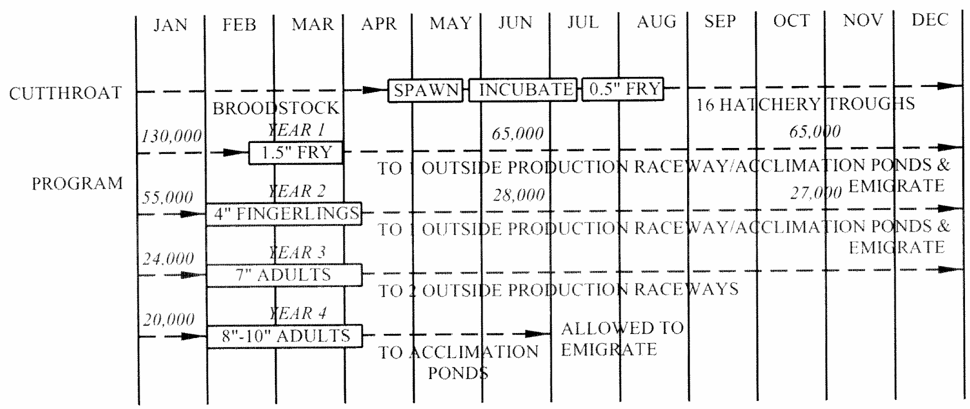


TABLE 3 – HATCHERY BUILDING FACILITY REQUIREMENTS COEUR D'ALENE TRIBAL TROUT FACILITY								
				Water				
	Gross SF	Lighting	HVAC	Peak Flow	Treatment	Aeration or Degassing	Electrical	Plumbing
PRODUCTION AREA								
Incubation	120	Yes	HV only	20 gpm @ 45-50°	Micro Filter Chiller UV	Yes	110 v GFIC outlets	Double Sink Trench Drains Supply Piping
Isolation/Early Rearing (Outdoors)	240	No	______	20 gpm	(same as outdoor production)	Yes	110 v GFIC outlets	Supply Piping
Fry Rearing 20 troughs 7' long	3,300	Yes (pink-filtered)	HV only	160 gpm @ 48-52° 580 gpm*	Micro Filter Chiller UV	Yes	110 v GFIC outlets	Trench Drains Supply Piping
Diagnostic Lab	200	Yes	Yes	________	________	Yes	Strip outlets	Double Sink Floor Drain
Office Space/Interpretive	870	Yes	Yes	________	________	________	110 v outlets	________
Kitchen/Dining/ Bunkroom	440	Yes	Yes	________	________	________	110 v outlets	Potable & Sewer
Restrooms	170	Yes	Yes	________	________	________	110 v outlets	Floor Drain Potable & Sewer
Electrical (E-Gen Set on outside pad)	40	Yes	_______	________	________	________	________	________
Subtotal	5,100 SF			200 gpm/ 620 gpm *				

* during production of 13-inch CTT

Table 4

Coeur d' Alene Tribal Trout Facility (Annual Supplementation Projections for Scheme B)

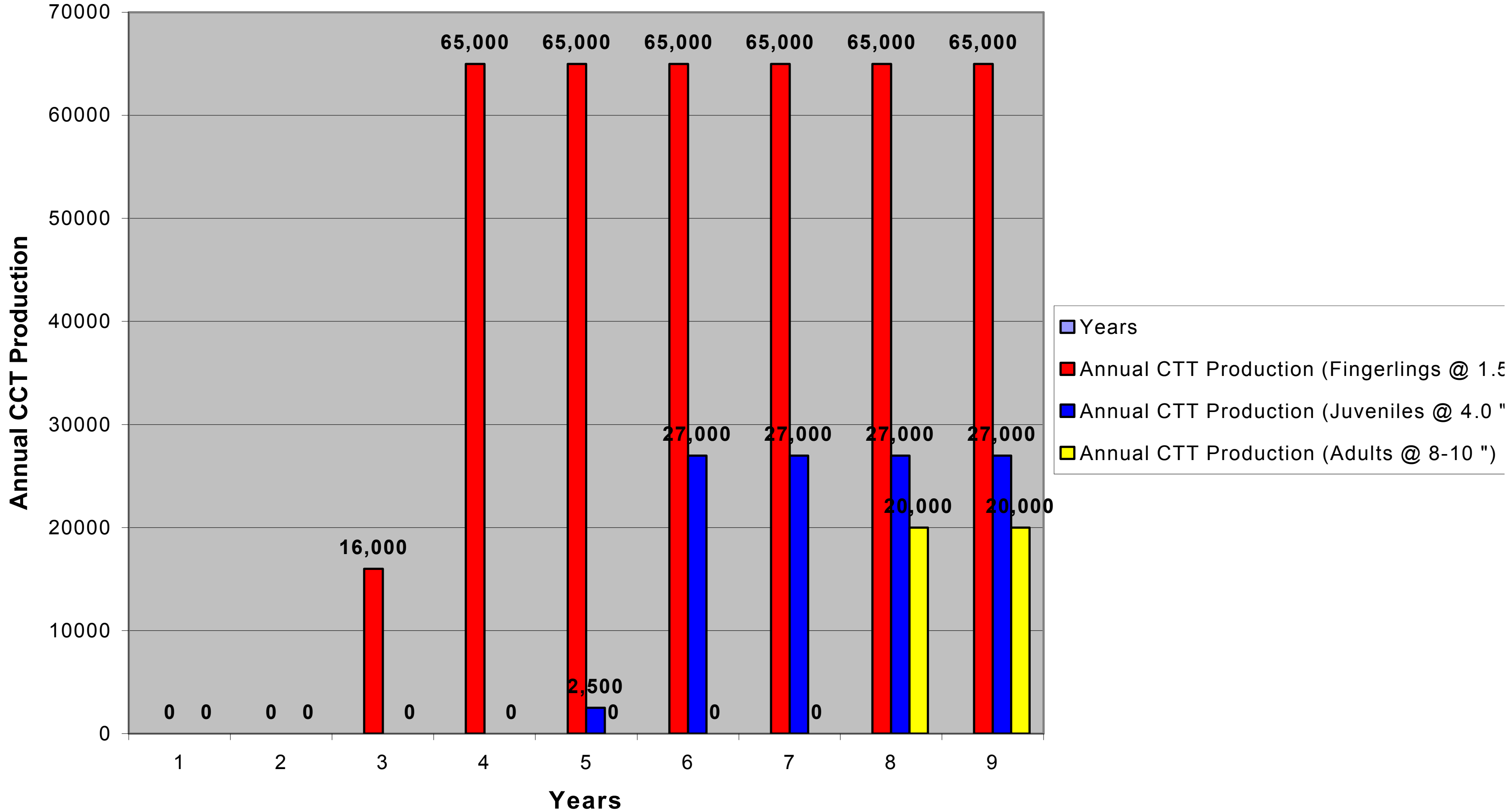


Table 5
Coeur d' Alene Tribal Trout Facility (Annual Production Projections for Scheme G exclusively)

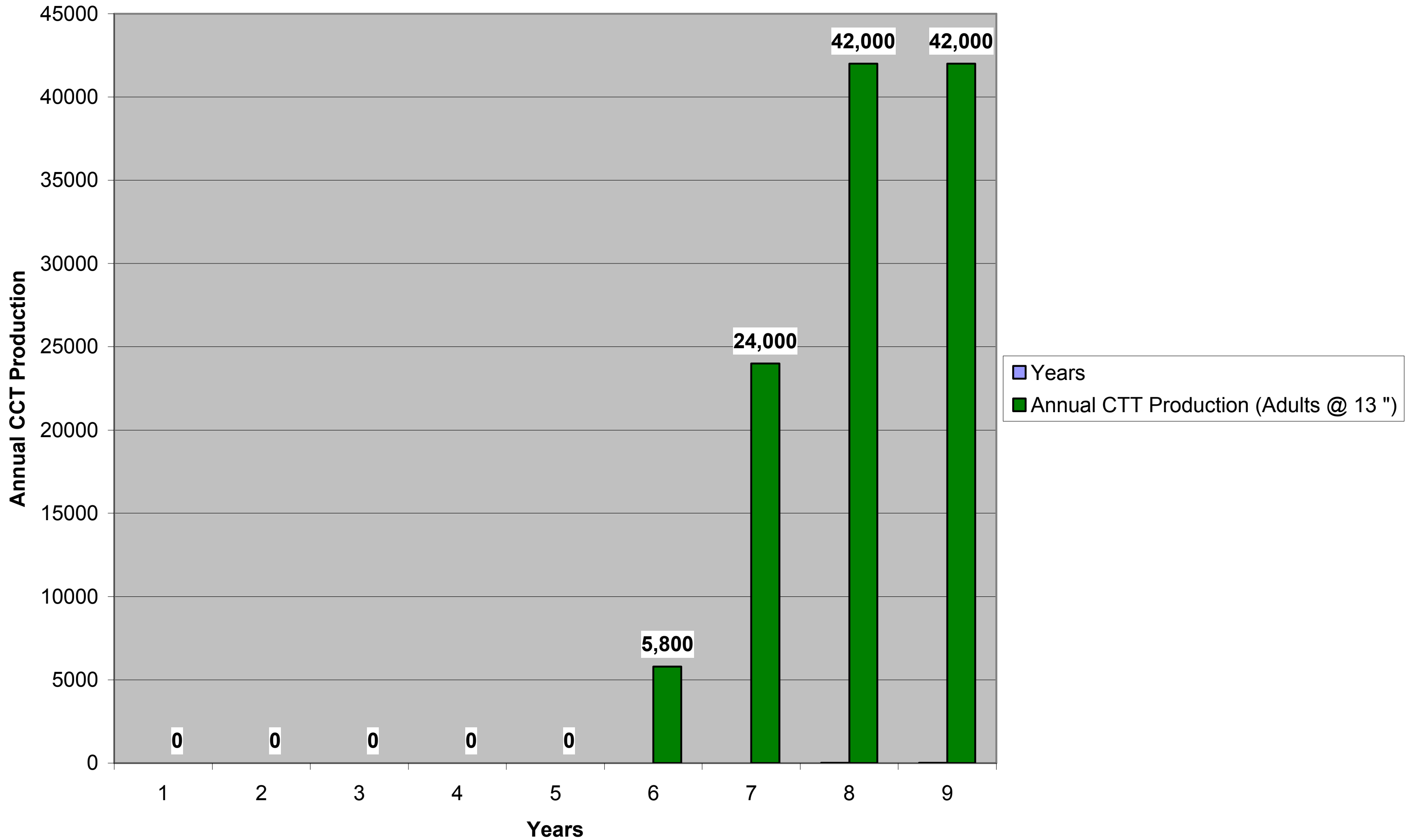
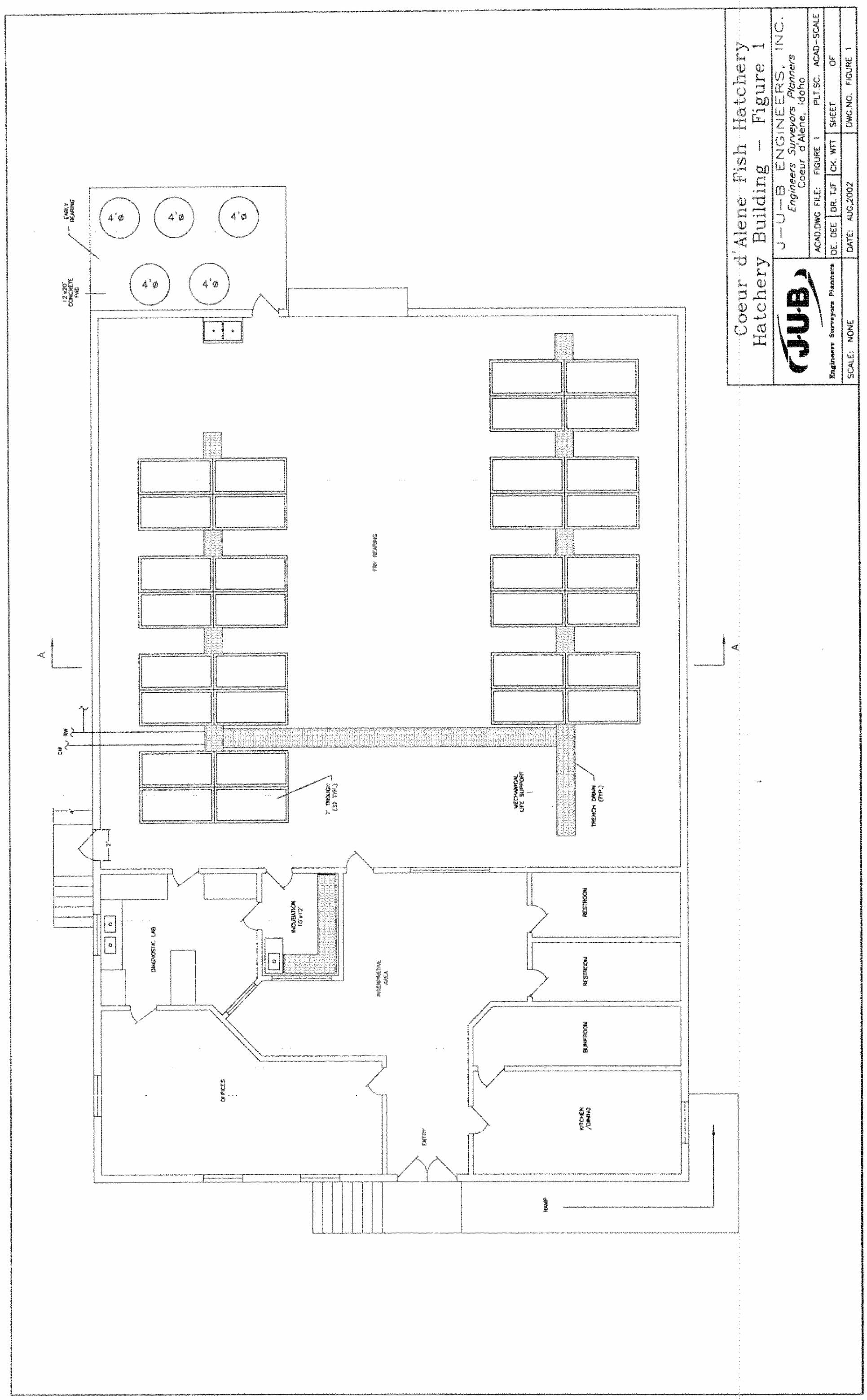
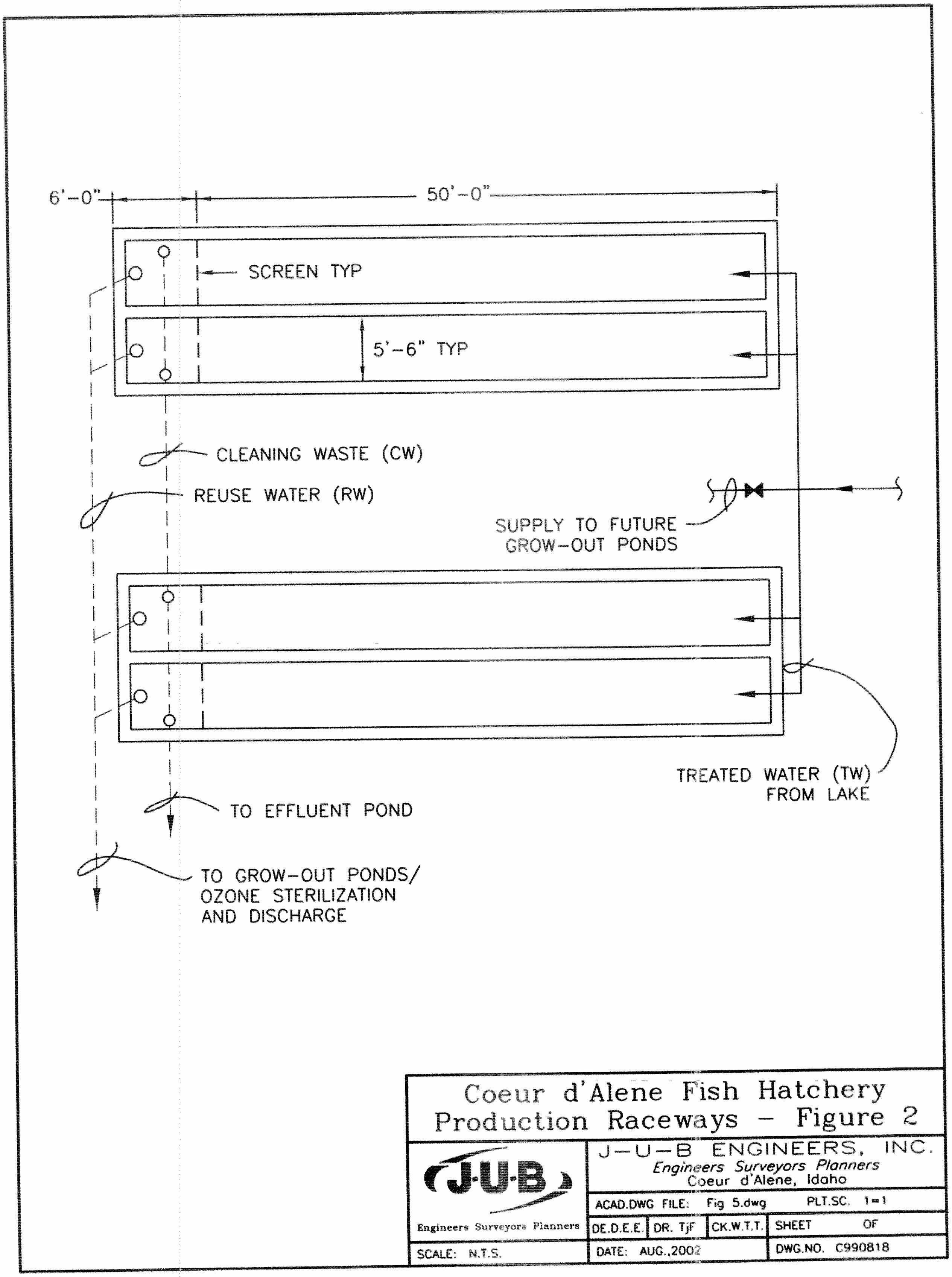


TABLE 6
RELEASE ALTERNATIVES CONSIDERED (B & G PREFERRED ALTERNATIVES CHOSEN)

Schemes	Assumptions	Density Index	Production	Production (lbs)	Cost (millions)	Water Quantity (GPM)*	Energy Requirements (kwH/yr)	Feed (lbs./year) **	Cost of Energy + Feed
A	Alternate Site Feasibility Report	0.5	RELEASE: 100,000 @ 4-inch	2,260	$2.90	1,000	538,000	6,500	$30,150
B	4 Raceways	0.5	RELEASE: 65,000 fingerlings @ 1.5 inches 27,000 juveniles @ 4.0 inches 20,000 adults @ 8-10 inches	6,128	$3.33	1,600	743,000	13,500	$43,900
C	6 Raceways	0.5	RELEASE: 55,000 @ 4 inches 20,000 @ 7 inches 23,000 @ 8-10 inches	9,719	$3.77	2,400	1,062,000	20,000	$63,100
D	13" Production	0.5	RELEASE: 10,000 @13 inches	10,000	$3.27	1,500	727,000	19,000	$45,850
E	13" Production	0.7	RELEASE: 14,000 @13 inches	14,000	$3.44	2,100	948,000	26,000	$60,000
F	13" Production, plus accelerated growth	0.7	RELEASE: 23,000 @13 inches	23,000	$3.69	2,700	1,174,000	43,000	$80,200
G	13" Production, plus accelerated growth, plus grow-out pond at hatchery	0.7	RELEASE: 42,000 @13 inches	46,000	$3.83	2,800	1,365,000	85,000	$110,750
H	13" Production at Pow-Wow site, utilizing existing on-site wells	0.5	RELEASE: 813 @ 13 inches	813	$200K	25			



Coeur d'Alene Fish Hatchery
Hatchery Building - Figure 1
J-U-B ENGINEERS, INC.
Engineers Surveyors Planners
Coeur d'Alene, Idaho
Engineers Surveyors Planners
SCALE: NONE
DE. DEE
DR. TJF
CK. WTT
DATE: AUG.2002
ACAD.DWG FILE: FIGURE 1
PLT.SC. ACAD-SCALE
SHEET OF
DWG.NO. FIGURE 1
4'ø
4'ø
4'ø
4'ø
4'ø
FRY REARING
MECHANICAL LIFE SUPPORT
DIAGNOSTIC LAB
INTERPRETIVE AREA
RESTROOM
RESTROOM
BUNKROOM
OFFICES
ENTRY
KITCHEN /DINING
RAMP
A
A


6'-0"
50'-0"
SCREEN TYP
5'-6" TYP
CLEANING WASTE (CW)
REUSE WATER (RW)
SUPPLY TO FUTURE GROW-OUT PONDS
TREATED WATER (TW) FROM LAKE
TO EFFLUENT POND
TO GROW-OUT PONDS/ OZONE STERILIZATION AND DISCHARGE
Coeur d'Alene Fish Hatchery
Production Raceways - Figure 2
J-U-B ENGINEERS, INC.
Engineers Surveyors Planners
Coeur d'Alene, Idaho
J-U-B
Engineers Surveyors Planners
ACAD.DWG FILE: Fig 5.dwg
PLT.SC. 1=1
DE.D.E.E.
DR. TjF
CK.W.T.T.
SHEET OF
SCALE: N.T.S.
DATE: AUG.,2002
DWG.NO. C990818

Production Raceways

Approximately 8 months after the newly hatched cutthroat fry are started on feed in the hatchery, one-half will be placed in the acclimation ponds and the rest will be transferred to the outdoor raceways, where they will be grown from 1.5-inch to the planting sizes of 4-inch and 8 to 10-inches. Their growth within the hatchery will also be controlled through manipulation of water temperature and feeding so as to mimic wild growth rates.

Annual production of cutthroat fingerlings will require separate raceways — one raceway each for the 4.0-inch and the 7–inch sizes, and two raceways for the 8-10-inch size and adults. Table 4 below presents information for the three fish sizes grown in the raceways. It shows that the cutthroat trout production program can be achieved with four raceways without exceeding a density index of 0.46or a flow index of 0.99. The number of fish shown assumes a mortality rate of 15 percent per year.

Table 7 – Cutthroat Trout Raceway Production

Fish Size (inches)	*Number/Pounds (per raceway)*	*Raceway Volume (cubic fee)*	*Density Index (D.I.)**	*Flow (gpm)*	*Flow Index (F.I.)*
4.0	55,000/1,243	825	0.38	400	0.78
7	24,000/2,664	825	0.46	400	0.95
8-10	20,000/5,440	1,650	0.36	600	0.99

* assumes 825 ft^3 of useable space per raceway

Each raceway will have inside dimensions of 5.5 ft. width by 56 ft. length and 3 ft. water depth, plus a freeboard of 1 ft. A single-pass system will be used in which the filtered and U.V. sterilized lake water will be aerated prior to discharging into each of the four raceways. The total effluent from all four raceways (1,400 gpm) will be ozone sterilized prior to being returned to the lake, unless it will be re-used in the grow-out ponds for the production of 13-inch CCT.

Figure 2 shows one possible arrangement for the single pass raceways. The raceways must be covered in order to preclude excessive temperature gain during summer months.

A screened-off 6.0-foot long settling area on the effluent end of each raceway will be provided to prevent waste and ammonia build-up from accumulating in the downstream grow-out ponds. This screened-off settling area will be totally accessible by simply removing the screen prior to harvesting the fish. The sole purpose for the screen is to prevent fish from stirring-up the waste and thus allowing it to flow downstream. A separate cleaning waste (CW) pipe system, which is shown on Figure 2, will operate by gravity by simply pulling a vertical standpipe that is cast into the bottom of the raceway. This action will sluice the concentrated waste directly to the effluent pond for treatment. The relatively clean raceway overflow (± 99% of all raceway flow) will be piped to the pond reuse system for aeration treatment, or directly to the ozone contact chamber prior to discharge back into the lake.

The final design version of the production raceways that are sketched on Figure 2 will use baffles to create eddies and higher velocity zones, and will result in a superior cutthroat trout grow-out scheme for the reasons listed below:

1) Truck access to one side of each raceway unit for transfer or planting operations.

2) Less stressful environment for fish (no staff climbing on raceway walls, on grated walkways or inside of raceways to perform normal cleaning and feeding duties).

3) Reduced contamination potential of raceway water due to the operations listed in 2, above, which can introduce mud or raceway waste debris carried on boots.

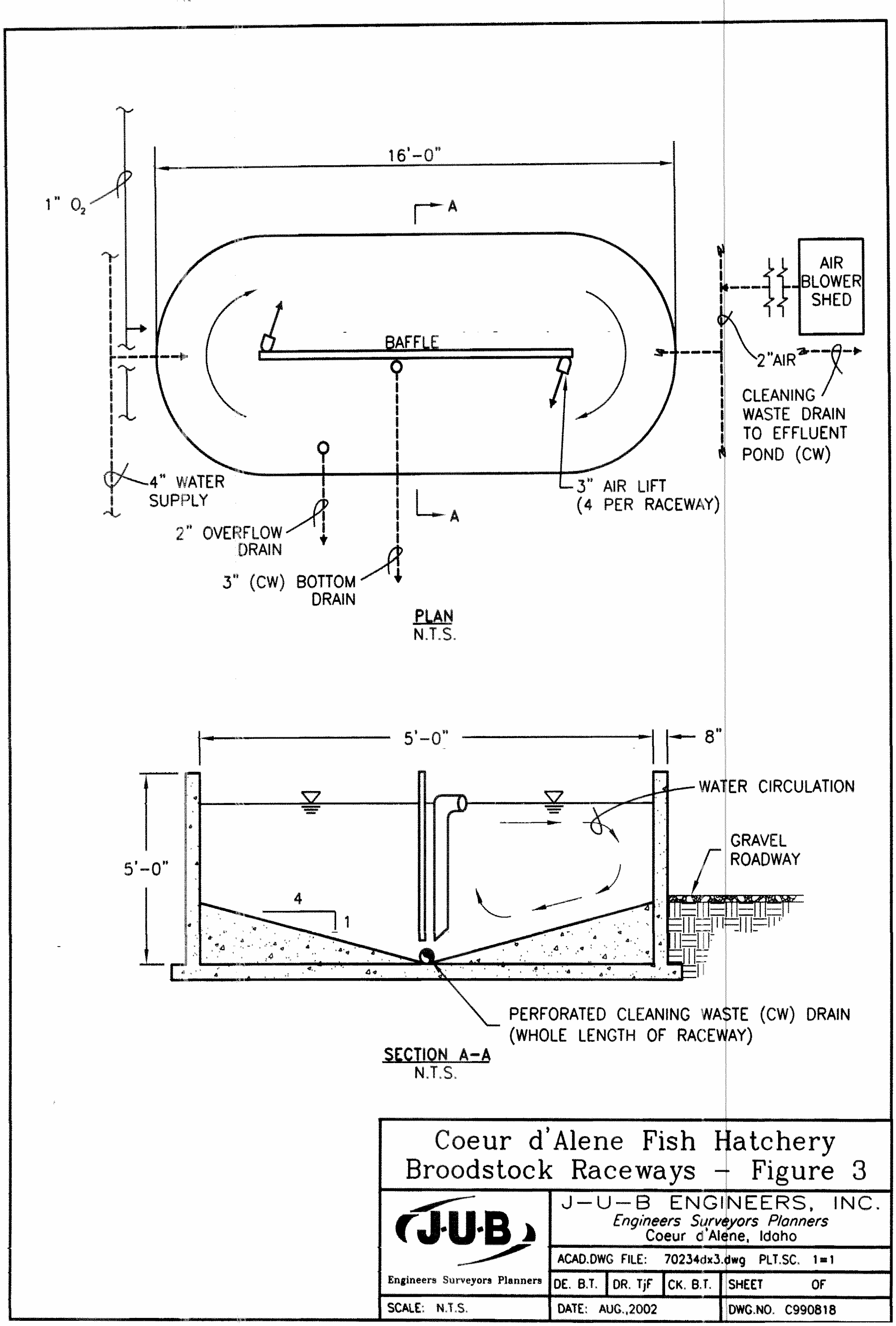
4) Shading of raceways will provide a better environment for the fish, and greatly reduce algae growth and cleaning requirements.

Broodstock Raceways

Cutthroat broodstock will be collected from each of the target tributaries. These fish will be collected as fingerlings (2-inch to 4-inch) and grown to 17-inch in four years. Each year 120 fingerlings will be collected from the same sites in the target watersheds. These fish will be individually marked and held in quarantine at the hatchery prior to being placed into one of four 4 ft. diameter early rearing tanks. They will be kept in the round tanks and closely monitored for 6 to 12 months, and will then be transferred to one of four broodstock raceways. The support of this broodstock program will be the number one priority at the new facility.

A plan and section of a possible design for the 5 ft. deep concrete broodstock raceways is sketched on Figure 3. Each raceway will be approximately 5 ft. wide by 16 ft. long, and have rounded ends to promote flow circulation. A wooden dividing baffle and four air lifts will provide a current throughout the raceway. The current could be adjusted by varying the amount of air supplied to each 3-inch airlift. This proposed broodstock raceway design will have a maximum density index (D.I.) of 0.10, which is believed conservative. The low pressure air (about 3 psi) required to operate the air lifts will be generated by a duplex air blower system housed in a nearby shed. Each one of the two air blowers will be capable of supporting the maximum air demand of all four broodstock raceways. Emergency power supply will be provided to the shed automatically during power outages.

Approximately 25 gpm of treated water will be supplied to each raceway when it is fully loaded with about 300 pounds of cutthroat broodstock (400 fish @.75 lbs each). The four air lifts will provide supplemental aeration and up to 100 gpm of additional circulated flow within the raceway. The total raceway through-flow of 125 gpm will be equivalent to a flow index (F.I.) of 0.20, which is quite conservative, unless raceway water temperature rises above say, 65° F. Shading for these shallow broodstock raceways is essential, and raceway covers will be provided. A screened 2-inch overflow drain located on one side of each raceway will maintain a constant water depth of 4 ft. in the raceways. A separate 2-inch perforated PVC drain placed along the bottom will be used to clean or empty the raceway. Both drains will be plumbed to the effluent pond. This proposed raceway design, with its induced water circulation pattern will result in broodstock raceways that are essentially self-cleaning. Oxygen lines will be provided to each of the four raceways for the times when treatment dictates that no effluent be allowed (no make-up water).


16'-0"
A
1" O_2
AIR BLOWER SHED
BAFFLE
2"AIR
CLEANING WASTE DRAIN TO EFFLUENT POND (CW)
4" WATER SUPPLY
3" AIR LIFT (4 PER RACEWAY)
2" OVERFLOW DRAIN
3" (CW) BOTTOM DRAIN
PLAN
N.T.S.
5'-0"
8"
WATER CIRCULATION
GRAVEL ROADWAY
5'-0"
4
1
PERFORATED CLEANING WASTE (CW) DRAIN (WHOLE LENGTH OF RACEWAY)
SECTION A-A
N.T.S.
Coeur d'Alene Fish Hatchery
Broodstock Raceways - Figure 3
J-U-B ENGINEERS, INC.
Engineers Surveyors Planners
Coeur d'Alene, Idaho
Engineers Surveyors Planners
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DE. B.T. DR. TjF CK. B.T. SHEET OF
SCALE: N.T.S. DATE: AUG.,2002 DWG.NO. C990818

Grow-Out Ponds

These ponds will be used in the final phase for the production of 42,000 13-inch cutthroat trout. The 64,000 4.0-inch fingerlings produced for this scheme in the 45 ft^3 troughs at the hatchery building will first be placed in the four production raceways (825 ft^3 each) and grown to a size of 8.5$\pm$ inches over a period of 12 months. The surviving 54,000 8.5-inch adults will then be placed in the two ponds for final grow-out to 13-inches over another 12 month period.

The two ponds are illustrated on Figure 4 and consist of a single concrete pond 30 ft. wide and 100 ft. long that is divided into two cells by a concrete wall along its centerline. The resultant raceway ponds will have dimensions of 14.5 ft. wide by 100 ft. long, and will be 6.5 ft. deep overall, but with a water depth of about 5$\pm$ ft. The two ponds will receive second pass water from both the hatchery building (580 gpm) and the four production raceways (1,400 gpm). This total flow of 1,980 gpm will receive oxygen recharge by means of two aeration columns located at the upstream end of the raceway ponds. In addition, the ponds will also receive up to 1,000 gpm (500 gpm per pond) of first pass water from the lake. Only the first pass flow will be filtered and U.V. sterilized.

The effluent from the two grow-out ponds (2,980 gpm) includes all the water used at the hatchery, with the exception of the 20 gpm incubation flow and 20 gpm isolation/early rearing flow-both of which will have been treated and then discarded. The pond effluent will be piped to the ozone contact chamber for sterilization prior to being discharged through a cascading open channel and into the lake. Concentrated waste will be collected in a sump at the downstream end of each raceway pond and will be pumped into the effluent pond for drying and disinfection. The dry processed waste can be used as fertilizer. Approximately 40 tons per year will be generated by the hatchery at the maximum production rate.

The low density (D.I. = 0.24) grow-out conditions afforded by the two large ponds, as well as water temperature and feeding regime manipulation, will ensure that the 4.0-inch (year 2) fish will be grown to the desired size of 13-inch (normally year 5 fish) in a total span of only 2 years.

The use of concrete ponds has several advantages over earthen ponds, the most obvious being:

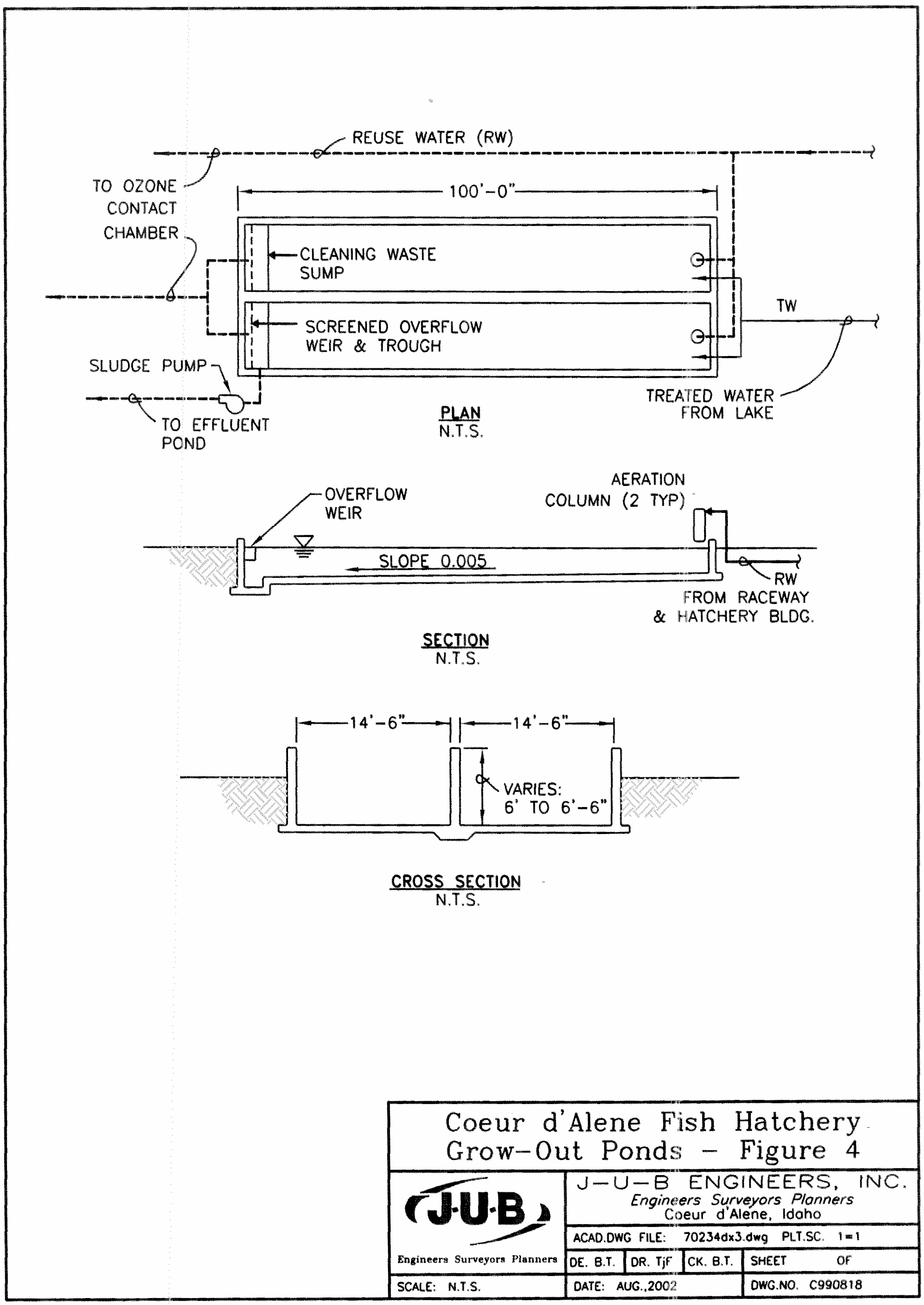
- 60 percent reduction in footprint area
- easier management (feeding, cleaning, crowding, sampling)
- easier harvesting

Other Improvements

The Coeur d'Alene trout production facility will require other improvements for its proper operation and security. A domestic (potable) water system, preferably with its own 5 gpm well will be essential, as will a septic waste system. A 20 gpm water well for incubation water at the hatchery building. A 1,200 ($\pm$) square-foot workshop/feed storage shed, that is adequately ventilated and rodent-proof will be required to properly store the sacked feed. The feed storage portion of the shed could be elevated, and a 42-inch high loading dock could be constructed to facilitate the unloading and transfer of feed. The ground-level workshop could also serve as a garage, and for the storing of expensive equipment (e.g. fish harvest pump, oxygen tanks, etc.)

Although the site appears to have adequate power supply nearby, its remoteness and the critical nature of the life support system dictate that two emergency generators (EG) be provided, one near the hatchery building, and one near the pump station and the water treatment platform. Each EG should include an automatic transfer switch in case of power failure, and should ideally be powered by propane.

Perimeter fencing and an entry gate will be required, and as an additional precaution, the hatchery manager's residence should be located near the entry road to the facility. An effluent pond designed to provide at least 1.5 hours of detention time at peak effluent flows (such as when a pond is drained) will mitigate the impact of the facility operations on the downstream environment. An ozone contact chamber, with a contact time of several minutes, will be used to sterilize all the hatchery effluent. The sterilized effluent will be directed to a cascading open channel to remove any ozone residual prior to discharging into the lake. Finally, telephone lines and a PC compatible monitor and alarm system, with auto-dial capabilities for emergencies, need to be installed at the office space and at the hatchery manager's residence. All of the above, and possibly additional improvements, will be fully described during the final design of the facility.


REUSE WATER (RW)
TO OZONE CONTACT CHAMBER
100'-0"
CLEANING WASTE SUMP
SCREENED OVERFLOW WEIR & TROUGH
TW
SLUDGE PUMP
TO EFFLUENT POND
PLAN
N.T.S.
TREATED WATER FROM LAKE
AERATION COLUMN (2 TYP)
OVERFLOW WEIR
SLOPE 0.005
RW
FROM RACEWAY & HATCHERY BLDG.
SECTION
N.T.S.
14'-6"
14'-6"
VARIES: 6' TO 6'-6"
CROSS SECTION
N.T.S.
Coeur d'Alene Fish Hatchery
Grow-Out Ponds – Figure 4
J-U-B
Engineers Surveyors Planners
J–U–B ENGINEERS, INC.
Engineers Surveyors Planners
Coeur d'Alene, Idaho
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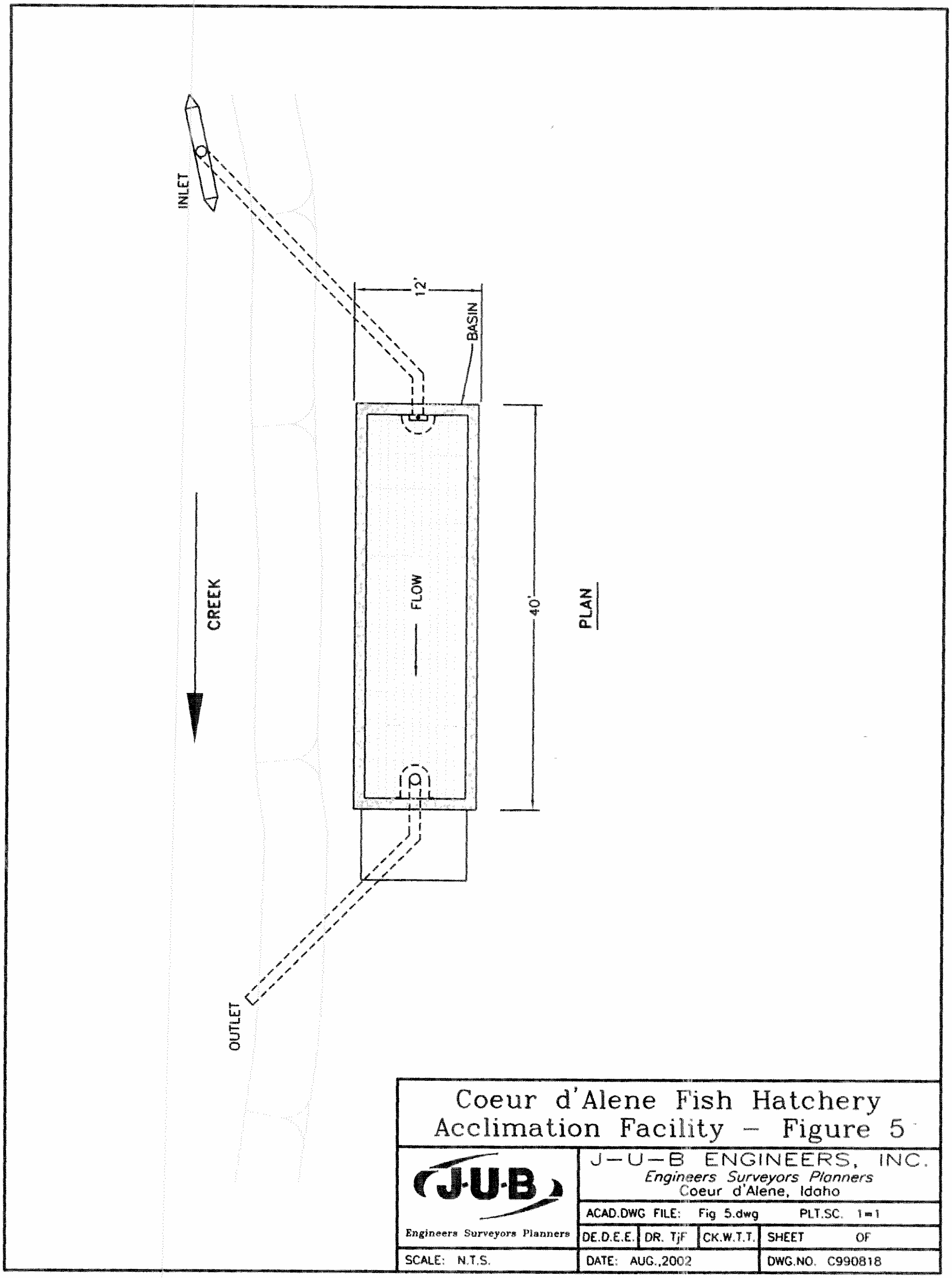
INLET
12'
BASIN
CREEK
FLOW
40'
PLAN
OUTLET
Coeur d'Alene Fish Hatchery
Acclimation Facility – Figure 5
J-U-B
Engineers Surveyors Planners
J–U–B ENGINEERS, INC.
Engineers Surveyors Planners
Coeur d'Alene, Idaho
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DE.D.E.E.
DR. TjF
CK.W.T.T.
SHEET OF
SCALE: N.T.S.
DATE: AUG.,2002
DWG.NO. C990818

Surface Water Supply System

Selective withdrawal of the Coeur d'Alene Lake water for temperature control will be accomplished by means of a double intake pipe system that features both a near surface intake and a deep (35 ft.±) intake. The intakes will be screened, and will be designed to minimize disturbance of bottom sediment both during construction and during operation. The shallow intake will likely be suspended from a float that is accessible from the shore. The deeper intake will likely be attached to four pilings. These pilings will terminate about 25 feet below normal lake level, and the intake will be located about 10 feet above the lake bottom. The intakes will likely consist of 14-inch diameter high density polyethylene pipe, which is nearly indestructible and is easily floated into position by small boats and then sunk by filling it with water.

The on-shore pump station will consist of a platform located a few feet above the high water mark. On the platform will be a pipe manifold and valves for selective withdrawal, and space for the addition of future pumps. Initially, two 40 H.P. pumps will provide the following operating flows:

1 pump = 1,700 gpm
2 pumps = 3,000 gpm

For the production of cutthroat trout up to 8-10 inch sizes as described in this report, one pump will suffice and the second pump will be on stand-by. For the production of 42,000 13-inch cutthroat trout, both pumps will need to be in operation, and a third similar pump should be installed (future).

Surface Water Treatment

Water from the lake pump station will be piped a short distance to two drum filters located on an elevated platform. These filters (30 microns) will remove some, but not all turbidity that may periodically appear in the lake. Clean water will discharge from the filters into three large aeration columns or these could be bypassed for temperature considerations. Adjacent to the aeration columns will be three 40 lamp UV sterilization units, each capable of handling 1,000 gpm. Sterilized water will be piped to a headbox, from where it will be distributed to the various production facilities. Water destined for the hatchery building fry rearing (160 gpm) will receive further treatment consisting of micron filtration and heating/chilling via heat pumps.

Probable Cost

The purpose of this cost estimate is to provide current information about project budget requirements. The estimate includes cost items for facility program implementation, except for office furnishings, vehicles, laboratory equipment, computers, and other specialty items. Since there is no direct control over the cost of labor and materials in the context of the competitive bidding process, a guarantee of cost estimate accuracy cannot be given. The project cost estimate presented at the end of this Section has been prepared without the benefit of detailed plans and specifications. More detailed cost data will be developed during the subsequent design phases.

Sources

Construction costs are based on unit prices which were determined by J-U-B Engineers and JC Aquaculture Consultants based on professional experience and recent bid results for similar projects in other locations. Costs were estimated in 2002 dollars and were not escalated to represent future construction costs. No allowances were made for extra costs related to overtime work or adverse weather conditions.

Design and Construction Contingency Allowance

Any construction project can have certain unpredictable expenses, both minor and major changes in process and design, estimating errors, rapid price changes for some components, labor shortages or strikes affecting both productivity and schedules and overlooked items. To cover the cost of these unpredictable expenses, an allowance for various contingencies must be included in the total project cost at all levels of estimating. The contingency is designed to reduce project risk and should be large enough to cover all likely unforeseen and unpredictable events, conditions and occurrences. The contingency will vary according to the type of project, complexity of design, length of construction and geographical location. This allowance can be reduced as the design progresses from concept through final working documents, but the contingency must remain throughout the life of the project as a reserve for events that experience shows will likely occur.

1) Design Contingency Allowance: A design contingency allowance relative to the complexity of the design is to be included in all levels of estimates to compensate for the lack of definition, omissions, underestimates of both quantities and costs, changes in the design or corrections to erroneous assumptions. Based on past experience, a minimum design contingency applicable for this phase of the project is 10 percent.

2) Construction Contingency Allowance: A construction contingency allowance is used at all levels of estimates to cover unknown site conditions, additional costs caused by longer project schedules, lower than anticipated productivity and cost overruns due to a lack of definition in the construction documents. Based on past experience, a minimum construction contingency applicable for this phase of the project is 15 percent.

J-U-B ENGINEERS, Inc. Suite 722, 422 W. RIVERSIDE AVE., SPOKANE, WA 99201 (509) 458-3727

ENGINEERS OPINION OF PROBABLE CONSTRUCTION COST

DATE: 31-Jul-02

PROJECT:
COEUR D'ALENE TRIBE TROUT PRODUCTION FACILITY

PROJECT DESCRIPTION:
CONCEPTUAL DESIGN - BROWNS BAY SITE - LAKE COEUR D'ALENE

OWNER PROJ. NO.: J-U-B PROJ. NO.: 70234

ITEM NO.	DESCRIPTION	SCHEDULE OF VALUES			
		QTY	UNIT	UNIT PRICE	BASE ESTIMATE
1.	Access Roadway	1	LS	$60,000.00	$60,000.00
	Subtotal				**$60,000.00**
2.	Hatchery Building (Cost Breakdown/SF)	5,200	SF	$80.00	$416,000.00
	Slabs, Footings and Erection ($29.00)				
	Stud Walls & Finish ($15.00)				
	Drop Ceilings ($ 8.00)				
	Kitchen & Bathroom Fixture ($10.00)				
	Windows & Screens ($ 5.00)				
	HVAC, Light & Elect ($ 13.00)				
	Stainless Sinks/Faucets	3	EA	$2,000.00	$6,000.00
	Subtotal				**$422,000.00**
3.	Hatchery Building Special Construction				
	Floor Trench & Grating	400	SF	$50.00	$20,000.00
	Case Work, Tile Work & Water Proofing	1	LS	$5,000.00	$5,000.00
	Concrete Landing, Ramps, Bollards	1	LS	$5,000.00	$5,000.00
	Outdoor Concrete Pad	240	SF	$12.50	$3,000.00
	Concrete Pad Roof & Columns	240	SF	$12.50	$3,000.00
	Loft Storage	250	SF	$16.00	$4,000.00
	Subtotal				**$40,000.00**
4.	Hatchery Life Support				
	Tanks, Troughs & Incubators	1	LS	$44,000.00	$44,000.00
	Distribution Piping	1	LS	$32,000.00	$32,000.00
	Subtotal				**$76,000.00**
5.	Water Treatment Building (700 SF)				
	Metal Building, Slabs & Footings	1	LS	$45,000.00	$45,000.00
	Elevated Service Platforms	400	SF	$120.00	$48,000.00
	Heating & Ventilation	1	LS	$8,000.00	$8,000.00
	Electrical & Lighting	1	LS	$27,000.00	$27,000.00
	Concrete Landing, Ramps, Bollards	1	LS	$5,000.00	$5,000.00
	Subtotal				**$133,000.00**
6.	Water Treatment Equipment				
	Heat Pumps & Filters	1	LS	$38,000.00	$38,000.00
	Headboxes & Aeration Columns	1	LS	$25,000.00	$25,000.00
	Ozone Generator	1	EA	$80,000.00	$80,000.00
	Ozone Effluent Contactor	1	EA	$38,000.00	$38,000.00
	Drum Filters	2	EA	$50,000.00	$100,000.00
	Oxygen Regulators & Piping	1	LS	$8,000.00	$8,000.00
	Incubation Aeration Tower & Storage Tank	1	LS	$8,000.00	$8,000.00
	U.V. Disinfection Units	3	EA	$40,000.00	$120,000.00
	Piping & Valves	1	LS	$30,000.00	$30,000.00
	Alkalinity, PH Formalin Drip	1	LS	$8,000.00	$8,000.00
	Electrical and Controls	1	LS	$33,000.00	$33,000.00
	Subtotal				**$488,000.00**

ENGINEERS OPINION OF PROBABLE CONSTRUCTION COST

DATE: 31-Jul-02

PROJECT:
COEUR D'ALENE TRIBE TROUT PRODUCTION FACILITY

PROJECT DESCRIPTION:
CONCEPTUAL DESIGN - BROWNS BAY SITE - LAKE COEUR D'ALENE

OWNER PROJ. NO.: | J-U-B PROJ. NO.: 70234

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT PRICE	BASE ESTIMATE
		SCHEDULE OF VALUES			
7.	Production Raceways				
	4 Raceways 56' x 5.5' x 4' Deep	4	EA	$32,000.00	$128,000.00
	Aluminum Screens & Baffles	1	LS	$10,000.00	$10,000.00
	Waste Drains	1	LS	$8,000.00	$8,000.00
	Yard Piping	1	LS	$19,000.00	$19,000.00
	Raceway Roof & Columns	1,900	SF	$20.00	$38,000.00
	Grading & Surfacing	1	LS	$15,000.00	$15,000.00
	Subtotal				**$218,000.00**
8.	Broodstock Raceways				
	4 Raceways 16' x 5' x 5' Deep	4	EA	$6,000.00	$24,000.00
	Wood Baffle & Stl. Supports	4	EA	$500.00	$2,000.00
	Airlifts & Air Blowers	1	LS	$7,000.00	$7,000.00
	Oxygen System	1	LS	$15,000.00	$15,000.00
	Waste Drains	1	LS	$8,000.00	$8,000.00
	Yard Piping	1	LS	$20,000.00	$20,000.00
	Roof & Columns 22 x 40	880	SF	$20.00	$17,600.00
	Grading & Surfacing	1	LS	$4,500.00	$4,500.00
	Subtotal				**$98,100.00**
9.	Workshop/Feed Storage (1,200 SF)				
	Metal Buildings, Slabs & Footings	1	LS	$52,500.00	$52,500.00
	Heating & Ventilation	1	LS	$4,000.00	$4,000.00
	Electrical & Lighting	1	LS	$5,000.00	$5,000.00
	Concrete Dock & Steps	1	LS	$3,000.00	$3,000.00
	Subtotal				**$64,500.00**
10.	Lake Water Pumping Station				
	Earthwork	1	LS	$10,000.00	$10,000.00
	Concrete Sump & Yard Piping	1	LS	$115,000.00	$115,000.00
	Dual Intake Pipe & Screen	1	LS	$120,000.00	$120,000.00
	Pump Station Enclosure	1	LS	$20,000.00	$20,000.00
	Pumps, Motors & Piping	1	LS	$50,000.00	$50,000.00
	Transmission Pipeline	300	LF	$40.00	$12,000.00
	Electrical & Controls	1	LS	$40,000.00	$40,000.00
	Subtotal				**$367,000.00**

ENGINEERS OPINION OF PROBABLE CONSTRUCTION COST

PROJECT:
COEUR D'ALENE TRIBE TROUT PRODUCTION FACILITY DATE: 31-Jul-02

PROJECT DESCRIPTION:
CONCEPTUAL DESIGN - BROWNS BAY SITE - LAKE COEUR D'ALENE

OWNER PROJ. NO.: J-U-B PROJ. NO.: 70234

ITEM NO.	DESCRIPTION	SCHEDULE OF VALUES			
		QTY	UNIT	UNIT PRICE	BASE ESTIMATE
11.	Grow-Out Ponds				
	Earthwork	1	LS	$110,000.00	$110,000.00
	Pump Sump & Piping	1	LS	$15,000.00	$15,000.00
	Sludge Pump & Motor	1	LS	$10,000.00	$10,000.00
	Electrical Service	1	LS	$5,000.00	$5,000.00
	Subtotal				**$140,000.00**
12.	Effluent Pond & Outlet Channel				
	Clearing & Grubbing	1	LS	$4,500.00	$4,500.00
	Earthwork - Cut & Fill	1	LS	$50,000.00	$50,000.00
	Plantings	1	LS	$6,000.00	$6,000.00
	Control Structures	1	LS	$22,000.00	$22,000.00
	Piping	1	LS	$7,000.00	$7,000.00
	Subtotal				**$89,500.00**
13.	Emergency Generator (200 kw)	1	LS	$70,000.00	$70,000.00
	Subtotal				**$70,000.00**
14.	Emergency Generator-Secondary (75 kw)	1	LS	$35,000.00	$35,000.00
	Subtotal				**$35,000.00**
15.	Monitor & Alarm System	1	LS	$12,000.00	$12,000.00
	Subtotal				**$12,000.00**
16.	Electrical Power Transmission & Distribution	1	LS	$150,000.00	$150,000.00
	Subtotal				**$150,000.00**
17.	Pad Mounted Transformers	1	LS	$6,000.00	$6,000.00
	Subtotal				**$6,000.00**
18.	Ground Water Supply Well (Potable & Incub)	2	EA	$15,000.00	$30,000.00
	Subtotal				**$30,000.00**
19.	Potable Water System	1	LS	$7,000.00	$7,000.00
	Subtotal				**$7,000.00**
20.	Septic Tank System	1	LS	$20,000.00	$20,000.00
	Subtotal				**$20,000.00**
21.	Manager's Residence				
	3 Bedroom Premanufactured Home	1	LS	$50,000.00	$50,000.00
	Foundation, Driveway, Utilities	1	LS	$20,000.00	$20,000.00
	Subtotal				**$70,000.00**

ENGINEERS OPINION OF PROBABLE CONSTRUCTION COST

DATE: 31-Jul-02

PROJECT:
COEUR D'ALENE TRIBE TROUT PRODUCTION FACILITY
CONCEPTUAL DESIGN - BROWNS BAY SITE - LAKE COEUR D'ALENE

OWNER PROJ. NO.: J-U-B PROJ. NO.: 70234

ITEM NO.	DESCRIPTION	SCHEDULE OF VALUES QTY	UNIT	UNIT PRICE	BASE ESTIMATE
22.	Parking Area & Interior Access Roads	1	LS	$15,000.00	$15,000.00
	Subtotal				**$15,000.00**
23.	Landscaping & Handicap Access	1	LS	$8,000.00	$8,000.00
	Subtotal				**$8,000.00**
24.	Entry Gate & Perimeter Fence	2,000	LF	$10.00	$20,000.00
	Subtotal				**$20,000.00**
25.	Clearing, Grubbing & Reseeding	6	AC	$1,500.00	$9,000.00
	Subtotal				**$9,000.00**
26.	Acclimation Ponds	4	EA	$36,000.00	$144,000.00
	Subtotal				**$144,000.00**
	Total				**$2,792,100.00**
	7%Construction Administration				$195,447.00
	25% Contingency				$698,025.00
	Grand Total				**$3,685,572.00**

13 APPENDIX B FEASIBILITY STUDY

FEASIBILITY STUDY

Alternate Site Feasibility Report

for the Coeur d'Alene Tribal Production Facility

PREPARED BY:

The Coeur d'Alene Hatchery Interdisciplinary Team

FOR:

The Coeur d'Alene Tribe

February 1, 2002

INTERDISCIPLINARY TEAM

Paul J. Anders, Ph.D.
Research Support Scientist II
University of Idaho
Paul has over seventeen years of fisheries research experience. He has been involved in a wide array of fisheries and aquatic ecology research. Paul authored or co-authored over 46 publications and reports involving fish genetics, population structure, early life history, reproductive biology, ecology, and conservation aquaculture.

Raymond C.P. Beamesderfer
Senior Fisheries Consultant
S.P. Cramer & Associates, Inc.
Ray has conducted original research and analyzed applied problems of fish biology for almost 20 years. He has extensive experience with salmon, steelhead, sturgeon, warmwater sportfish, and nongame species; has published numerous scientific articles on fish sampling, population dynamics, and species interactions; and has special expertise in the use of statistics and computer modeling to solve difficult fish questions.

Dr. Ernest Brannon
Director, Aquaculture Research Institute
University of Idaho
Ernie has nearly 50 years of experience related to fisheries management issues. Currently he a state aquaculture extension specialist, a professor of fisheries resources and animal science and director of the Aquaculture Research Institute at the University of Idaho. Dr. Brannon has authored numerous scientific publications and is well known for his contributions to fisheries science.

John Cussigh
Hatchery Scientist
JC Aquaculture
John is a world renowned expert in the life support requirements for an array of different fish species. John has assisted the design team on options and solutions for life support systems.

Douglas E. Ensor, P.E.
Civil Engineer
J-U-B Engineers, Inc.
Doug brings to the team over twenty years of applied engineering experience. He is a well respected engineer who specializes in hydraulics, water resources, irrigation, and fish passage issues. Doug has concentrated his efforts on water supply and site design for the proposed fish hatchery.

Jeffery Jay Jordan
Tribal Fisheries Biologist
Coeur d' Alene Tribe
Jeff has three years of professional experience in the evaluation and management of aquatic ecosystems. Currently he is serving as a tribal biologist on the trout production facility and is conducting a bathymetric study on Coeur d' Alene Lake.

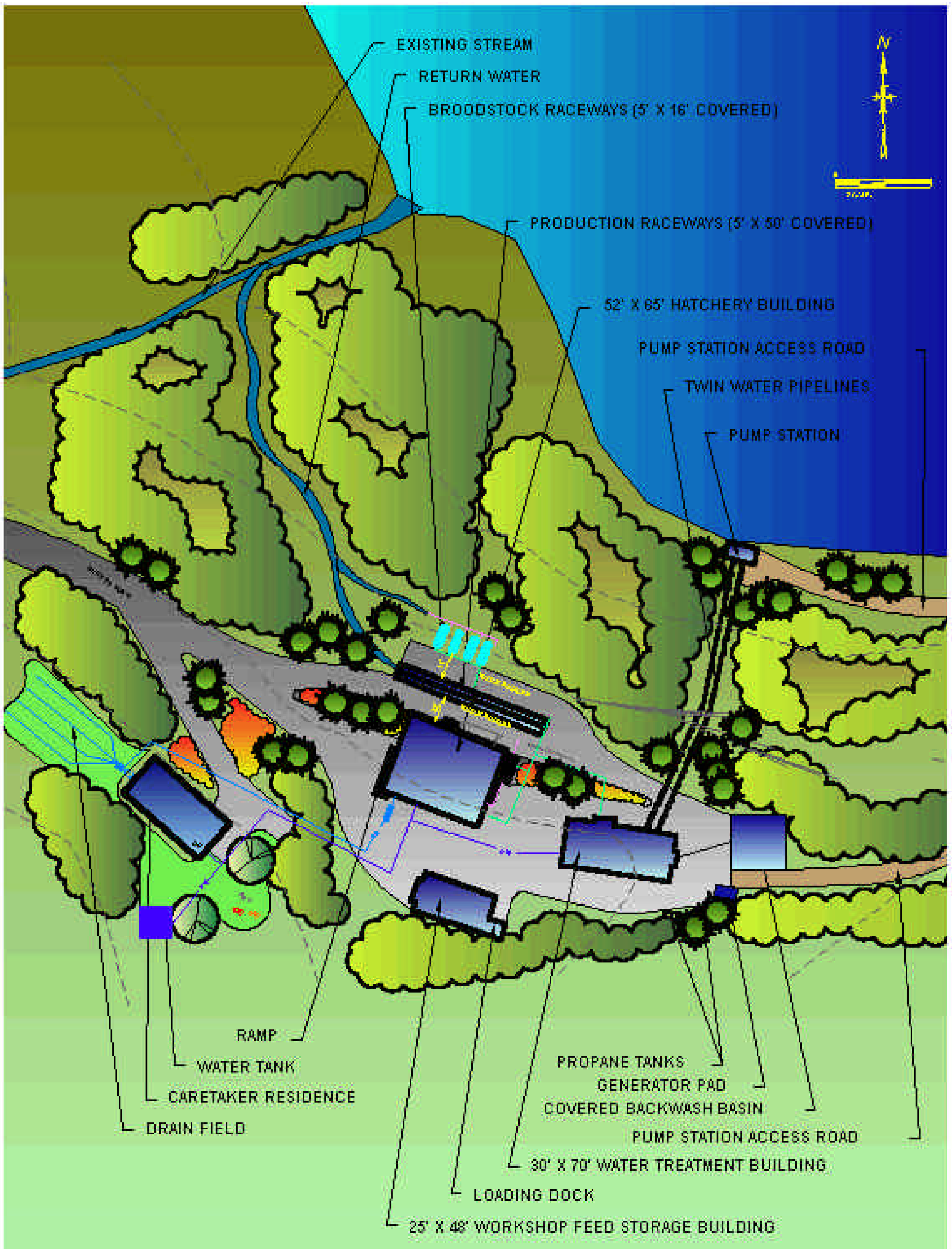
Ron Peters
Fisheries Program Manager
Coeur d' Alene Tribe
Ron is responsible for the oversight, coordination and implementation of all fisheries projects undertaken be the Coeur d' Alene Tribe. Mr. Peters has over ten-years of professional experience in the evaluation and management of aquatic ecosystems. Prior to his tenure at the Coeur d' Alene Tribe, Ron was employed by the Quinault Indian Nation, in charge of their sockeye salmon management and water quality laboratory.

Dr. Dale R. Ralston
Ralston Hydrologic Services, Inc.
Dale presently serves as President of Ralston Hydrologic Services, Inc. based in Moscow, Idaho. He started the company in 2000 after taking an early retirement from the University of Idaho after 25 years of running the hydrology masters and P.h.D. programs. Dale has spent his entire career working in hydrogeology with research and consulting in topics as varied as well hydraulics, ground water management, contaminant characterization and remediation and design/construction of wells. Part of his consulting business involves teaching short-courses around the country for the National Ground Water Association.

Jason R. Scott, CFP
Fisheries Biologist
J-U-B Engineers, Inc.
Jason is a professional biologist providing expertise in aquatic research, aquatic habitat evaluation and enhancement, natural resource management, limiting factors analysis, and strategic watershed planning. Mr. Scott is currently working with the Coeur d' Alene Tribal staff on implementing a predation study on Coeur d' Alene Lake.

David L. Smith
Habitat Research Specialist
University of Idaho
David has a diverse background involving the integration of biology and engineering into solutions to complex environmental problems. His current research is focused on linking hydraulics and biology as it relates to salmonid habitat.

William T. Towey
Environmental Group Manager
J-U-B Engineers, Inc.
William has over a decade of experience with natural resource issues within the Columbia River Basin. He is the J-U-B project manager for the design and permitting of the Coeur d' Alene Hatchery. William is currently assisting the tribal efforts in their engagement in the regional three-step hatchery review process.


EXISTING STREAM
RETURN WATER
BROODSTOCK RACEWAYS (5' X 16' COVERED)
PRODUCTION RACEWAYS (5' X 50' COVERED)
52' X 65' HATCHERY BUILDING
PUMP STATION ACCESS ROAD
TWIN WATER PIPELINES
PUMP STATION
RAMP
WATER TANK
CARETAKER RESIDENCE
DRAIN FIELD
PROPANE TANKS
GENERATOR PAD
COVERED BACKWASH BASIN
PUMP STATION ACCESS ROAD
30' X 70' WATER TREATMENT BUILDING
LOADING DOCK
25' X 48' WORKSHOP FEED STORAGE BUILDING

INTRODUCTION

The Coeur d'Alene Tribe (Tribe), in pursuit of their cutthroat trout hatchery, agreed to further investigate site opportunities closer to the available water source of Coeur d'Alene Lake.

The investigations were conducted using an interdisciplinary approach by a team of eleven recognized scientists in the fields of hatchery life support systems, aquatic habitats, fishery ecology, and hydrogeology (attached team biographies). Various team members researched seven sites on Coeur d'Alene Lake (Exhibit B) and ultimately narrowed the review to two optimal lake site locations (Exhibit C). The third site considered for the evaluation was chosen from earlier conceptual design processes. A detailed description of the selection process, that narrowed the lake site locations, can be found in Exhibit A.

The three sites selected for detailed analysis include: 1)The Pow-Wow ground site (previously studies in earlier conceptual phases) 2) The Gap site and 3) Browns Bay site. This report will describe each site and the various analyses that contributed to a final site recommendation. The final review of the chosen sites focused on water quantity, equipment requirements, energy costs, land availability, impact to existing home-sites, proximity to Tribal waters, and capital construction costs (Exhibit G). The final preferred site was reviewed, and recommended, by the entire team to ensure consistency with program objectives.

SITE SELECTION

Each of the three sites was evaluated for their advantages, limitations, hydrogeologic attributes, and costs. Once these parameters were attained, a matrix (Exhibit E) was developed to illustrate the comparisons made towards the final recommendation.

POW-WOW SITE

This area is the original site chosen by Tribe in their preliminary hatchery investigations. This site was selected for the conceptual hatchery planning document submitted to the Northwest Power Planning Council as part of the three-step process.

This site was evaluated extensively for the water quantity needs of the hatchery. As groundwater quantity issues are challenging in this area, numerous wells were drilled, pump tested and recovery rates analyzed to determine whether sufficient targets would be met long-term. A final water quantity report (Exhibit F) was completed that describes the potential for this site.

Advantages

Many positive attributes were identified in the earlier site feasibility study/conceptual plan report dated September of 1999. They included: 1) good topography for hydraulic flow of water in and out of the hatchery 2) good topography for effluent discharge and effluent polishing 3) opportunity for enhanced wetland creation and mitigation due to the existing wetlands on-site and 4) significant surface water flow availability to supplement groundwater supply systems. In addition to these attributes, no land purchase costs would be involved since this site is tribally owned and managed

Limitations

Proximity to groundwater sources is a limiting factor for this particular site. Acceptable groundwater sources, to support a hatchery design of a complex water reuse system (94%), were identified in earlier investigations. However, the increased cost of water transport from the wells to the proposed site is fairly substantial.

Also, extensive water pipelines from the satellite wells would require several easements and approvals to pass through private property and railways.

Hydrogeology

The water quantity for the Pow-Wow site was thoroughly examined in the conceptual design phase of the three-step process. The Tribe initiated an extensive well field exploratory investigation in order to effectively meet the targeted goal of 60gpm continuous. The investigations concluded that the potential was good that operation of a well field using three wells would yield the desired continuous pumping rate. In addition, the Tribe secured access to the City of Worley well, which is documented as being an excellent producer. This particular well would be primarily used as backup water in the event of an emergency. Water from the city well requires additional pretreatment before use.

Costs

This system would require expenditures of approximately $1.95 million for water supply/water treatment/life support equipment costs. The estimated annual energy needs to operate this hatchery are 1.0 million KwH/year. The peak monthly demand would be 117,000 KwH/mo (Exhibit D).

The pipeline system, for water conveyance to the hatchery site, is extensive and costly. Cost would also be incurred to gain pipeline easements. The total estimated cost opinion for this option is $3.32 M.

THE GAP SITE

The Gap is located on the southern west side of Coeur d'Alene Lake. The acreage identified for sale is approximately 97 timbered acres with 2,500 ft of lake- frontage.

Advantages

The Gap site is located on tribal waters and is easily accessible to the Coeur d'Alene Tribal headquarters. The site location allows for withdrawal from Coeur d'Alene Lake, eliminating the need for a water recirculation system. The topography, although challenging, would allow development of an engineered stream channel for hatchery effluent, and for return hatchery fish.

Limitations

The major limitations of this site are its steep topography, difficult access, and shallowness of the Lake at this location. The shallow lake depth would dictate the use of large chillers (300 h.p.) and energy recovery heat exchangers. This situation would also require boilers during the winter months. An ozone disinfection system would be required to treat the effluent to prevent harm to existing fish stocks in the lake.

The hatchery would be located approximately 200 feet above the lake elevation, and would require 90 h.p. in pumping to lift the approximate 2.2 cfs of water to the hatchery. Site work for this property would be extensive given the steep topography.

The location is privately owned and would require purchase.

Hydrogeology

A preliminary evaluation of ground water development was conducted for the Gap site, as well as, the Brown's Bay site (Exhibit F). The report concludes that the potential for development of a 30 to 50-gpm water supply from a well at either site is good to excellent (70%-80% probability of success). Recommendations for well sites are also included in this report. It is also suggested that development of a 200 to 300-gpm water supply from a well is low (about 20 to 30 percent probability of success).

The ability to extract surface water from Coeur d'Alene Lake eliminates the concern for over-appropriating ground water.

Costs

The conditions at the site would require an expenditure of approximately $1.74 million for water supply/water treatment/life support equipment costs. The annual energy needs to operate the facility are estimated at 2.6 million KwH/year. The peak monthly power demand is estimated at 270,000 KwH/mo, and would require an emergency power supply of 450 Kw (Exhibit D).

The site is in private ownership and land values and acreage would be negotiated. The hatchery footprint requires approximately 10-20 acres. Purchase price for the entire 103 timbered acres is $2.95M and includes 2,500ft of lake- frontage**.** The total estimated cost opinion for this alternative is $4.39 M.

THE BROWN'S BAY SITE

Located just north of the Gap site, Browns Bay is also located on the west side of Coeur d'Alene Lake and is in Tribal waters. The acreage identified for sale is approximately 103 timbered acres with 6,200 ft of lake- frontage.

Advantages

This site offers ease of access, good topography, deep hydrographic contours near shore, and relatively low water lift requirements. The deepness of near-shore water will enable the selective withdrawal of either deep or near surface water to best match the physiological requirements of the cultured fish. This ability to control water temperatures by natural means will require much less mechanical water tempering and thus greatly reduce costs. The topography allows for the design of an engineered stream channel to serve the dual purposes of water effluent transport and return fish to the hatchery.

The site location allows for withdrawal from Coeur d'Alene Lake, eliminating the need for a total recirculation system. The site characteristics allow the use of the most reliable and easy to operate facility based on a much more simplistic water supply system than other site alternatives.

Limitations

The topography of this site will require advanced site preparations to construct the facility and infrastructure. The location is privately owned property and would require purchasing.

Hydrogeology

The hydrogeological results for Brown's Bay are consistent with those described for the Gap site.

Costs

The conditions at the site would require an expenditure of approximately $1.27 M for water supply/water treatment/life support equipment costs. The annual energy needs to operate the facility are estimated at 538,000 KwH/year. The peak monthly power demand is estimated at 47,000 KwH/mo (Exhibit D). The estimated acreage for site development is between 10-20 acres. Therefore, as with the Gap site, final acreage and value will be negotiated. The total estimated cost opinion for this alternative is $3.90 M.

RECOMMENDED SITE SELECTION

Based on the analysis of the alternative site matrices (Exhibit G), the Brown's Bay site clearly has the advantage over the other two sites in lower operation and maintenance costs (due to lower power consumption), and overall construction costs. The Brown's Bay Site and the Gap site are more desirable due to the water quantity of Coeur d'Alene Lake. This added benefit, however, comes with the added cost of land purchase. The greatest limiting factors for the Pow-Wow site and the Gap site are the increased cost due to water conveyance, and steep topography and power requirements, respectively.

Generally, the Brown's Bay site meets or exceeds all parameters that were identified for the analysis of the alternative sites. Based on the complete information contained within this report, it is recommended that the Brown's Bay site be used for the Coeur d'Alene Production Facility.

Alternate Site Selection Process

<u>Gather Available Property Information</u>

A local real estate agent, with familiarity with Coeur d'Alene Lake, was retained to obtain information on all available property (10-20 acres) on Coeur d' Alene Lake. A list was developed of seven sites that met the area requirements.

<u>Develop Criteria</u>

A checklist was developed to further assist the team in evaluating the potential of each of the seven sites. Topography, power access, water availability (near-shore contour relief), location relevant to tribal waters and offices, and degree of remoteness were areas of defined as important.

<u>Conduct Site Visits</u>

Site visits were conducted for each of the seven selected sites. Properties were accessed by ground transport and by boat. Checklists were then completed for each site.

<u>Narrow Site Options</u>

Based on the results of the site visits, the interdisciplinary team narrowed the focus of the study to two sites that matched the desired attributes.

Selected Site Investigations

The two selected sites, along with the previously studied hatchery site, were subjected to additional investigations. These studies included: 1) ground water potential 2) estimated energy consumption rates 3) capital construction costs and 4) general site suitability.

Final Site Recommendation

Based on the results of the specific site analysis, team members recommended the site that would meet or exceed all hatchery requirements in the most cost-effective manner.

Mrk4
Mrk5
COEUR D'ALENE
INDIAN RESERVATION
LAKE
HARRISON
COEUR D'ALENE LAKE
Copyright (C) 2001, Maptech, Inc.

Exhibit B

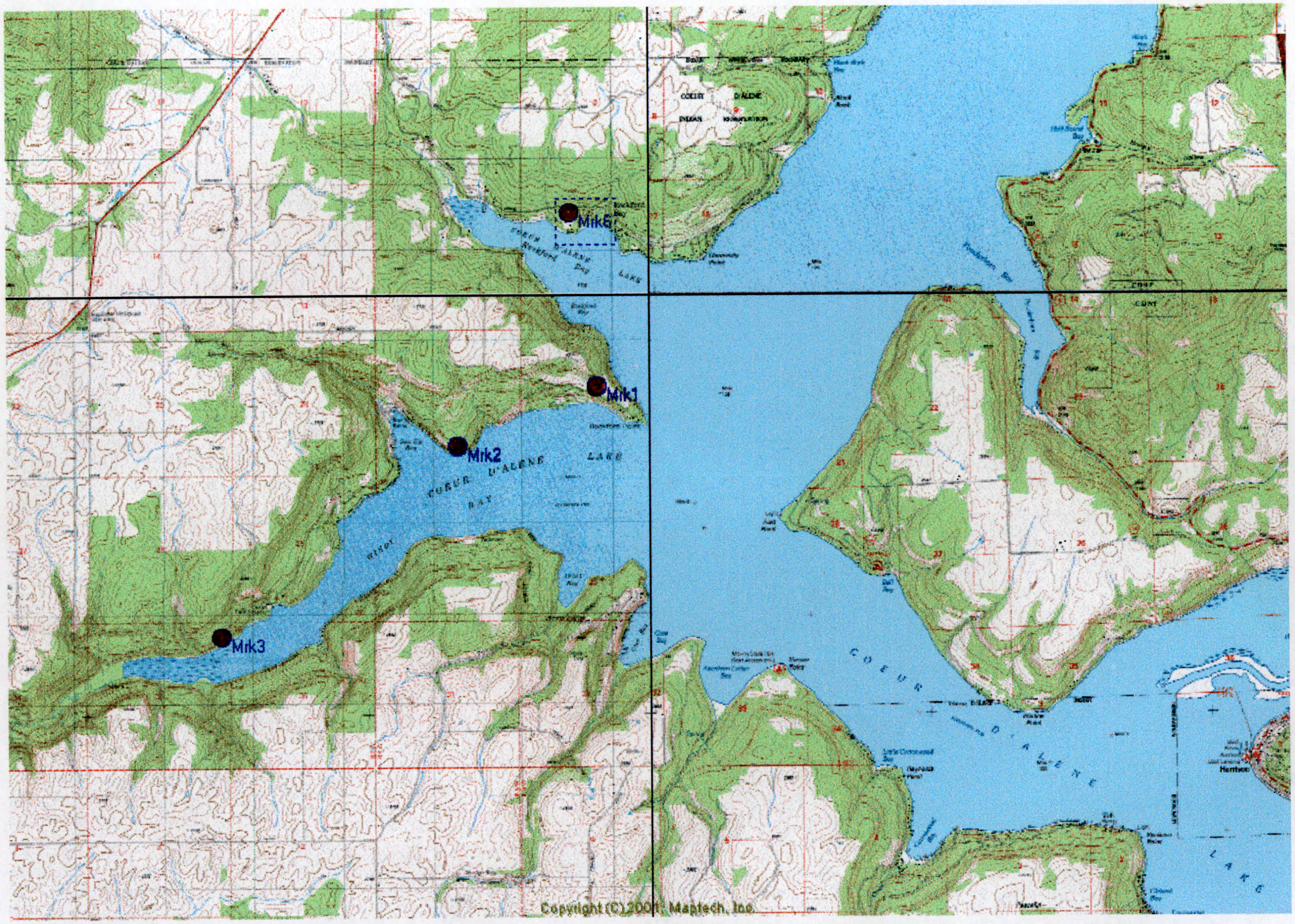
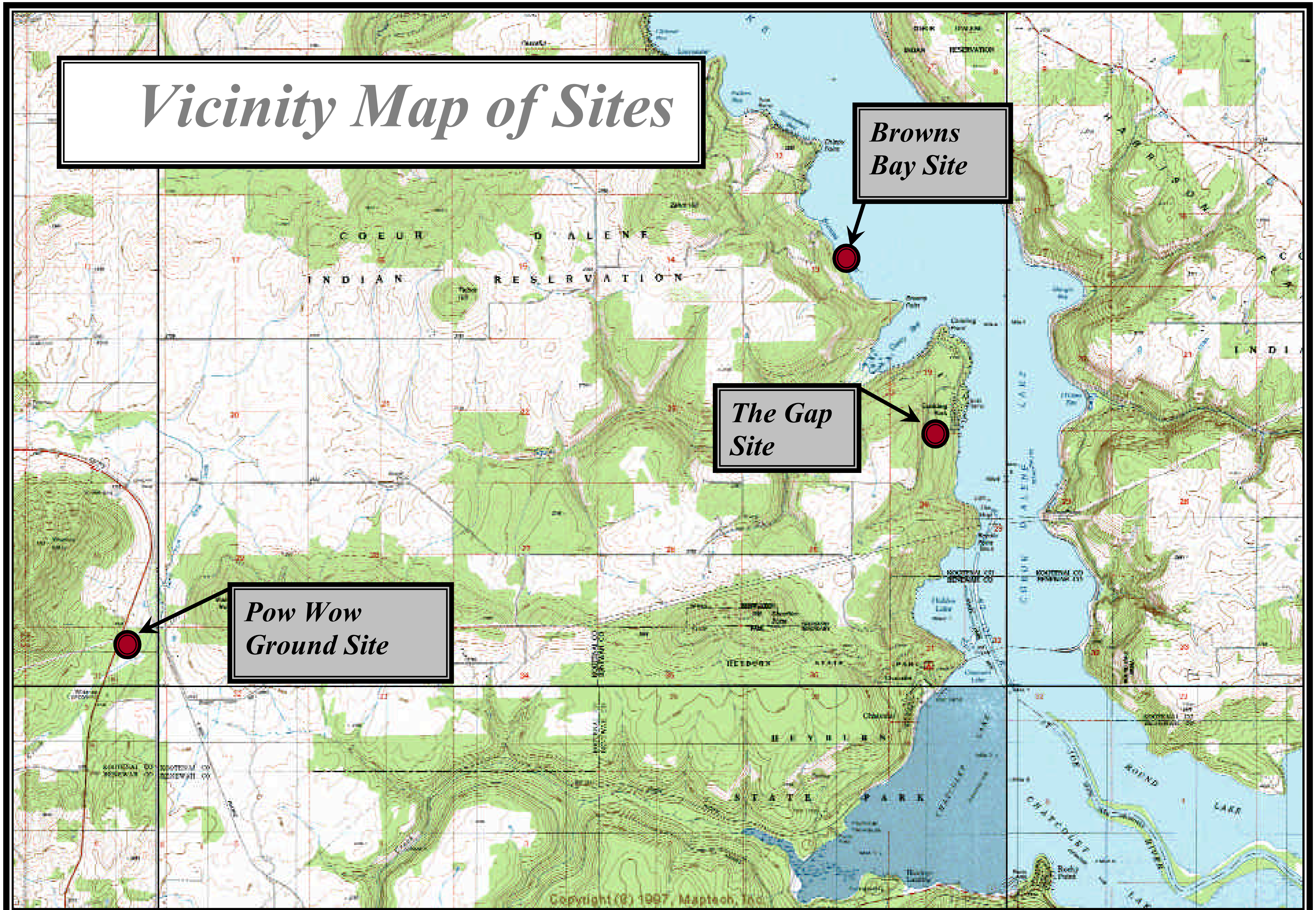
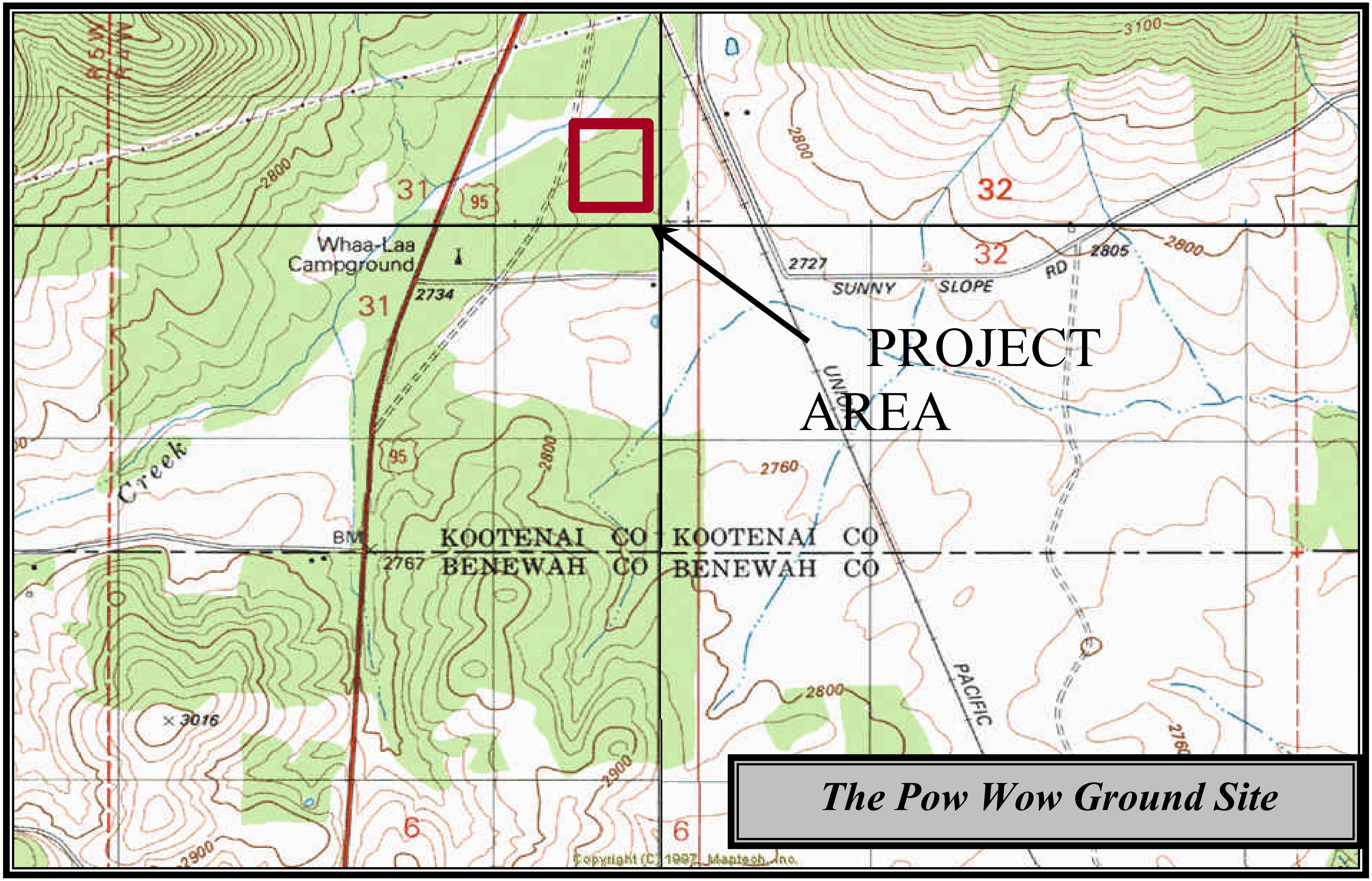

Mrk6
Mrk1
Mrk2
COEUR D'ALENE
LAKE
BAY
Mrk3
COEUR D'ALENE
LAKE
Copyright (C) 2001, Maptech, Inc.

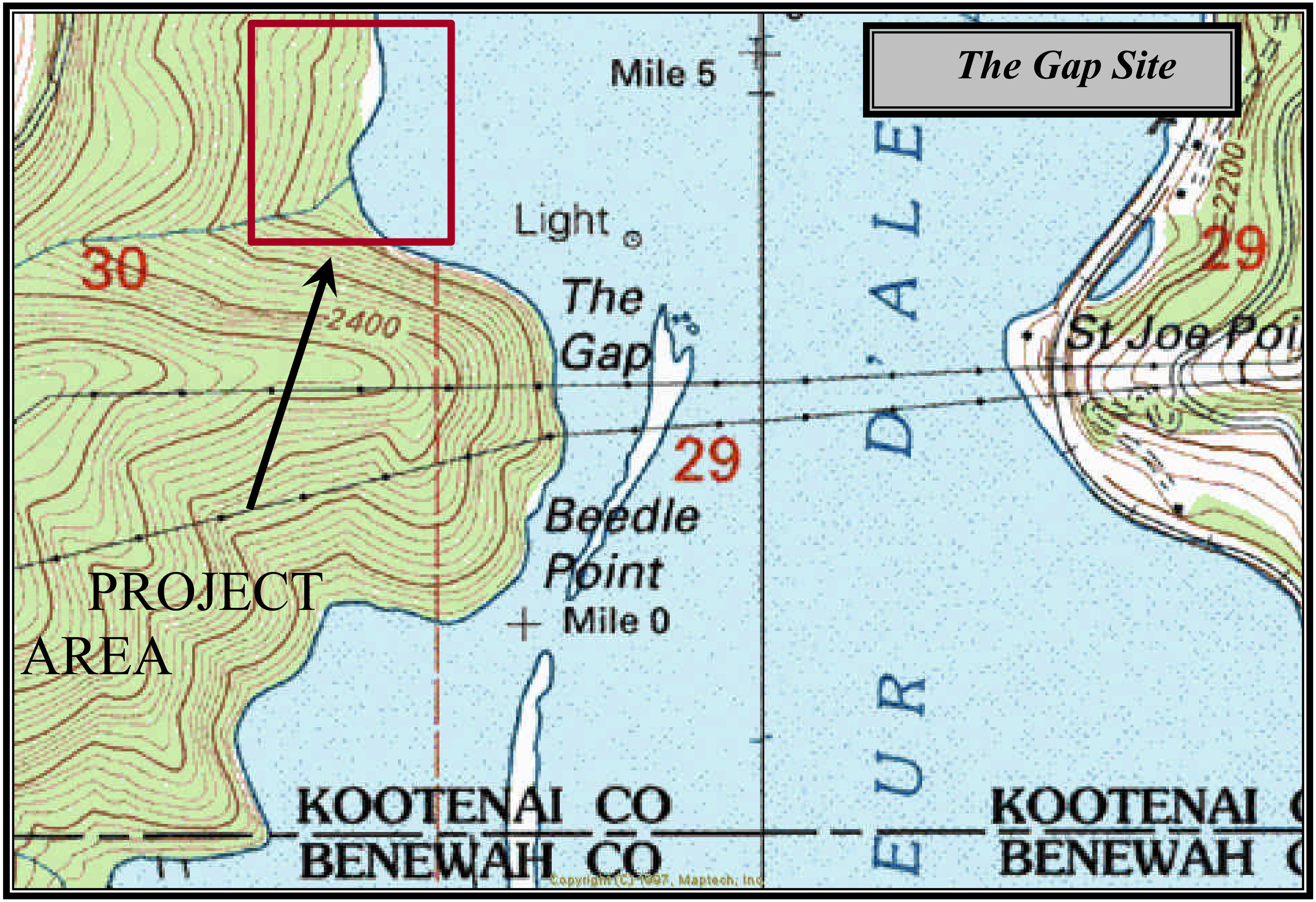
Exhibit B

Exhibit C


Vicinity Map of Sites
Browns Bay Site
The Gap Site
Pow Wow Ground Site
COEUR D'ALENE INDIAN RESERVATION
HEYBURN STATE PARK
Copyright (C) 1997, Maptech, Inc.



The Pow Wow Ground Site



The Gap Site
Mile 5
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2400
The
Gap
29
Beedle
Point
Mile 0
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St Joe Poi
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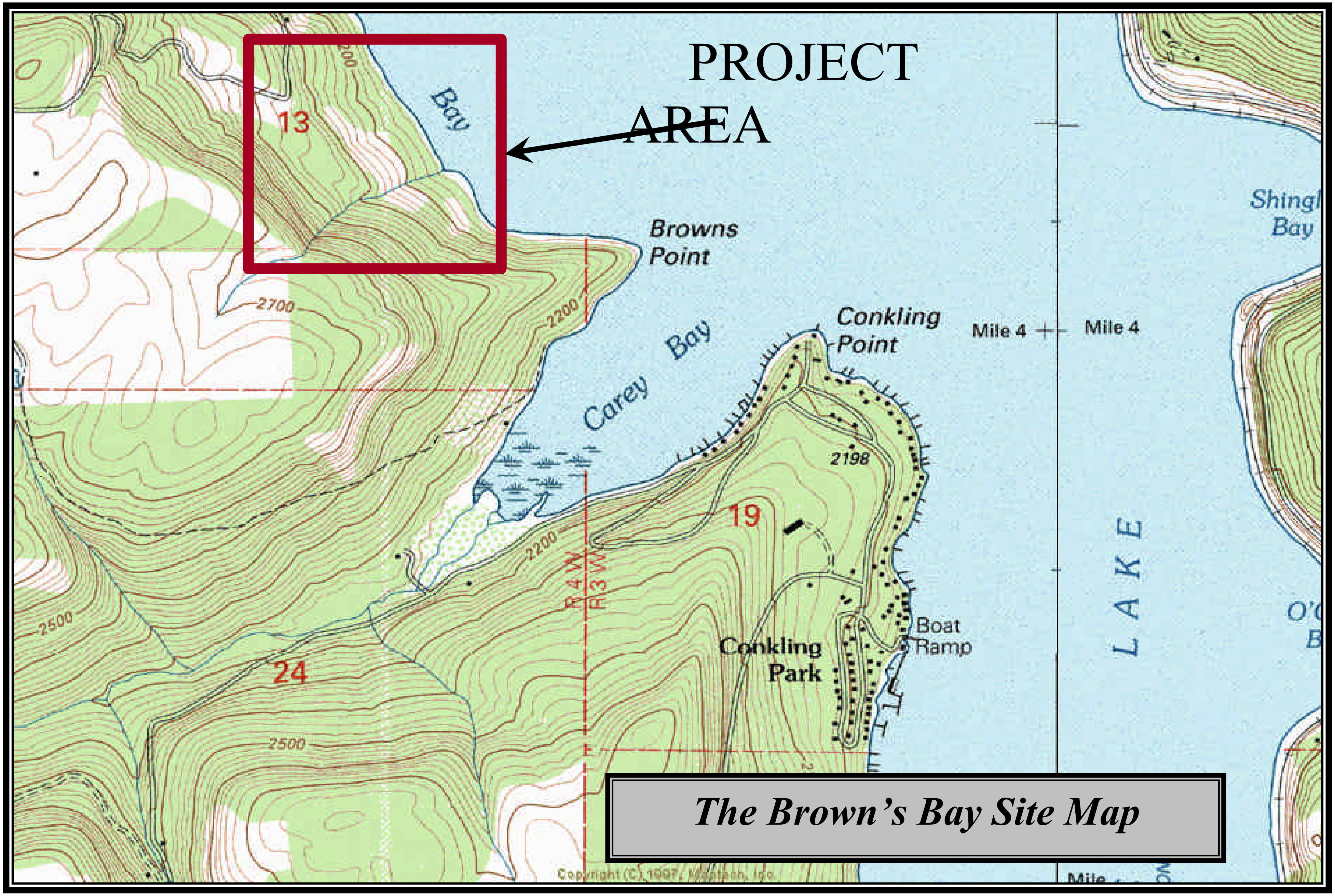
Copyright (C) 1997, Maptech, Inc



The Brown's Bay Site Map

Coeur d'Alene Hatchery
Estimated Energy Consumption
at Pow Wow Site

Assumptions:

- 90% water reuse system with 60 gpm ground water make-up
- 1,600 - 12"/0.75 CTT Broodstock (1,200 lbs total)
- 100,000 - 4"/22.6 per 1000 CTT Fingerling's (2,260 lbs total)

Hatchery Item	Rated HP	KwH/mo.	Mo/yr	Annual Consumption
Well Field (pumping & treatment)	15 HP	8,100	mo.	56,700
Rock Cr. Diversion & Treatment	10 HP	5,400	5 mo.	27,000
Building HVAC, Electric & lighting	15 HP	8,100	12 mo.	97,200
Water Treatment/Life Support:				
- Chillers	60 HP	32,400	4 mo.	129,600
- Heaters	100 HP	54,000	4 mo.	216,000
- U.V. Disinfection (1,000 gpm)	5 HP	2,700	12 mo.	32,400
- Filters & pumps	10 HP	5,400	8 mo.	43,200
- Ozone Generators & Destruct	5 HP	2,700	12 mo.	32,400
- Oxygen Generators/Supply	7.5 HP	4,050	12 mo.	48,600
- Air Blowers/Drum Filter	7.5 HP	4,050	12 mo.	48,600
- Re-use Sump Pumps	20HP	10,800	12 mo.	129,600
- Fractional meters (Alklinity & ph drip, etc.)	1.5 HP	810	12 mo.	9,720
- Effluent pumping	2 HP	1,080	12 mo.	12,960
Residence	--	2,000	12 mo.	24,000
Subtotal				907,980
Miscellaneous @ 10%	--	7,475		90,800
Totals:	Peak ~ 117,000 kwh/mo			
	or			998,780 kwh/yr
	163 kw			

Coeur d'Alene Hatchery
Estimated Energy Consumption
at The Gap Site

Assumptions:

- Single pass lake water (1,000 gpm); no groundwater
- 1,600 - 12"/0.75 lb CTT Broodstock (1,200 lbs total)
- 100,000 - 4"/22.6 1,000 CTT Fingerlings (2,260 lbs total)

Hatchery Item	Rated HP	KwH/mo.	X Mo/yr	Annual Consumption
Pump Station: 2.2 cfs, 215' TDH, 60% Eff.	90	48,600	12 mo.	583,200
6,000 ft^2 Building HVAC, Elect. & Light	15	8,100	12	97,200
Water Treatment/Life Support:				
- Chillers: 1,000 GPM, 13°F, 90% E	300	162,000	4	648,000
- Heat Exchange Booster Pumps	15	8,100	8	121,500
- Surface Water Drum Filters	5	2,700	12	32,400
- Heaters	300	162,000	4	648,000
- U.V. Disinfection (1,000 gpm)	18	9,700	12	116,400
- Ozone Effluent Treatment	10	5,400	12	64,800
- Oxygen Generators/supply	7.5	4,050	12	48,600
Residence		2,000	12	24,000
Subtotal				2,384,100
Miscellaneous @ 10%		19,850		238,400
Totals:	Peak ~ 270,000 kwh/mo			
	or			2,622,500 kwh/yr
	375kw			

Coeur d'Alene Hatchery
Estimated Energy Consumption
at Browns Bay Site

Assumptions:

- Single pass lake water (1,000 gpm); no groundwater
- Temperature control via deep and shallow lake intakes
- Small well (20 gpm) for incubation/fry rearing
- 1,600 - 12"/0.75 lb CTT broodstock (1,200 lbs total)
- 100,000 - 4"/22.6 per 1,000 CTT fingerlings (2,260 lbs total)

Hatchery Item	Rated HP	KwH/ mo.	Mo/yr	Annual Consumption
Pump Station: 2.2 cfs, 60' TDH, 60% Eff.	25	13,500	12	162,000
Small well on site	1	500	12	6,000
3,600 ft^2 Building, HVAC, Elect & Lighting	10	5,400	12,	64,800
Water treatment/life support				
- Chillers/heaters (heat pumps)	20	10,800	5	54,000
- U.V. Disinfection (1,000 gpm)	5	2,700	12.	32,400
- Surface water drum filters	5	2,700	12	32,400
- Ozone effluent treatment	10	5,400	12	64,800
- Oxygen generators/supply	7.5	4,050	12	48,600
Residence	--	2,000	12.	24,000
Subtotal				489,000
Miscellaneous @ 10%	--			49,000
Totals:	Peak ~ 47,000 kwh/mo			
	or		Annual =	538,000 kwh/yr
	65 kw			

Alternative Site Matrix

Sites	Ownership	Water Quantity Groundwater	Water Quantity Surface Water	Land Availability	Energy Requirements kwH/yr	Construction Costs	Estimated Land Costs	Total Cost Estimate
Pow-Wow Site	Tribally owned	60 gpm groundwater makeup	Rock Creek 9 months/year	Available	998,780	$3.321 M	0	$3.2 M
The Gap Site	Private	30 –50 gpm available for incubation/ other	Coeur d'Alene Lake unlimited	Available	2,600,000	$3.413 M	$900 K	$4.31 M
Brown's Bay Site	Private	30 – 50 gpm available for incubation/ other	Coeur d'Alene Lake unlimited	Available	538,000	$2.902.M	$1.0 M	$3.90 M

Alternative Site Matrix

Site	Water Supply System	Treatment Equipment	Structures	Life Support/ Raceways	Wastewater System	Emergency Standby Power	Power Availability	Access Roadway	Site Work	Energy Usage
Pow-Wow Site	H	H	N	N	H	N	L	L	L	N
The Gap Site	N	N	N	N	N	H	N	H	H	H
Brown's Bay Site	L	L	N	N	N	L	H	N	N	L

Ralston Hydrologic Services, Inc.

GROUND WATER CONSULTING AND EDUCATION

1122 East B Street, Moscow, ID USA 83843

Voice and FAX 208-883-0533, E-mail ralston@moscow.com

ANALYSIS OF WELL YIELD POTENTIAL FOR A PORTION OF THE COEUR D'ALENE RESERVATION NEAR WORLEY, IDAHO

Prepared for

J-U-B Engineers, Inc.

Spokane, Washington

February 2001

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Figure 3	Well S-1 Depth to Water Plot (9/7 to 9/23/99 Aquifer Test)
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Figure 5	Observation Well Depth to Water Plot From S-1 Aquifer Test
Figure 6	Well A-1 Depth to Water Plot (4/28 to 5/18/00 Aquifer Test)
Figure 7	Well A-1 Discharge Plot (4/28 to 5/18/00 Aquifer Test)
Figure 8	Well A-2 Depth to Water Plot (9/26 to 9/28/00 Aquifer Test)
Figure 9	Well A-2 Discharge Plot (9/26 to 9/28/00 Aquifer Test)
Figure 10	Well B-2 Depth to Water Plot (12/15/00 to 115101 Aquifer Test)
Figure 11	Well B-2 Discharge Plot (12/15/00 to 115101 Aquifer Test)

INTRODUCTION

This report provides a summary of the information gained from the drilling and hydraulic testing of a series of test wells drilled in the Worley, Idaho area as part of a hatchery development program on the Coeur d'Alene Indian Reservation. The goal of the ground water investigation program is to develop a well field that will supply a continuous flow of about 60 gpm (gallons per minute) for hatchery uses. This yield may be obtained from one or more wells pumping continuously or from a number of individual wells pumped sequentially.

Two objectives must be considered during the ground water evaluation program. First, the production wells must yield sufficient water to meet project objectives. Second, the wells must be capable of yielding these amounts over long periods of time. The first objective may be satisfied by penetrating portions of the subsurface that have large enough openings (pores in unconsolidated sediments or fractures in consolidated rock) to yield the desired discharge rate. The selection of drilling sites to meet this objective is based on understanding the subsurface geologic conditions. Data obtained from aquifer tests may be used to estimate individual well yields.

The second objective of long-term productivity is more difficult to evaluate. Prior to the construction and operation of wells, ground water systems are in a state of dynamic equilibrium; natural recharge is equal to natural discharge. Ground water recharge in the Worley area is from precipitation and stream losses within the watershed. Natural ground water discharge in the Worley area occurs as springs and seeps in the deep canyons tributary to Coeur d'Alene Lake to the east and as ground water outflow to the west. Annual ground water pumpage from wells must necessarily be less than annual recharge for long-term water production to be possible. Development of a new well necessarily causes some decline in ground water levels and ultimately decreased ground water discharge. Ground water levels will decline then ultimately stabilize if the amount of water removed by pumping is less than recharge rates. However, mining of ground water with associated continuous water level decline will occur if pumpage exceeds recharge rates. Thus, long-term well operation for hatchery operations in the Worley area depends on understanding ground water flow systems and recharge-discharge relationships.

The assessment of long-term well productivity is based on three different evaluation approaches. First, how large is the aquifer? A large, laterally extensive aquifer has a greater surface area for recharge and more water in storage. Long-term development of a production well (or well field) is much more likely in a large aquifer than in an aquifer that is closely bounded by low permeability rocks. Second, how does the aquifer respond to water removal during an aquifer test? The critical aspect here is whether the aquifer water levels fully recover in a reasonable period of time after pumping has stopped. Significant residual drawdown long after the end of the test is evidence of a highly bounded aquifer that would not be suitable for long-term development. The third evaluation approach is to monitor ground water levels during one or more annual recharge events. An aquifer where water levels respond to spring snowmelt related recharge events is a much better candidate for long-term development than one that appears to be isolated from surface recharge events.

This report presents an evaluation of data collected to date from the drilling and testing of a number of wells following the procedures outlined above. This type of ground water study always suffers from a lack of detailed subsurface information. Extrapolation of the existing data is a necessary investigation approach.

A report entitled **"Ground Water Development Potential For A Portion of The Coeur d'Alene Reservation Near Plummer And Worley, Idaho"** (Ralston, 2000) presents a summary of the site geology and the results of the drilling and testing of the first two test wells. A portion of the information from the Ralston (2000) report is presented within the current document.

HYDROGEOLOGIC SETTING

The area of interest is located where an ancestral topography composed mostly of metamorphic rocks was inundated by a sequence of basalt flows and associated sediments. Figure I is a partial copy of a draft geologic map in preparation by the Idaho Geological Survey. The metamorphic basement rocks outcrop at numerous locations and underlie the basalt and sediments at depth. Figure I shows the basement rocks with a "Y" followed by several additional letters (Yrb, Ywml, Ywu, Ysp, Ysr and Yxq). Relative to a ground water development project, the differences between these geologic map units are insignificant. Sediments are shown over much of the mapped area. The sediments are identified either as Ts or Oal (gold and yellow colors). Basalt of the Priest Rapids member of the Wanapum Formation (Tpr - brown color) outcrop in the northern portion of the area and in the canyons. Deeper basalt units *(Ted* - dark brown: Tgn2 - salmon color) outcrop in the canyons and along the lake.

The basalt is the most viable target for well development within the area of interest. Aquifers (water producing zones) are located along contact zones between successive flows. The individual basalt flows vary in thickness but average 150 to 250 feet over much of northern Idaho and eastern Washington. Variations occur where the basalt laps up on ancestral highs or where the flows filled canyons in the ancestral topography. Two regional basalt aquifers are present in much of northern Idaho and eastern Washington. The upper of these two aquifers occurs in the Wanapum Formation while the lower is in the Grande Ronde Formation (Tpr and Tgn2 on Figure 1). Typically, water levels are 50 to 150 feet lower in the underlying Grande Ronde aquifer than in the overlying Wanapum aquifer. Higher well yields generally are obtained in the Grande Ronde unit.

Most of the sediments found in the basalt sequence in the area of interest are finegrained, representing deposition in a low-energy environment. The logs show primarily clay and shale. Thus, the sediments are not good water producing zones.

Most of the metamorphic rocks have low hydraulic conductivity and are not viable targets for large yield water supply development. The metamorphic rocks typically are identified on well driller logs as shale or granite. However, in some localized areas shale sequences within the metamorphic rocks allow higher water production levels.

The bedrock (metamorphic rock) outcrops shown on Figure I represent the ancestral ridges or high lands that were not covered by the basalt and sediments. The thickness of basalt and associated sediments is greatest at the locations of the ancestral valleys. The approximate locations of these valleys may be inferred from the geologic map. The present location of Plummer Creek probably overlies an ancestral valley in the basement rock. The creek has eroded a deep canyon and basement rocks are not exposed, A second basement valley probably is located east of Worley near the present alignment of Squaw Creek. The area northwest of Worley probably is a third ancestral valley.

A review of the well logs from the test wells plus the older existing wells indicates that the subsurface is a complex mosaic of basalt flows and sedimentary interbeds overlying irregular bedrock topography. The basalt flows probably filled in a steep upland drainage, causing rapid deposition of sediment and, in places, invasion into the sediments by the encroaching basalt flows. As a further complication, the metamorphic rocks in the area are highly weathered. Some of the sediments below the lowermost basalt flow may be weathered basement rocks.

The complex subsurface geology results in a very complex network of local aquifers, possibly with a limited lateral interconnection. This makes extrapolation of ground water conditions from well to well very difficult. The key to meeting the project objectives is to find areas where well yields are high enough and where there is a reasonable degree of interconnection of aquifers over a large area.

ANALYSIS OF WELL DATA

Seven test wells were constructed as part of this project. The locations of the wells are shown on Figure 2. In addition, a new well for the City of Worley was constructed in 1999 and an aquifer test conducted. Table I presents construction information for these wells. The following sections describe the construction and hydraulic testing of the project test wells plus the new City of Worley well.

Well S-1

Well S-1 is the southernmost of the test wells constructed for the project (Figure 2). This well was drilled near Sunny Slope Road in a small valley surrounded on three sides by hills composed of metamorphic rocks. Basalt was intercepted in the well starting at 58 feet to the bottom of the well at 160 feet. The basalt likely is part of the Wanapum Formation (Tpr on Figure 1). The basalt aquifer likely has limited areal extent because of the nearby location of the metamorphic rock ridges. The static depth to water is about 33 feet below land surface. A copy of the well log for well S-1 is presented in Appendix A.

An aquifer test was run using well S- I as the pumping well and an existing well as the observation well. A pump in well S-1 was turned on September 7, 1999 and pumped continuously until September 23, 1999. Figure 3 shows the water level record for well S-1. The pumping rate was held near 60 gpm for about 12 days and then stepped briefly up to about 80 and then about 95 gpm (Figure 4). Water level data were obtained intermittently for about 42 days after the end of the test. Figure 5 presents the water level response pattern for the observation well located less than 100 feet from S- 1.

The S- I aquifer test demonstrates that the well can yield about 60 gpm with a demonstrated pumping period of about 16 days (Figure 4). However, both the pumping and observation wells show incomplete water level recovery that is characteristic of small, bounded aquifers. Well S- I had recovered only within about three feet of the original static level after a recovery period roughly equal to the pumping period. The residual drawdown was more than 1.6 feet after more than 42 days of recovery (as compared to about 16 days of pumping). The observation well showed a similar lack of full water level recovery (Figure 5). **Questions related** to the long-term productivity of this well as a water supply source for the hatchery are addressed in a later section of the report.

Well A-1

Well A- I was drilled to a depth of 433 feet at a site slightly south of the Conkling Road (Figure 2). According to the well log submitted by the driller, well A- I only obtained water from a basalt layer in the depth range of 393 to 433 feet. Well A- I is located north of the small basin penetrated by well S- I but relatively near the deep canyons that provide drainage to the east toward Coeur d'Alene Lake. The Ralston (2000) report provides a conceptual geologic cross section that includes the A- I well. The lower basalt aquifer penetrated by well A-I likely is part of the Grande Ronde Formation (Tgn2 on Figure 1). The lateral continuity of this aquifer probably is limited because of the metamorphic ridge to the south and the presence of the deep canyons to the east.

An aquifer test was conducted by pumping well A- I in the time period of April 28 to May 18, 2000. The water level and discharge records for this test are presented in Figures 6 and 7. The pumping rate was held at near 60 gpm. The linear nature of the water level pattern shown on Figure 6 in the time period of five to 20 days after the start of pumping indicates the presence of negative boundaries formed by the truncation or edge of the aquifer. The bounded nature of the aquifer also is shown by the lessened pattern of water level recovery shown on Figure 6. Only about one week of recovery data was taken after about 20 days of pumping. However, the water levels appear to be trending toward a stable level five to ten feet below the original static. More information on long-term recovery of water levels in this well is presented in a later section of the report.

Well A-2

Well A-2 was drilled at a location slightly less than one-half mile north of well AI near the boundary of sections 19 and 20 (Figure 2). The drillers log (Appendix A) shows basalt in the depth interval of 18 to 295 feet with a small aquifer in the depth range of 275 to 285 feet. The well penetrated clay then shale to total depth. According to the well log, an aquifer was penetrated in the shale in the depth range of 3 10 to 3 65 feet. The depth to water in the well is slightly less than 70 feet.

A 24-hour aquifer test was run on well A-2 in September 2000. Figure 8 shows the water level pattern in the well during and after the test. Figure 9 illustrates that the pumping rate was held at about 70 gpm. The water level in the pumping well dropped relatively rapidly about 60 feet and then started to stabilize. One day after the end of the pumping test the water levels had recovered to within two feet of the original static. The short length of the pumping period prevents detailed interpretation of the long-term productivity of this well.

Wells B-1 and B-2

The focus of the test drilling and aquifer-testing program moved closer to the City of Worley in late 2000. This was in part because of high reported well yields from several City of Worley wells. Also a well drilled near the silos in the east portion of Worley had high reported yields.

Well B-1 was drilled in November 2000 to a depth of 344 feet at a location near the old silo well (Figure 2). This well intercepted mostly basalt in the depth range of 24 to 338 feet but the driller reported only small water production. His estimated well yield is 50 to 60 gpm (Table I and Appendix A).

The B-2 notation was given to the old well located at the silo. The original drillers log for this well (drilled in 1976) shows a depth of 305 feet with basalt from 20 feet to the bottom of the well (Appendix A). Water producing zones were noted in the depth intervals of 70 to 100 feet and 160 to .180 feet. A drilling rig was set over well B-2 in December 2000 and the well was cleaned out to a reported depth of 300 feet. A section of 4-inch diameter PVC casing was set in the well with perforations in the depth range of 200 to 240 feet. The perforations consist of reported 1/8-inch by 6-inch saw cuts in the 4-inch diameter casing. This gives an estimated open area of about 0.8 square feet and a design yield (at an entrance velocity of 0. 1 ft/sec) of about 3 7 gpm. The drillers log indicates that the annular space between the PVC casing and the drilled hole was backfilled with "pea gravel."

A 2 1 -day aquifer test was conducted in December 2000 and January 2001 where well B-2 was pumped and water level data were collected on wells B-1 and B-2. Figures I I and 12 provide the water level and pump discharge data for well B-2. Water level data for well B- I are presented on Figure 13. Figure 12 shows that well B-2 was pumped at a rate of about 70 gpm at the start of the test decreasing to 65 gpm at the end of the test. About 90 feet of drawdown was measured in the pumping well. The total drawdown in well B-1, located within 200 feet of well B-2 was slightly over 40 feet. The water level in well B-2 recovered to within about 0.3 feet of the original static about 26 days after the well was shut off (Figure 10). A comparison of the initial and final water level for well B- I is confusing and probably represents measurement error in the data record. The depth to water in well B-I prior to the aquifer test on December 15, 2000 was reported as 68.67 feet. The water level reading on January 30, 2001 (about 25 days after the pump was turned off) was 77.04 feet. This would show about 9 feet of residual drawdown if correct. The water levels in both wells were measured on January 30, 2001 and the approximate difference between the casing elevations was determined. These figures indicate that the water level elevations are within 0.2 feet of being the same in the two wells. The static depth to water of 76 feet in B-2 prior to the start of the test should have corresponded to a similar level in well B-1. Likely, the lack of full water level recovery shown for well B-I on Figure 12 probably represents water level measurement error early in the test period.

The estimated long-term yield that can be obtained from well B-2 is discussed in a later section of the report. A recommended well field pumping program also is presented in that section.

Well B-3

Well B-3 is located several thousand feet northeast of the B-2/B-1 well pair. This well was drilled to a depth of 405 feet in January 2001. Basalt was penetrated in the depth range of about 3 to 296 feet. Clay was found under the basalt in the depth interval of about 296 to 330 feet. About 70 feet of shale was penetrated in the bottom of the well. Water producing zones are identified on the drillers log from the basalt in the depth ranges of 65 to 69 feet and 235 to 242 feet and from the shale in the depth range of 330 to 405 feet. The casing used in the well is described on Table 1.

A 24-hour aquifer test was conducted on well B-3 on January I I - 12, 200 1. Figure 13 presents the water level data while Figure 14 presents a plot of the discharge rate. The water level plot for well B-3 is very irregular because the discharge rate had to be continually adjusted downward to keep the water level above the pump. Figure 14 shows that the initial pumping rate was about 70 gpm with a gradual reduction to about 3 5 gpm at the end of the test. Water level data show that the water level in the well was about 6.7 feet below the original static level one day after the pump was turned off. A water level measurement taken eight days after the pump was turned off shows that the water level was about 2.2 feet higher than the static level at the start of the test. The water level in the well may have still been rising on January 11, 2001 (the start of the aquifer test) because drilling (including airlift pumping) was not completed until January 5, 200 1. As is discussed later in the report, this well is not a good candidate for inclusion in a well field for the hatchery.

Well B-4

Well B-4 was drilled north of the City of Worley near the sewage lagoons (Figure 2). The well was drilled to a depth of 445 feet and penetrated layers of basalt and clay (see Appendix A for the drillers log). Basalt was penetrated in the depth intervals of 14 to 237 feet and 325 to 414 feet. The driller reported a low yield (12 gpm) with water noted only in the depth range of 237 to 321 in an interval logged as "clay and clay with wood". An aquifer test was not run in this well because of the small reported yield.

Worley City Well

The City of Worley relies on three wells for their municipal water supply, Information on these wells is given in Table 1. According to the available records, the first of the three wells was drilled in 1954 with the second in 1977 and the third in 1999. The well log for the 1999 well is included in Appendix A.

An aquifer test was run on the newest City of Worley well in September 2000. Figure 15 presents the water level data from the test while Figure 16 is a plot of the discharge rate. A step drawdown test was run on the well. The well was pumped at 200 gpm for two hours at which time the rate was increased to 250 gpm. A third rate of 300 was achieved starting four hours into the test. The total testing period was about eight hours. Water level recovery data were taken for 30 minutes after the pump was turned off. Maximum drawdown was about 19 feet with only about 1.7 feet of residual drawdown after 30 minutes of recovery. There is no doubt that this is an excellent well.

The City of Worley was contacted in an effort to obtain historic well discharge and water level data. Apparently no water level data are available for any of the city wells. The limited pump discharge data that was found are presented in Figure 17. Average well discharge, in gallons per day, were calculated from roughly monthly readings of well discharge totalizing meters. The new city well (West Park) was the dominant source of water for the city after it was put on line in 2000.

WATER QUALITY

Water quality data are available from the test wells and the newest City of Worley well. Table 2 presents the results of analyses of well water analyzed at the Spokane Tribal Laboratories for wells S-1, A-1, A-2, B-2 and B-3. Anatek Labs results for the City of Worley well drilled in 1999 also are included. Some important constituents were not included in most of the analyses. These include calcium on the cation side and bicarbonate/carbonate on the anion site. The total dissolved solids reported for the samples are low. The water likely is a calcium-bicarbonate type.

ANALYSIS OF WELL FIELD PRODUCTIVITY

The target yield of 60-gpm continuous flow probably cannot be maintained from any single one of the test wells constructed to date. However, there is a good chance that the desired yield can be obtained by operation of three or four of the wells as a well field. The most likely well field operation would include sequential operation of the wells with rest periods equal to or exceeding the pumping times. The two dominant questions are as follows. First, what is the reasonably expected yield of each well? Second, what on/off pumping cycle will be required for each well to operate over a long time period as part of the well field? These questions are addressed in the following paragraphs.

The amount of water that can be pumped from an individual well is dependent on the following factors: 1) the transmissive characteristics of the aquifer, 2) the hydraulic efficiency of the well and 3) the available drawdown (distance between the static water level and the pump setting). Specific capacity is the discharge of the well divided by drawdown and is a measure of the first two of these factors. A highly efficient well that penetrates a high transmissivity aquifer will have a high specific capacity value in gallons per minute per foot of drawdown. The efficiency of an uncased well is high. Within cased wells, the entrance velocity of the water moving through the perforations dominantly impacts the efficiency of the well. An entrance velocity greater than about one foot per second leads to low efficiency wells.

The specific capacity characteristics of the test wells and the newest City of Worley well are presented on Figure 18 for the first two days of pumping. The plot shows that the City of Worley well has a much higher specific capacity than any of the test wells. Wells A- I and S- I have specific capacity values in the range of three to four gpm/ft while wells A-2 and B-2 have specific capacity values near one gpm/ft. Well B-3 is the least productive of the test wells that were pumped.

Long-term operation of the test wells in a well field depends on the size and location of boundaries on the aquifer(s) penetrated and on the annual recharge to those aquifers. The size of an aquifer can be deduced by examination of the hydrogeologic setting. For example, well S-1 probably penetrates the aquifer with the most limited areal extent. The deeper aquifer penetrated by well A- I also probably is of limited areal extent. The second way to assess the long-term productivity of a specific well is by examination of long-term water level recovery patterns. Figure 19 presents a plot of residual drawdown (the difference between the recovering water level and the original static level) versus the ratio of the time since the pump was turned on divided by the time since the pump was turned off (t/t'). The time ratio values are presented on a logarithmic scale.

Several interesting concepts can be derived from an analysis of Figure 19. First, the extrapolation of the data plots to a residual drawdown value of zero (complete recovery) gives a measure of the long-term productivity of the penetrated aquifer. Water levels in a highly productive, large-scale aquifer should nearly fully recover in a time period equal to the pumping period (th'=2). Only the Worley City well and test well B-2 have this characteristic. Second, the amount of residual drawdown as the lines are extrapolated to a t/t' value of about two gives a measure of the long-term water level decline that might be expected with operation of the well as part of a well field. The length of the aquifer test represented by the field data also is a consideration. For example, well B-3 was pumped for only one day yet has about five feet of residual drawdown at t/t'= 2. This would be a very poor long-term water supply source. On the other extreme, well B-2 has nearly full recovery at t/t'=2 yet was pumped for 21 days. This well would be a reliable component of a hatchery well field. Wells S- I and A-2 have similar residual drawdown values at t/t'=2 but well S- I was pumped for 16 days while well A-2 was only pumped for one day.

Analysis of the discharge and water level data collected to date indicates that well B-2 has the best long-term yield characteristics. Wells S-1 and A-2 appear suitable for inclusion in a well field design although there are questions relative to long-term yield characteristics of these wells. Well A-I has better specific capacity characteristics than wells A-2 and B-2 but the excessive residual drawdown causes concern with respect to long-term well yields. The short and long-term yield characteristics of well B-3 are poor; this well should be removed from any further consideration in the well field.

All of the test wells were measured on January 30, 2001. A comparison of these data to previous measurements can provide insight with respect to long-term well productivity. This comparison of depth to water values is shown below.

Well	First measurement	Last measurement
S-1	9/7/99 3)2.65 ft	1/30/01 32.34 ft
A-1	2/28/00 132.70 ft	1/30/01 133.81 ft
A-2	9/26/00 69.05 ft	1/30/01 64.71 ft
B-2	12/15/00 76.00 ft	1/30/01 76.00 ft
B-3	1/11/01 32.02ft	1/30/0132.3)4 ft

All of the measurements of depth to water are within about one foot of the first measurement except for well A-2. The January 2001 measurement is five feet above the static level taken just before the aquifer test in September 2000. The reasons for this water level difference are unknown. The fact that the January 2001 measurements in all wells are near or above the original supports the idea that the tested aquifers in the Worley area do receive some annual recharge.

Long-term measurement of water levels in all of the wells is a useful way to further document the productivity of the aquifers in the area. Water level measurement on at least a monthly frequency is needed. Hydrographs based on these data may show responses to snowmelt or precipitation events and thus provide an additional level of understanding of recharge amount and locations.

CONCLUSIONS AND RECOMMENDATIONS

The ground water systems in the area in and southeast of Worley are very complex. The ground water complexity rises from the complex nature hydrogeologic framework of basalt, sediments and basement rocks. The primary concern with respect to water supply for the hatchery is long-term yield of the wells. The short-term yield characteristics have been documented as part of the aquifer-testing program.

The potential is good that operation of a well field using wells B-2, S- I and A-2 will yield the desired continuous pumping rate of 60 gpm. The available aquifer test data indicate that well B-2 has the best combination of suitable yield rate and nearly full water level recovery after testing. This well probably can be operated perhaps fifty percent of the time to supply the target yield. The remainder of the time the desired yield can be achieved by alternate operation of wells S- I and A-2. Possible lack of full water level recovery is a problem in both of these wells. In particular, our understanding of the long-term yield characteristics of well A-2 is limited because only a one-day aquifer test was conducted. Well A- I can contribute to the hatchery program but probably cannot be pumped at a rate of 60 gpm for any more than one or two months per year because of the slow water level recovery rate of this aquifer. Well B-3 does not have the yield characteristic to be included in the well field design.

Additional data collection efforts would greatly improve our understanding of the ground water systems and the long-term reliability of a well field. These efforts are listed below.

- <u>At least monthly water level data collection in all</u> wells -- The seasonal and annual water level fluctuations would provide important information relative to aquifer recharge characteristics.

- <u>Continuous water level data collection in well B-2 --</u> A data logger installed and operated in well B-2 would provide information relative to possible hydraulic connection with the City of Worley wells.

- <u>Long-term aquifer test of well</u> A-2 -- A 15 to 25 day aquifer test is needed on well A-2 in order to assess the long-term productivity of this well.

- <u>Water quality sampling and analysis</u> -- A more complete analysis of water quality within the target wells is needed. The analysis should include all common ions (such as bicarbonate and carbonate) in addition to specific constituents of importance to hatchery operation.

Table I Test Well and Worley City Well Information

Well ID	Location	Elev.	Well Depth	Depth to Water	Water Elev.	Rep. Yield	Tested Yield	First string of casing Depth	First string of casing Diameter	Second string of casing Depth	Second string of casing Diameter	Perforated Interval	Aquifer Description
		(feet)	(feet)	(feet)	(feet)	(gpm)	(gpm)	(feet)	(inches)	(feet)	(inches)	(feet)	
S-1	47/4 31 NW NE	2745	160	25	2720	100	60	0 to 58	6" steel	0 to 157	4" PVC	117 to 157	basalt
A-1	47/4 30 NE NE	2740	433	145	2595	50	60	0 to 65	8" steel	0 to 433	4" PVC	398 to 433	basalt
A-2	47/4 19 NE SE	2677	383	69	2608	150	70	0 to 18	8" steel		open	18 to 383	shale
B-1	47/5 24 NW SW	2660	344	69	2591	50		0 to 87	8" steel		open	87 to 344	basalt
B-2	47/5 24 NW SW	2660	240	76	2584	100	70	0 to 60	8" steel	18 to 242	4" PVC	200 to 240	basalt
B-3	47/5 24 NE SW	2640	405	32	2608	45	35	0 to 20	8" steel		open	20 to 405	basalt/shale
B-4	47/5 23 NE NE	2622	445	100	2522	12		0 to 18	8" steel	0 to 442	4" PVC	open 442 to 445	clay
W-1954	47/5 23 NE SE	508	345					0 to 400	8" steel				
W-1977	47/5 23 NE SE	204		350				0 to 38	8" steel	0 to 152	6" steel	open 152 to 204	basalt
W-1999	47/5 23 NE SE	2655	242	90	2565	300	300			0 to 242	8" steel	220 to 242	basalt

Notes:

1 Well elevations are estimated from USGS topographic maps

2 Depth to water values for test wells S-1, A-1, A-2, B-1, B-2 and B-3 are from aquifer test data

3 Well B-2 was drilled originally in 1976 to a depth of 305 feet and recompleted in 1999 to 240 feet

4 Tested yields are after about 24 hours of pumping

5 Well depths, casing information, reported yields and aquifer descriptions are from driller logs

6 The three City of Worley wells are listed by the reported date of drilling

7 Depth to water measurements for test well B-4 and the three City of Worley wells are from the drillers logs

Table 2 Water Quality Data From Test Wells

Well		S-1	A-1	A-2	B-2	B-3	B-3	Worley
Sampling date		5/17/00	4/28/00	10/5/00	114101	1/11/01	1/12/01	9/16/99
Laboratory		-------Spokane Tribal Laboratories ---- - -						Anatek
Total dissolved solids	mg/l	110		130		120	180	21094
Total suspended solids	mg/1	<2		<2	4	<2	264	8
Turbidity	NTU	0.5	1.1	4.6	2.0	220.0	73.1	1.7
Hardness (as CaC03)	mg/l							102
pH								7.85
Conductivity	US/cm							270
Chloride	mg/l	0.89	0.76	1.75	0.94	2.21	1.51	1.90
Fluoride	mg/1	0.38	0.26	0.42	0.16	0.33	0.49	0.38
Nitrate as N	mg/l	0.01	0.07	0.03	0.00	0.33	0.49	<.5
Nitrite as N	mg/1	<. 005	<,005	<.005	<.005	<.005	<. 005	
Total phosphorous	mg/1		0.04	0.04	0.04	0.04	0.03	
Ortho-phosphorous as P	mg1l	<.005		0.02	0.02	0.04	0.03	0.04
Sulfate	mg/l	1.67	2.86	14.90	2.97	6.25	5.84	4.91
Ammonia as N	mg/l							<. 1
TKN	mg/l			<.030	0.040	0.159	0.072	
Total alkalinity as CaC03	mg1l	102.0		106.0	144.0	97.6	120.0	115.0110.0
Bicarbonate as CaC03	mg/l							
Carbonate as CaCO3	mg/l							
Aluminum	mg/l	<.010	<.010	<.010	<.010	<.010	<.010	<.001
Antimony	mg/l							<,001
Arsenic	mg/l	<.020	<.020	<.020	<.020	<.020	<~020	<.005
Barium	mg/l	0.03	0.04	0.06	0.03	0.03	0.03	0.05

Beryllium	mg/l	<.001	<.001	<.001	<.001	<.001	<.001	<.001
Cadmium	mg/l	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.001
Calcium	mg/l							20.8
Chromium	mg/l	<.002	<.002	<.002	<.002	<.002	<.002	<.005
Cobalt	mg/l							
Copper	mg/l	<.002	<.002	<.002	<.002	<.002	<.002	0.002
Iron	mg/l	0.09	0.44	0.04	0.35	<.002	0.00	0.59
Lead	mg/l	<.001	<.001	<.001	<.001	0.005	0.002	<.001
Magnesium	mg/l	8.71	8.98	15.20	8.11	10.50	10.40	11.40
Manganese	mg/l	0.03	0.04	0.05	0.04	0.04	0.04	0.03
Mercury	mg/l		<. 0002					<.001
Nickel	mg/l	<.005	<.005	<.005	<.005	<.005	<.005	<.001
Potassium	mg/l	3.21	3.24	2.61	3.55	2.15	1.98	3.00
Selenium	mg/l			<.002	<. 002	<.002	<.002	<.005
Silicon	mg/1							
Silver	mg/l	<.002	<.002	<.002	<.002	<.002	<.002	<.01
Sodium	mg/1	9.73	9.35	14.20	8.74	13.20	12.40	10.90
Thallium	mg/l							<.001
Zinc	mg/1			0.09	0.01	<,002	<.002	0.03

J-U-B ENGINEERS, Inc. Suite 722, 422 W. RIVERSIDE AVE., SPOKANE, WA 99201 (509) 458-3727

ENGINEERS OPINION OF PROBABLE CONSTRUCTION COST

DATE: 31-Jan-02

PROJECT:
COEUR D'ALENE TRIBE TROUT PRODUCTION FACILITY

PROJECT DESCRIPTION:
TO: ALTERNATIVE SITE STUDY - POW WOW GROUND SITE

OWNER PROJ. NO.: J-U-B PROJ. NO.: 70234

ITEM NO.	DESCRIPTION	SCHEDULE OF VALUES QTY	UNIT	UNIT PRICE	BASE ESTIMATE
1.	Groundwater Supply (On-site)				
	Pipeline	3,400	LF	$16.00	$54,400.00
	Electrical	1	LS	$20,000.00	$20,000.00
	Subtotal				**$74,400.00**
2.	Groundwater Supply (Off-site Area A)				
	Pipeline	9,600	LF	$16.00	$153,600.00
	Electrical	1	LS	$25,000.00	$25,000.00
	Pipe Jack Railroad Right-of-Way	1	LS	$20,000.00	$20,000.00
	Right-of-way/Easement Acquistion	1	LS	$5,000.00	$5,000.00
	Subtotal				**$203,600.00**
3.	Groundwater Supply (Off-site Area B)				
	Pipeline	11,000	LF	$16.00	$176,000.00
	Electrical	1	LS	$25,000.00	$25,000.00
	Right-of-way/Easement Acquistion	1	LS	$10,000.00	$10,000.00
	Subtotal				**$211,000.00**
4.	Well completion	4	EA	$11,250.00	$45,000.00
	Subtotal				**$45,000.00**
5.	Rock Creek Diversion Structure				
	Concrete Vault Sump	1	LS	$20,000.00	$20,000.00
	Control Vault	1	LS	$5,000.00	$5,000.00
	Electrical Controls	1	LS	$20,000.00	$20,000.00
	Piping	1,040	LF	$16.00	$16,640.00
	Subtotal				**$61,640.00**
6.	Access Roadways (Partial Upgrade)	1	LS	$50,000.00	$50,000.00
	Subtotal				**$50,000.00**
7.	Hatchery Building (Cost Breakdown/SF)	3,380	SF	$80.00	$270,400.00
	Slabs, Footings and Erection ($29.00)				
	Stud Walls & Finish ($15.00)				
	Drop Ceilings ($ 8.00)				
	Kitchen & Bathroom Fixture ($10.00)				
	Windows & Screens ($ 5.00)				
	HVAC, Light & Elect ($ 13.00)				
	Stainless Sinks/Faucets	3	EA	$2,000.00	$6,000.00
	Subtotal				**$276,400.00**

ENGINEERS OPINION OF PROBABLE CONSTRUCTION COST

DATE: 31-Jan-02

PROJECT:
COEUR D'ALENE TRIBE TROUT PRODUCTION FACILITY

PROJECT DESCRIPTION:
ALTERNATIVE SITE STUDY - POW WOW GROUND SITE

OWNER PROJ. NO.: J-U-B PROJ. NO.: 70234

ITEM NO.	DESCRIPTION	SCHEDULE OF VALUES			
		QTY	UNIT	UNIT PRICE	BASE ESTIMATE
8.	Hatchery Building Special Construction				
	Floor Trench & Grating	120	SF	$50.00	$6,000.00
	Case Work, Tile Work & Water Proofing	1	LS	$5,000.00	$5,000.00
	Concrete Landing, Ramps, Bollards	1	LS	$5,000.00	$5,000.00
	Outdoor Concrete Pad	400	SF	$12.50	$5,000.00
	Concrete Pad Roof & Columns	400	SF	$12.50	$5,000.00
	Loft Storage	250	SF	$16.00	$4,000.00
	Subtotal				**$30,000.00**
9.	Hatchery Life Support				
	Tanks, Troughs & Incubators	1	LS	$27,000.00	$27,000.00
	Distribution Piping & Reuse Valves	1	LS	$22,000.00	$22,000.00
	Subtotal				**$49,000.00**
10.	Water Treatment Building (2,100 SF)				
	Metal Building, Slabs & Footings	1	LS	$125,000.00	$125,000.00
	Elevated Service Platforms	100	SF	$120.00	$12,000.00
	Heating & Ventilation	1	LS	$8,000.00	$8,000.00
	Electrical & Lighting	1	LS	$27,000.00	$27,000.00
	Stainless Sink & Faucet	1	EA	$2,000.00	$2,000.00
	Concrete Landing, Ramps, Bollards	1	LS	$5,000.00	$5,000.00
	Subtotal				**$179,000.00**
11.	Recycle Water Treatment Equipment				
	Heaters, Heat Pumps, UV, Filters & Pumps	1	LS	$78,000.00	$78,000.00
	Headboxes & Aeration Column	1	LS	$8,500.00	$8,500.00
	Ozone Generator & Destruct	1	EA	$22,000.00	$22,000.00
	Ozone Contactor/Protein Skimmer	1	EA	$40,000.00	$40,000.00
	Biofilters	3	EA	$30,000.00	$90,000.00
	Oxygen Regulators & Piping	1	LS	$8,000.00	$8,000.00
	Chillers (25 H.P.)	2	EA	$38,000.00	$76,000.00
	Counterflow Column & Blowers	1	LS	$20,000.00	$20,000.00
	Piping & Valves	1	LS	$30,000.00	$30,000.00
	Alkalinity, PH Formalin Drip	1	LS	$8,000.00	$8,000.00
	Subtotal				**$380,500.00**
12.	Makeup Water Treatment Equipment				
	Groundwater Filter	1	LS	$30,000.00	$30,000.00
	Surface Water Prefilter	1	LS	$27,000.00	$27,000.00
	Surface Water Filter	1	LS	$30,000.00	$30,000.00
	Chemical Supply & Feed	1	LS	$10,000.00	$10,000.00
	Activated Carbon System	1	LS	$10,000.00	$10,000.00
	Backwash Basin	1	LS	$46,000.00	$46,000.00
	Subtotal				**$153,000.00**

ENGINEERS OPINION OF PROBABLE CONSTRUCTION COST

DATE: 31-Jan-02

PROJECT:
COEUR D'ALENE TRIBE TROUT PRODUCTION FACILITY

PROJECT DESCRIPTION:
ALTERNATIVE SITE STUDY - POW WOW GROUND SITE

OWNER PROJ. NO.: J-U-B PROJ. NO.: 70234

ITEM NO.	DESCRIPTION	QTY	UNIT	UNIT PRICE	BASE ESTIMATE
		SCHEDULE OF VALUES			
13.	Production Raceways				
	4 Raceways 50' x 5' x 4' Deep	4	EA	$28,000.00	$112,000.00
	Aluminum Screens & Baffles	1	LS	$10,000.00	$10,000.00
	Aeration Columns & Valves	4	EA	$1,500.00	$6,000.00
	Reuse & Waste Drains	1	LS	$12,000.00	$12,000.00
	Yard Piping	1	LS	$19,000.00	$19,000.00
	Raceway Roof & Columns	1,800	SF	$20.00	$36,000.00
	Grading & Surfacing	1	LS	$15,000.00	$15,000.00
	Subtotal				**$210,000.00**
14.	Broodstock Raceways				
	4 Raceways 15' x 5' x 5' Deep	4	EA	$6,000.00	$24,000.00
	Wood Baffle & Stl. Supports	4	EA	$500.00	$2,000.00
	Airlifts	20	EA	$50.00	$1,000.00
	Reuse & Waste Drains	1	LS	$12,000.00	$12,000.00
	Yard Piping	1	LS	$20,000.00	$20,000.00
	Roof & Columns 22 x 40	880	SF	$20.00	$17,600.00
	Grading & Surfacing	1	LS	$4,500.00	$4,500.00
	Subtotal				**$81,100.00**
15.	Workshop/Feed Storage (1,200 SF)				
	Metal Buildings, Slabs & Footings	1	LS	$52,500.00	$52,500.00
	Heating & Ventilation	1	LS	$4,000.00	$4,000.00
	Electrical & Lighting	1	LS	$5,000.00	$5,000.00
	Concrete Deck & Steps	1	LS	$3,000.00	$3,000.00
	Subtotal				**$64,500.00**
16.	Pump Station				
	Earthwork	1	LS	$2,000.00	$2,000.00
	Concrete Sump & Yard Piping	1	LS	$22,000.00	$22,000.00
	Floor Slab & Hatch	1	LS	$4,000.00	$4,000.00
	Pump Shed	1	LS	$9,000.00	$9,000.00
	Pumps, Motors & Piping	1	LS	$23,000.00	$23,000.00
	Electrical & Controls	1	LS	$8,500.00	$8,500.00
	Subtotal				**$68,500.00**
17.	Effluent Pond				
	Earthwork	1	LS	$15,000.00	$15,000.00
	Pump Sump & Piping	1	LS	$15,000.00	$15,000.00
	Sludge Pump & Motor	1	LS	$10,000.00	$10,000.00
	Electrical Service	1	LS	$5,000.00	$5,000.00
	Subtotal				**$45,000.00**

ENGINEERS OPINION OF PROBABLE CONSTRUCTION COST

DATE: 31-Jan-02

PROJECT:
COEUR D'ALENE TRIBE TROUT PRODUCTION FACILITY
ALTERNATIVE SITE STUDY - POW WOW GROUND SITE

OWNER PROJ. NO.:

J-U-B PROJ. NO.: 70234

ITEM NO.	DESCRIPTION	SCHEDULE OF VALUES			
		QTY	UNIT	UNIT PRICE	BASE ESTIMATE
29.	Entry Gate & Perimeter Fence	2,000	LF	$10.00	$20,000.00
	Subtotal				**$20,000.00**
30.	Clearing, Grubbing & Reseeding	3	AC	$1,500.00	$4,500.00
	Subtotal				**$4,500.00**
31.	Acclimation Ponds	4	EA	$36,000.00	$144,000.00
	Subtotal				**$144,000.00**
	Total				**$2,615,140.00**
	7%Construction Administration				$183,059.80
	20% Contingency				$523,028.00
	Grand Total				**$3,321,227.80**

J-U-B ENGINEERS, Inc. Suite 722, 422 W. RIVERSIDE AVE., SPOKANE, WA 99201 (509) 458-3727

ENGINEERS OPINION OF PROBABLE CONSTRUCTION COST

DATE: 31-Jan-02

PROJECT:
COEUR D'ALENE TRIBE TROUT PRODUCTION FACILITY

PROJECT DESCRIPTION:
TO: ALTERNATIVE SITE STUDY - THE GAP SITE - LAKE COEUR D'ALENE

OWNER PROJ. NO.: J-U-B PROJ. NO.: 70234

ITEM NO.	DESCRIPTION	SCHEDULE OF VALUES QTY	UNIT	UNIT PRICE	BASE ESTIMATE
1.	Access Roadway	1	LS	$80,000.00	$80,000.00
	Subtotal				**$80,000.00**
2.	Hatchery Building (Cost Breakdown/SF)	3,380	SF	$80.00	$270,400.00
	Slabs, Footings and Erection ($29.00)				
	Stud Walls & Finish ($15.00)				
	Drop Ceilings ($ 8.00)				
	Kitchen & Bathroom Fixture ($10.00)				
	Windows & Screens ($ 5.00)				
	HVAC, Light & Elect ($ 13.00)				
	Stainless Sinks/Faucets	3	EA	$2,000.00	$6,000.00
	Subtotal				**$276,400.00**
3.	Hatchery Building Special Construction				
	Floor Trench & Grating	120	SF	$50.00	$6,000.00
	Case Work, Tile Work & Water Proofing	1	LS	$5,000.00	$5,000.00
	Concrete Landing, Ramps, Bollards	1	LS	$5,000.00	$5,000.00
	Outdoor Concrete Pad	400	SF	$12.50	$5,000.00
	Concrete Pad Roof & Columns	400	SF	$12.50	$5,000.00
	Loft Storage	250	SF	$16.00	$4,000.00
	Subtotal				**$30,000.00**
4.	Hatchery Life Support				
	Tanks, Troughs & Incubators	1	LS	$27,000.00	$27,000.00
	Distribution Piping	1	LS	$22,000.00	$22,000.00
	Subtotal				**$49,000.00**
5.	Water Treatment Building (2,100 SF)				
	Metal Building, Slabs & Footings	1	LS	$125,000.00	$125,000.00
	Elevated Service Platforms	100	SF	$120.00	$12,000.00
	Heating & Ventilation	1	LS	$8,000.00	$8,000.00
	Electrical & Lighting	1	LS	$27,000.00	$27,000.00
	Stainless Sink & Faucet	1	EA	$2,000.00	$2,000.00
	Concrete Landing, Ramps, Bollards	1	LS	$5,000.00	$5,000.00
	Subtotal				**$179,000.00**
6.	Water Treatment Equipment				
	Heaters, Heat Exchangers & Pumps	1	LS	$75,000.00	$75,000.00
	Headboxes & Aeration Column	1	LS	$8,500.00	$8,500.00
	Ozone Generator	1	EA	$20,000.00	$20,000.00
	Ozone Effluent Treatment Discharge Pipe	1	EA	$68,000.00	$68,000.00
	Drum Filters	2	EA	$20,000.00	$40,000.00
	Oxygen Regulators & Piping	1	LS	$8,000.00	$8,000.00
	Chillers (300 H.P.)	2	EA	$150,000.00	$300,000.00
	U.V. Disinfection	1	LS	$80,000.00	$80,000.00
	Piping & Valves	1	LS	$30,000.00	$30,000.00
	Alkalinity, PH Formalin Drip	1	LS	$8,000.00	$8,000.00
	Electrical and Controls	1	LS	$80,000.00	$80,000.00
	Subtotal				**$717,500.00**

ENGINEERS OPINION OF PROBABLE CONSTRUCTION COST

DATE: 31-Jan-02

PROJECT:
COEUR D'ALENE TRIBE TROUT PRODUCTION FACILITY

PROJECT DESCRIPTION:
ALTERNATIVE SITE STUDY - THE GAP SITE - LAKE COEUR D'ALENE

OWNER PROJ. NO.:

J-U-B PROJ. NO.: 70234

ITEM		SCHEDULE OF VALUES			
NO.	DESCRIPTION	QTY	UNIT	UNIT PRICE	BASE ESTIMATE
7.	Production Raceways				
	4 Raceways 50' x 5' x 4' Deep	4	EA	$28,000.00	$112,000.00
	Aluminum Screens & Baffles	1	LS	$10,000.00	$10,000.00
	Aeration Columns & Valves	4	EA	$1,500.00	$6,000.00
	Waste Drains	1	LS	$8,000.00	$8,000.00
	Yard Piping	1	LS	$19,000.00	$19,000.00
	Raceway Roof & Columns	1,800	SF	$20.00	$36,000.00
	Grading & Surfacing	1	LS	$15,000.00	$15,000.00
	Subtotal				**$206,000.00**
8.	Broodstock Raceways				
	4 Raceways 15' x 5' x 5' Deep	4	EA	$6,000.00	$24,000.00
	Wood Baffle & Stl. Supports	4	EA	$500.00	$2,000.00
	Airlifts	20	EA	$50.00	$1,000.00
	Waste Drains	1	LS	$8,000.00	$8,000.00
	Yard Piping	1	LS	$20,000.00	$20,000.00
	Roof & Columns 22 x 40	880	SF	$20.00	$17,600.00
	Grading & Surfacing	1	LS	$4,500.00	$4,500.00
	Subtotal				**$77,100.00**
9.	Workshop/Feed Storage (1,200 SF)				
	Metal Buildings, Slabs & Footings	1	LS	$52,500.00	$52,500.00
	Heating & Ventilation	1	LS	$4,000.00	$4,000.00
	Electrical & Lighting	1	LS	$5,000.00	$5,000.00
	Concrete Deck & Steps	1	LS	$3,000.00	$3,000.00
	Subtotal				**$64,500.00**
10.	Lake Water Pumping Station				
	Earthwork	1	LS	$10,000.00	$10,000.00
	Concrete Sump & Yard Piping	1	LS	$175,000.00	$175,000.00
	Intake Pipe & Screen	1	LS	$60,000.00	$60,000.00
	Pump Station Enclosure	1	LS	$12,000.00	$12,000.00
	Pumps, Motors & Piping	1	LS	$45,000.00	$45,000.00
	Transmission Pipeline	1,000	LF	$30.00	$30,000.00
	Electrical & Controls	1	LS	$35,000.00	$35,000.00
	Subtotal				**$367,000.00**

ENGINEERS OPINION OF PROBABLE CONSTRUCTION COST

PROJECT:
COEUR D'ALENE TRIBE TROUT PRODUCTION FACILITY

PROJECT DESCRIPTION:
ALTERNATIVE SITE STUDY - THE GAP SITE - LAKE COEUR D'ALENE

OWNER PROJ. NO.: | J-U-B PROJ. NO.: 70234

ITEM NO.	DESCRIPTION	SCHEDULE OF VALUES QTY	UNIT	UNIT PRICE	BASE ESTIMATE
11.	Effluent Pond				
	Earthwork	1	LS	$30,000.00	$30,000.00
	Pump Sump & Piping	1	LS	$15,000.00	$15,000.00
	Sludge Pump & Motor	1	LS	$10,000.00	$10,000.00
	Electrical Service	1	LS	$5,000.00	$5,000.00
	Subtotal				**$60,000.00**
12.	Release Channel				
	Clearing & Grubbing	1	LS	$4,500.00	$4,500.00
	Earthwork - Cut & Fill	1	LS	$50,000.00	$50,000.00
	Plantings	1	LS	$6,000.00	$6,000.00
	Control Structures	1	LS	$8,500.00	$8,500.00
	Piping	1	LS	$7,000.00	$7,000.00
	Subtotal				**$76,000.00**
13.	Emergency Generator (450 kw)	1	LS	$120,000.00	$120,000.00
	Subtotal				**$120,000.00**
14.	Monitor & Alarm System	1	LS	$12,000.00	$12,000.00
	Subtotal				**$12,000.00**
15.	Electrical Power Transmission & Distribution	1	LS	$85,000.00	$85,000.00
	Subtotal				**$85,000.00**
16.	Pad Mounted Transformers	1	LS	$6,000.00	$6,000.00
	Subtotal				**$6,000.00**
17.	Ground Water Supply Well (Potable)	1	LS	$25,000.00	$25,000.00
	Subtotal				**$25,000.00**
18.	Potable Water System	1	LS	$7,000.00	$7,000.00
	Subtotal				**$7,000.00**
19.	Septic Tank System	1	LS	$20,000.00	$20,000.00
	Subtotal				**$20,000.00**
20.	Manager's Residence				
	3 Bedroom Premanufactured Home	1	LS	$50,000.00	$50,000.00
	Foundation, Driveway, Utilities	1	LS	$20,000.00	$20,000.00
	Subtotal				**$70,000.00**
21.	Parking Area & Interior Access Roads	1	LS	$25,000.00	$25,000.00
	Subtotal				**$25,000.00**

ENGINEERS OPINION OF PROBABLE CONSTRUCTION COST

DATE: 31-Jan-02

PROJECT:

COEUR D'ALENE TRIBE TROUT PRODUCTION FACILITY

ALTERNATIVE SITE STUDY - THE GAP SITE - LAKE COEUR D'ALENE

OWNER PROJ. NO.: J-U-B PROJ. NO.: 70234

ITEM NO.	DESCRIPTION	SCHEDULE OF VALUES			
		QTY	UNIT	UNIT PRICE	BASE ESTIMATE
22.	Landscaping & Handicap Access	1	LS	$8,000.00	$8,000.00
	Subtotal				**$8,000.00**
23.	Entry Gate & Perimeter Fence	3,500	LF	$10.00	$35,000.00
	Subtotal				**$35,000.00**
24.	Clearing, Grubbing & Reseeding	6	AC	$1,500.00	$9,000.00
	Subtotal				**$9,000.00**
25.	Acclimation Ponds	4	EA	$36,000.00	$144,000.00
	Subtotal				**$144,000.00**
	Total				**$2,748,500.00**
	7%Construction Administration				$192,395.00
	20% Contingency				$549,700.00
	Grand Total				**$3,490,595.00**

J-U-B ENGINEERS, Inc. Suite 722, 422 W. RIVERSIDE AVE., SPOKANE, WA 99201 (509) 458-3727

ENGINEERS OPINION OF PROBABLE CONSTRUCTION COST

DATE: 31-Jan-02

PROJECT:
COEUR D'ALENE TRIBE TROUT PRODUCTION FACILITY

PROJECT DESCRIPTION:
TO: ALTERNATIVE SITE STUDY - BROWNS BAY SITE - LAKE COEUR D'ALENE

OWNER PROJ. NO.: J-U-B PROJ. NO.: 70234

ITEM NO.	DESCRIPTION	SCHEDULE OF VALUES			
		QTY	UNIT	UNIT PRICE	BASE ESTIMATE
1.	Access Roadway	1	LS	$60,000.00	$60,000.00
	Subtotal				**$60,000.00**
2.	Hatchery Building (Cost Breakdown/SF)	3,380	SF	$80.00	$270,400.00
	Slabs, Footings and Erection ($29.00)				
	Stud Walls & Finish ($15.00)				
	Drop Ceilings ($ 8.00)				
	Kitchen & Bathroom Fixture ($10.00)				
	Windows & Screens ($ 5.00)				
	HVAC, Light & Elect ($ 13.00)				
	Stainless Sinks/Faucets	3	EA	$2,000.00	$6,000.00
	Subtotal				**$276,400.00**
3.	Hatchery Building Special Construction				
	Floor Trench & Grating	120	SF	$50.00	$6,000.00
	Case Work, Tile Work & Water Proofing	1	LS	$5,000.00	$5,000.00
	Concrete Landing, Ramps, Bollards	1	LS	$5,000.00	$5,000.00
	Outdoor Concrete Pad	400	SF	$12.50	$5,000.00
	Concrete Pad Roof & Columns	400	SF	$12.50	$5,000.00
	Loft Storage	250	SF	$16.00	$4,000.00
	Subtotal				**$30,000.00**
4.	Hatchery Life Support				
	Tanks, Troughs & Incubators	1	LS	$27,000.00	$27,000.00
	Distribution Piping	1	LS	$22,000.00	$22,000.00
	Subtotal				**$49,000.00**
5.	Water Treatment Building (2,100 SF)				
	Metal Building, Slabs & Footings	1	LS	$125,000.00	$125,000.00
	Elevated Service Platforms	100	SF	$120.00	$12,000.00
	Heating & Ventilation	1	LS	$8,000.00	$8,000.00
	Electrical & Lighting	1	LS	$27,000.00	$27,000.00
	Stainless Sink & Faucet	1	EA	$2,000.00	$2,000.00
	Concrete Landing, Ramps, Bollards	1	LS	$5,000.00	$5,000.00
	Subtotal				**$179,000.00**
6.	Water Treatment Equipment				
	Heat Pumps & Heat Exchangers	1	LS	$45,000.00	$45,000.00
	Headboxes & Aeration Column	1	LS	$8,500.00	$8,500.00
	Ozone Generator	1	EA	$20,000.00	$20,000.00
	Ozone Effluent Treatment Discharge Pipe	1	EA	$38,000.00	$38,000.00
	Drum Filters	2	EA	$20,000.00	$40,000.00
	Oxygen Regulators & Piping	1	LS	$8,000.00	$8,000.00
	Incubation Aeration Tower & Storage Tank	1	LS	$8,000.00	$8,000.00
	U.V. Disinfection	1	LS	$80,000.00	$80,000.00
	Piping & Valves	1	LS	$30,000.00	$30,000.00
	Alkalinity, PH Formalin Drip	1	LS	$8,000.00	$8,000.00
	Electrical and Controls	1	LS	$70,000.00	$70,000.00
	Subtotal				**$355,500.00**

ENGINEERS OPINION OF PROBABLE CONSTRUCTION COST

DATE: 31-Jan-02

PROJECT:
COEUR D'ALENE TRIBE TROUT PRODUCTION FACILITY

PROJECT DESCRIPTION:
ALTERNATIVE SITE STUDY - BROWNS BAY SITE - LAKE COEUR D'ALENE

OWNER PROJ. NO.: J-U-B PROJ. NO.: 70234

ITEM NO.	DESCRIPTION	SCHEDULE OF VALUES			
		QTY	UNIT	UNIT PRICE	BASE ESTIMATE
7.	Production Raceways				
	4 Raceways 50' x 5' x 4' Deep	4	EA	$28,000.00	$112,000.00
	Aluminum Screens & Baffles	1	LS	$10,000.00	$10,000.00
	Aeration Columns & Valves	4	EA	$1,500.00	$6,000.00
	Waste Drains	1	LS	$8,000.00	$8,000.00
	Yard Piping	1	LS	$19,000.00	$19,000.00
	Raceway Roof & Columns	1,800	SF	$20.00	$36,000.00
	Grading & Surfacing	1	LS	$15,000.00	$15,000.00
	Subtotal				**$206,000.00**
8.	Broodstock Raceways				
	4 Raceways 15' x 5' x 5' Deep	4	EA	$6,000.00	$24,000.00
	Wood Baffle & Stl. Supports	4	EA	$500.00	$2,000.00
	Airlifts	20	EA	$50.00	$1,000.00
	Waste Drains	1	LS	$8,000.00	$8,000.00
	Yard Piping	1	LS	$20,000.00	$20,000.00
	Roof & Columns 22 x 40	880	SF	$20.00	$17,600.00
	Grading & Surfacing	1	LS	$4,500.00	$4,500.00
	Subtotal				**$77,100.00**
9.	Workshop/Feed Storage (1,200 SF)				
	Metal Buildings, Slabs & Footings	1	LS	$52,500.00	$52,500.00
	Heating & Ventilation	1	LS	$4,000.00	$4,000.00
	Electrical & Lighting	1	LS	$5,000.00	$5,000.00
	Concrete Deck & Steps	1	LS	$3,000.00	$3,000.00
	Subtotal				**$64,500.00**
10.	Lake Water Pumping Station				
	Earthwork	1	LS	$10,000.00	$10,000.00
	Concrete Sump & Yard Piping	1	LS	$145,000.00	$145,000.00
	Dual Intake Pipe & Screen	1	LS	$110,000.00	$110,000.00
	Pump Station Enclosure	1	LS	$12,000.00	$12,000.00
	Pumps, Motors & Piping	1	LS	$15,000.00	$15,000.00
	Transmission Pipeline	300	LF	$30.00	$9,000.00
	Electrical & Controls	1	LS	$30,000.00	$30,000.00
	Subtotal				**$331,000.00**

ENGINEERS OPINION OF PROBABLE CONSTRUCTION COST

PROJECT:
COEUR D'ALENE TRIBE TROUT PRODUCTION FACILITY

PROJECT DESCRIPTION:
ALTERNATIVE SITE STUDY - BROWNS BAY SITE - LAKE COEUR D'ALENE

OWNER PROJ. NO.: | J-U-B PROJ. NO.: 70234

ITEM NO.	DESCRIPTION	SCHEDULE OF VALUES QTY	UNIT	UNIT PRICE	BASE ESTIMATE
11.	Effluent Pond				
	Earthwork	1	LS	$30,000.00	$30,000.00
	Pump Sump & Piping	1	LS	$15,000.00	$15,000.00
	Sludge Pump & Motor	1	LS	$10,000.00	$10,000.00
	Electrical Service	1	LS	$5,000.00	$5,000.00
	Subtotal				**$60,000.00**
12.	Release Channel				
	Clearing & Grubbing	1	LS	$4,500.00	$4,500.00
	Earthwork - Cut & Fill	1	LS	$50,000.00	$50,000.00
	Plantings	1	LS	$6,000.00	$6,000.00
	Control Structures	1	LS	$8,500.00	$8,500.00
	Piping	1	LS	$7,000.00	$7,000.00
	Subtotal				**$76,000.00**
13.	Emergency Generator (100 kw)	1	LS	$45,000.00	$45,000.00
	Subtotal				**$45,000.00**
14.	Monitor & Alarm System	1	LS	$12,000.00	$12,000.00
	Subtotal				**$12,000.00**
15.	Electrical Power Transmission & Distribution	1	LS	$150,000.00	$150,000.00
	Subtotal				**$150,000.00**
16.	Pad Mounted Transformers	1	LS	$6,000.00	$6,000.00
	Subtotal				**$6,000.00**
17.	Ground Water Supply Well (Potable & Incub)	1	LS	$15,000.00	$15,000.00
	Subtotal				**$15,000.00**
18.	Potable Water System	1	LS	$7,000.00	$7,000.00
	Subtotal				**$7,000.00**
19.	Septic Tank System	1	LS	$20,000.00	$20,000.00
	Subtotal				**$20,000.00**
20.	Manager's Residence				
	3 Bedroom Premanufactured Home	1	LS	$50,000.00	$50,000.00
	Foundation, Driveway, Utilities	1	LS	$20,000.00	$20,000.00
	Subtotal				**$70,000.00**
21.	Parking Area & Interior Access Roads	1	LS	$15,000.00	$15,000.00
	Subtotal				**$15,000.00**

ENGINEERS OPINION OF PROBABLE CONSTRUCTION COST

DATE: 31-Jan-02

PROJECT:
COEUR D'ALENE TRIBE TROUT PRODUCTION FACILITY
ALTERNATIVE SITE STUDY - BROWNS BAY SITE - LAKE COEUR D'ALENE

OWNER PROJ. NO.: J-U-B PROJ. NO.: 70234

ITEM NO.	DESCRIPTION	SCHEDULE OF VALUES			
		QTY	UNIT	UNIT PRICE	BASE ESTIMATE
22.	Landscaping & Handicap Access	1	LS	$8,000.00	$8,000.00
	Subtotal				**$8,000.00**
23.	Entry Gate & Perimeter Fence	2,000	LF	$10.00	$20,000.00
	Subtotal				**$20,000.00**
24.	Clearing, Grubbing & Reseeding	6	AC	$1,500.00	$9,000.00
	Subtotal				**$9,000.00**
25.	Acclimation Ponds	4	EA	$36,000.00	$144,000.00
	Subtotal				**$144,000.00**
	Total				**$2,285,500.00**
	7%Construction Administration				$159,985.00
	20% Contingency				$457,100.00
	Grand Total				**$2,902,585.00**

ENGINEERS OPINION OF PROBABLE CONSTRUCTION COST

PROJECT:
COEUR D'ALENE TRIBE TROUT PRODUCTION FACILITY

PROJECT DESCRIPTION:
ALTERNATIVE SITE STUDY - POW WOW GROUND SITE

OWNER PROJ. NO.: | J-U-B PROJ. NO.: 70234

ITEM NO.	DESCRIPTION	SCHEDULE OF VALUES			
		QTY	UNIT	UNIT PRICE	BASE ESTIMATE
18.	Constructed Wetland				
	Clearing & Grubbing	1	LS	$1,500.00	$1,500.00
	Earthwork - Cut & Fill	1	LS	$20,000.00	$20,000.00
	Herbaceous Plants	1	LS	$2,000.00	$2,000.00
	Control Structures	1	LS	$6,500.00	$6,500.00
	Piping	1	LS	$7,000.00	$7,000.00
	Subtotal				**$37,000.00**
19.	Emergency Generator (150 kw)	1	LS	$55,000.00	$55,000.00
	Subtotal				**$55,000.00**
20.	Monitor & Alarm System	1	LS	$12,000.00	$12,000.00
	Subtotal				**$12,000.00**
21.	Electrical Power Distribution	1	LS	$5,000.00	$5,000.00
	Subtotal				**$5,000.00**
22.	Pad Mounted Transformers	1	LS	$4,000.00	$4,000.00
	Subtotal				**$4,000.00**
23.	30,000 Gallon Equalizing/Storage Tank	1	LS	$30,000.00	$30,000.00
	Subtotal				**$30,000.00**
24.	Potable Water System	1	LS	$7,000.00	$7,000.00
	Subtotal				**$7,000.00**
25.	Septic Tank System	1	LS	$20,000.00	$20,000.00
	Subtotal				**$20,000.00**
26.	Manager's Residence				
	3 Bedroom Premanufactured Home	1	LS	$50,000.00	$50,000.00
	Foundation, Driveway, Utilities	1	LS	$20,000.00	$20,000.00
	Subtotal				**$70,000.00**
27.	Parking Area & Interior Access Roads	1	LS	$16,000.00	$16,000.00
	Subtotal				**$16,000.00**
28.	Landscaping & Handicap Access	1	LS	$8,000.00	$8,000.00
	Subtotal				**$8,000.00**

14 APPENDIX C GENETIC ANALYSIS REPORT: COEUR D'ALENE BASIN WESTSLOPE CUTTHROAT TROUT

GENETIC ANALYSIS OF WESTSLOPE CUTTHROAT TROUT IN TRIBUTARIES OF COEUR D'ALENE LAKE

PROGRESS REPORT WTSGL99-101

to

The Coeur d'Alene Tribe

Wild Trout and Salmon Genetics Laboratory

JANUARY 1999

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ABSTRACT

We used non-lethal sampling and the polymerase chain reaction to amplify species-specific nuclear DNA markers differentiating westslope cutthroat trout (*Oncorhynchus clarki lewisi*), rainbow trout (*O. mykiss*) and their hybrids. Samples from 16 sample sites in tributaries to Coeur d'Alene Lake, Idaho were analyzed. Six sites contained samples of westslope cutthroat trout with no evidence of hybridization. The remaining ten sites included at least one hybrid individual. Three of these locations contained a single hybrid individual. When present, hybridization occurs at a low level and most likely represents episodic events of migration into these systems by rainbow trout or hybrid individuals.

INTRODUCTION

Westslope cutthroat trout (Oncorhynchus clarki lewisi) have declined throughout their range (Allendorf and Leary 1988). Many of the remaining populations have been negatively impacted by hybridization with non-native trout. Intentional introduction of other salmonids has been commonplace throughout the species range. These introductions include non-native forms of rainbow trout (O. mykiss) and other subspecies of cutthroat trout that readily hybridize with westslope cutthroat trout. Various anthropogenic actions, such as hydroelectric dam construction, over grazing, and timber harvest, have dramatically altered the habitat of these fish, exacerbating the effects of hybridization.

Identification of non-hybridized populations is an important first step toward preservation and rehabilitation of native westslope cutthroat populations (Campton 1987). These data are necessary to direct management actions such as removal of exotic species or construction of barriers to prevent invasion by introduced species. In addition, if a native westslope brood stock is to be established, genetic confirmation of the purity of the founding stock for that program is imperative.

We have developed a non-lethal method to identify hybrids between cutthroat trout and rainbow trout. This technique, known as PINES, uses polymerase chain reaction (PCR) primers complementary to interspersed nuclear elements to amplify DNA fragments specific to each species (Spruell et al. 1997; Spruell et al. submitted; Smithwick et al. in prep). Using this method, we can determine the species composition of populations without causing the substantial mortality associated with other techniques.

In this report, we present our results for the initial phase of the genetic analysis of westslope cutthroat trout in tributaries of Coeur d'Alene Lake, Idaho. We describe the use of PINEs to detect hybrids in 16 locations and summarize the results of the analysis. These data will be incorporated by the Coeur d'Alene tribe to manage the native fish fauna in Coeur d'Alene Lake and its tributaries.

MATERIALS AND METHODS

Samples were obtained from 16 sites by the Coeur d'Alene tribe. Fin clips were stored in 95% ethanol and transported to the Wild Trout and Salmon Genetics Lab at the University of Montana for analysis.

Primers complementary to various interspersed elements were synthesized, incorporating a fluorescent label to allow visualization (Table 1). Products were amplified under the following conditions. PCRs contained approximately 25 ng of genomic DNA, 1 µl 10X Perkin-Elmer PCR buffer, 4.5 mM MgCl2, 0.2 mM of each dNTP, 5.0 pmoles of primer and 0.5 U Taq. Reactions were completed in a MJ Research PTC-100 thermal cycler using the following profile: 3 min. at 95°C, followed by 30 cycles of 91°C for 1 min., 60°C for 1 min., 72°C for 2.5 min., then 72°C for an additional 2.5 min. Products were stored at 12°C until electrophoretic analysis was completed.

Amplified products were size fractionated on a 4.5% denaturing polyacrylamide gel for 1 hour and 15 minutes at 65 watts. DNA fragments were visualized using a Hitachi FMBIO-100™ fluorescent imager.

Gels were visually inspected for fragments previously determined to be diagnostic for each Oncorhynchus subspecies (Smithwick et al. in prep). The size of each of these fragments was confirmed using the MapMarkerLOW™ size standard (BioVentures Inc.) and FMBIO data analysis software (Version 6.0, Hitachi Software). Samples of each species previously confirmed to be pure (Spruell et al. 1997) were also included on each gel to ensure consistent scoring across all gels. Each population was screened with a minimum of two PINE primer combinations.

RESULTS

The identification of each individual was determined by the number of bands diagnostic for each species or sub-species. Six of the 16 sample locations contained westslope cutthroat trout and no individuals containing markers diagnostic for rainbow trout (Table 2). The remaining ten sample sites contained at least one hybrid individual (Table 2). Three of these locations (Lake Cr. #2, Whitetail Cr., and S. E. F. Benewah Cr.) contained a single hybrid fish.

DISCUSSION

Our analysis indicates fish from six sample sites (Table 2) contain westslope cutthroat trout and no individuals containing markers diagnostic for rainbow trout or any other subspecies of cutthroat trout. In addition, all individuals from these populations contained all markers diagnostic for westslope cutthroat. These markers provide greater than 95% confidence that hybridization exceeding a level of 1% would be detected in this analysis.

We did not detect evidence of extensive hybridization in any of the samples analyzed. This pattern of hybridization is consistent with relatively infrequent episodic hybridization events. The maximum number of hybrid individuals (28%) found was in Cherry Creek. That sample also had the highest level of hybridization. On average, hybrid individuals contained 37.5% of the rainbow trout markers. However, these same individuals also contained 100% of the markers diagnostic for westslope cutthroat. If this population had experienced high levels of hybridization for an extended period of time, we would expect to see the loss of westslope markers. Thus, even in Cherry Creek it appears as though hybridization events occur episodically not continually.

Three locations (Lake Creek #2, Whitetail Cr., and S.E. F. Benewah Cr.) contained a single hybrid individual. We cannot eliminate the possibility that the markers found in these individuals are naturally found at a low level in westslope cutthroat trout. However, these individuals did not all contain the same diagnostic marker. We also did not observe these markers in any individual from the six "pure" populations. Finally, these markers were observed with other rainbow trout markers in other hybrid individuals. These three fish will be investigated in more detail using microsatellites however, it is most probable that they are hybrids.

In the next phase of this study, we will analyze all samples using microsatellite loci. These loci are ideally suited to detect population differentiation at small geographic scales. Although these markers are rarely diagnostic, the distribution of allele sizes found in different species within a limited geographic area are often non-overlapping. It is likely that during the course of the microsatellite analysis, additional hybrid individuals will be identified. However, it is unlikely that a substantial number of such individuals will be found.

The results of this study indicate that restoration of the native westslope cutthroat in Coeur d'Alene Lake and its tributaries is promising. None of the sample sites have high proportions of hybrid individuals. Those hybrids that are present in the system appear to be hybridized at a low level. This pattern of hybridization is consistent with infrequent migration of rainbow trout or hybrids into the system.

REFERENCES

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Table 1. Primer sequences used to generate species-specific PINE fragments.

Primer	Sequence	Reference
Fok I 5'	CCAACTGAGCCACACGGGAC	Kido et al. 1991
Hpa I 5'	AACCACTAGGCTACCCTGCC	Kido et al. 1991
Hpa I 3'	TGAGCTGACAAGGTACAAATC	Kido et al. 1991
Sma I 5'	AACTGAGCTACAGAAGGACC	Kido et al. 1991
Tc 1	TGATTGGTGGAGTGCTGCAG	Greene and Seeb 1997
33.6	TGGAGGAGGGCTGGAGGAGGGCAC	Jeffreys et a. 1985

Table 2. Sample locations, sample size, number of hybrid individuals, and average level of hybridization for westslope cutthroat trout in Coeur d'Alene Lake tributaries.

Tributary	Sample Location	Number	Number of Hybrids	Average *O. myk* bands p in hyb indivi
Fighting Cr.	Fighting Cr.	29	2	30.
Lake Cr.	Lake Cr. #1	45	3	33.
	Lake Cr. #2	13	1	20.
	Bozard Cr.	25	4	25.
	W. F. Lake Cr.	33	0	0.0
Coeur d'Alene R.	Evans Cr.	33	0	0.0
	S. F. Evans Cr.	22	0	0.0
St. Joe R.	Hells Gulch Cr.	27	0	0.0
	Cherry Cr.	29	8	37.
	Alder Cr.	6	0	0.0
Benewah Cr.	Benewah Cr. #1	24	3	33.
	Benewah Cr. #2	10	0	0.0
	Bull Cr.	30	2	30.
	Windfall Cr.	33	3	30.
	Whitetail Cr.	17	1	20.
	S. E. F. Benewah Cr.	22	1	20.

GENETIC ANALYSIS OF WESTSLOPE CUTTHROAT IN TRIBUTARIES OF COUER D'ALENE LAKE

FINAL REPORT WTSGL99-106

to

The Coeur d' Alene Tribe

Wild Trout and Salmon Genetics Laboratory

JUNE 1999

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SUMMARY

We used seven microsatellite loci to determine the genetic relationships among westslope cutthroat trout collected from 16 sample locations in tributaries to Lake Coeur d' Alene, Idaho. These sample locations have statistically significant differences in allele frequencies at one or two loci. However, the overall genetic distances as estimated using two techniques are quite small. These results are consistent with a system in which gene flow occurs but not at a sufficient rate to make these populations genetically homogeneous. The differences in allele frequencies are probably the result of genetic drift in small populations.

INTRODUCTION

Westslope cutthroat trout (*Oncorhynchus clarki lewisi*) are declining throughout their range. Westslope cutthroat trout in tributaries to Coeur d' Alene Lake, Idaho are no exception to this trend. Historically substantial populations exhibiting both resident and migratory and life histories occurred in many of these tributaries. Genetic analyses can be used both to estimate the level of hybridization within a population and to assess the relationships among samples collected at various locations. These genetic data can then be incorporated into a management strategy for the species.

A major threat to the persistence of all native westslope cutthroat populations is hybridization with non-native rainbow trout (*Oncorhynchus mykiss*). The available data indicate that hybrid swarms can form rapidly after the two species begin to interbreed. Once such a hybrid swarm is formed, elimination of the exotic genes is virtually impossible.

We examined 16 populations of westslope cutthroat trout from Coeur d' Alene Lake, Idaho to assess their hybrid status (Spruell et al. 1999). Although some hybrid individuals were identified, most of the populations contained few hybrids. These results are not consistent with persistent hybridization or the presence of a hybrid swarm. Based on these results, recovery of native westslope cutthroat in this system is promising.

An accurate description of the genetic population structure of a species is necessary for effective conservation and management. This requirement is especially true for small populations that may be at risk of extinction. Managing multiple reproductively isolated populations as a single breeding unit may break down adaptive distinctions. Conversely, treating sub-populations from a larger metapopulation as independent biological units may overestimate the impending threat to each population and may therefore lend a false sense of urgency to intensive management actions.

In this report, we present results of a microsatellite survey intended to assess the genetic relationships among westslope cutthroat sampled from 16 tributaries to Coeur 'd Alene Lake , Idaho. These data will be used by the Coeur d' Alene Tribe to manage the native fish fauna in Coeur d' Alene Lake and its tributaries.

MATERIALS AND METHODS

Samples

Samples were obtained from 16 sites by the Coeur d' Alene Tribe. Fin clips were stored in 95% ethanol and transported to the Wild Trout and Salmon Genetics Lab at the University of Montana for analysis. Based on our previous work (Spruell et al. 1999) some of those samples were of hybrid origin. However, in most cases the number of hybrids was low. Those few hybrid individuals should not dramatically alter the allele frequencies determined at microsatellites. Therefore, we analyzed all samples.

Microsatellites

Seven microsatellite loci were amplified in an MJ Research PTC-100 thermocycler using the profiles and conditions of the individuals initially describing each locus (Table 1). Amplified products were size fractionated on 7% denaturing polyacrylamide gels and visualized using a Hitachi FMBIO-100 fluorescent imager. Product sizes were determined using MapMarkerLOW™ size standards (Bio Ventures

Inc.) and Hitachi FMBIO software (version 6.0). Each gel also included previously amplified individuals to ensure consistent scoring across all gels.

Data Analysis

Allele frequencies, heterozygosities, deviations from Hardy-Weinberg expectations, exact probability of population differentiation and F-statistics were calculated using GENEPOP (Raymond & Rousset 1995). We used allele frequencies and the Cavalli-Sforza and Edwards (CSE) chord distance option of PHYLIP (Felsenstein 1992) to construct a matrix of genetic distance for all pair-wise population comparisons. We then used the UPGMA algorithm in PHYLIP to construct a dendrogram of the populations. The dendrogram was visualized using TREEVIEW PCC (Page 1996). We completed a principal components analysis using the covariance matrix of allele frequencies using MINITAB (release version 11) omitting the largest allele at each locus to account for the non-independence of allele frequencies within a locus (for review see Cavalli-Sforza et al. 1993).

RESULTS

All seven microsatellite loci analyzed were polymorphic in Coeur d' Alene Lake westslope cutthroat trout (Table 2 and 3). After correction for multiple tests (Rice 1989), statistically significant deviations from expected Hardy-Weinberg genotypic proportions were observed at a single locus (*OMY301*) in the Bull Creek sample. Relative heterozygosities over these loci ranged from 0.235 in the Bull Creek sample to 0.421 in the Whitetail Creek sample. In most cases, the most common two alleles were shared by all populations.

Pair-wise comparisons of allele frequencies indicate statistically significant ($P<0.005$) differentiation between many pairs of populations for at least one locus (Table 3). This differentiation is reflected in an index of gene diversity (F_{ST}) of 0.038.

Both the UPGMA dendrogram (Fig. 1) and the plot of principle components one and two (Fig. 2) indicate that other than a slight tendency for Lake Creek samples to group together, there is little correlation between geographic location and genetic similarity. In fact, two of the most genetically similar populations based on the CSE chord distance estimator (Benewah 1 and Bozard) are among the most geographically distant pairs.

DISCUSSION

Allelic distributions, estimators of pair-wise divergence, and significance measures indicate little correlation between geographic distance and genetic differentiation. Based on this overall lack of geographical structuring, an island model of migration (see pp. 192-194 in Hartl and Clark 1997for review) does not seem unreasonable for these populations. Assuming an island model and an F_{ST} of 0.038, the estimated rate of gene flow among populations is approximately seven individuals per generation (Allendorf & Phelps 1981). However, this estimate is based on past conditions. The current level of migration may be reduced since the number of migrants (Nm) decreases in proportion to the reduction in population size. That is, for a constant migration rate (m), reducing the population size (N) will cause a corresponding decrease in the number of migrants per generation. Nevertheless, sufficient migration to prevent the loss of rare alleles has probably taken place in the recent past.

The level of genetic differentiation estimated in Coeur d' Alene cutthroat trout by microsatellites appears to be considerably less than estimates from other areas obtained using allozymes. For example, across the range of the species, the estimated F_{ST} is 0.333 (R. F. Leary, pers. comm.). Within the South Fork of the Flathead River, F_{ST} was estimated to be 0.150 (R. F. Leary, pers. comm.). Both of these values were based on allozymes in which genetic distinction should arise more slowly. Thus, the microsatellite-based F_{ST} estimates presented in this report appear to be quite low for westslope cutthroat trout. However, levels of heterozygosity appear to be reasonably high, minimizing the possibility that inbreeding depression is currently a problem.

Samples of westslope cutthroat from Coeur d' Alene Lake tributaries differ significantly in allele frequencies but have low estimated values of genetic distance. This may appear to be a contradiction. However, differentiation may occur even with some level of gene flow. One migrant per generation is sufficient to prevent the loss of rare alleles. More migrants are necessary to produce a genetically homogeneous population. If the migration rate is below this threshold, genetic drift will alter allele frequencies at random loci. This appears to be the case in these samples. In most cases each pair of populations is differentiated by one or two loci. Thus, it appears that within the recent past, these populations were reasonably large and somewhat interconnected. Yet, they are currently declining in number.

Hatchery supplementation has been suggested as one alternative to increase the number of westslope cutthroat trout in tributaries of Coeur d' Alene Lake. Once the goals of a supplementation project have been established, efforts to increase the numbers of naturally spawning populations must be undertaken considering both the genetic and demographic risks. If it is determined that hatchery supplementation is a viable option, the brood stock source, the duration of the supplementation program, and a mechanism to monitor the effects of hatchery fish should be identified. This monitoring program should first and foremost determine if the hatchery program is having a beneficial effect on fish numbers, justifying the genetic and demographic risks.

In the case of Coeur d' Alene Lake westslope cutthroat trout, sample sites appear genetically quite similar. Thus, risk that local adaptations will be eliminated due to outbreeding depression is lessened. However, given the complex life history of migratory fish in this system, some concern must remain. We cannot be certain that migratory forms from one area will thrive in another. Assuming only one brood stock will be created, the best alternative is probably to collect fish from multiple source populations and use this mixture as the brood stock. However, care must be given to insure that the collection of brood stock does not jeopardize the existence of the source populations.

The greatest genetic risks of a properly managed hatchery in this system are domestication of the brood stock and inadvertent introgression with rainbow trout. We have characterized many of the tributaries that might serve as brood stock. Therefore, managers can avoid using individuals from hybridized populations. However, some routine genetic monitoring should be initiated to identify and eliminate any hybrid individuals that may be included in the brood stock. The brood stocks should also be maintained in a manner to maximize the number of breeders in order to avoid inbreeding depression and minimize domestication.

The long-term solution to the decline of westslope cutthroat trout in Coeur d' Alene Lake is to identify and correct the causes of the decline. In many cases, these causes are probably related to habitat degradation. If habitat rehabilitation will take longer than westslope cutthroat trout will persist in these tributaries, more intensive short-term management, such as hatchery supplementation could be considered. However, these actions should be directed toward a goal of recovery of self-sustaining natural populations.

ACKNOWLEDGMENTS

We thank Jonathan Miller and Dan Spencer for technical assistance.

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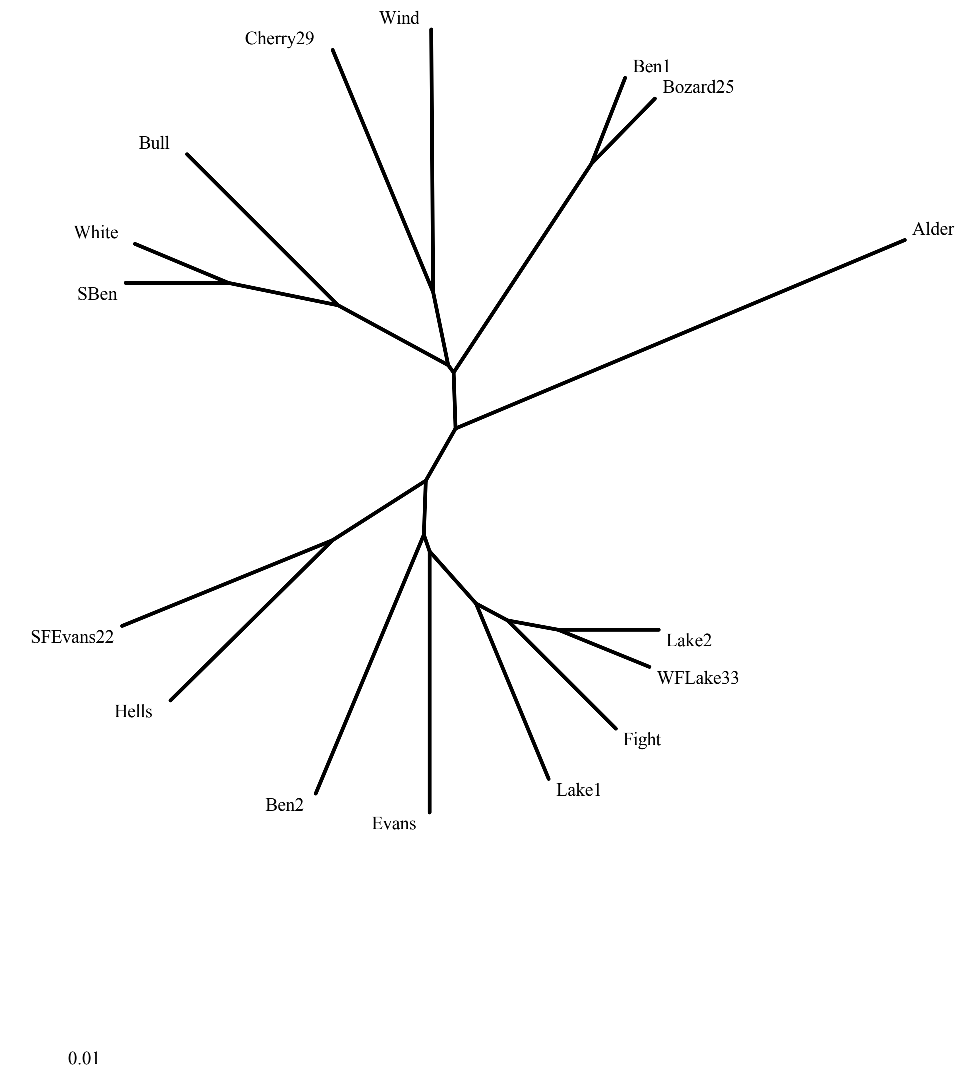

Figure 1: UPGMA dendrogram of sample locations based on Cavalli-Sforza and Edwards chord distance.

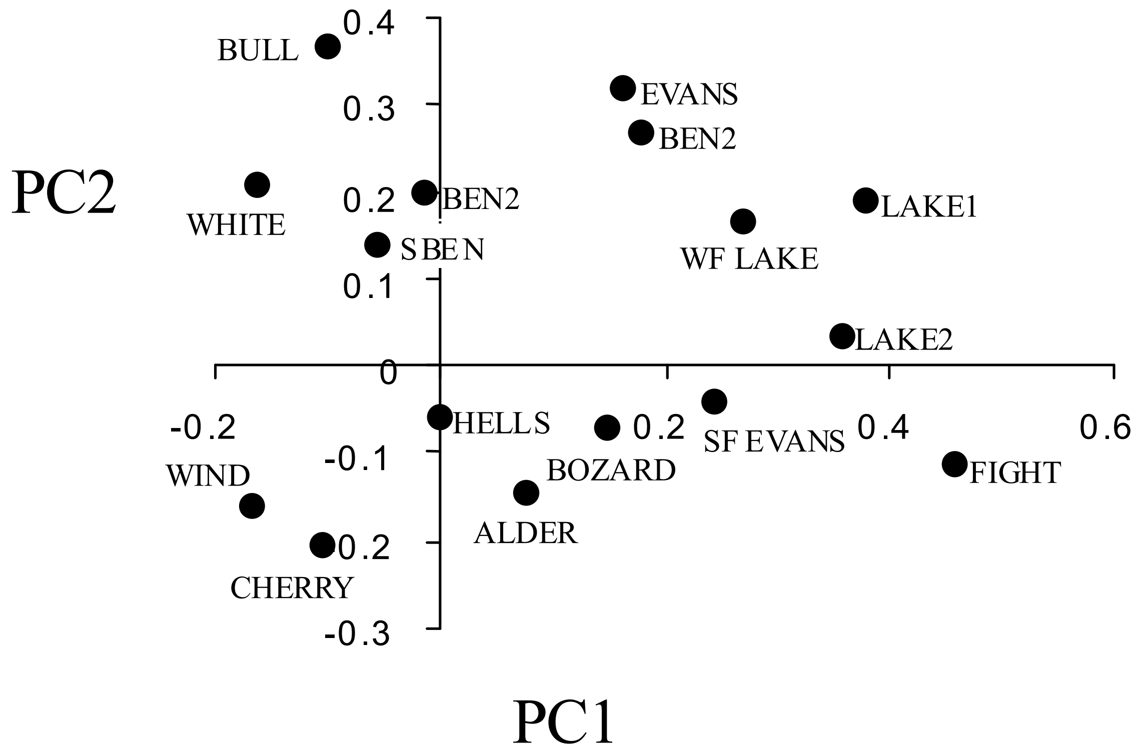

Figure 2. Plot of principal components one and two calculated using seven microsatellite loci. Distance between points is representative of genetic similarity.

Table 1 Microsatellite loci, number of alleles, and size range of alleles found in westslope cutthroat from tributaries to Coeur d'Alene Lake.

Locus	Number of Alleles	size range	Reference
OMY111	5	105-132	Danzmann and Ferguson pc
OMY 301	4	63-73	Danzmann and Ferguson pc
SFO8	3	204-212	Angers et al. 1995
SSA311	5	138-152	Slettan et al. 1995
SSA456	4	152-158	Danzmann and Ferguson pc
uSTR60-1	4	113-119	Estoup et al. 1993
uSTR60-2	3	128-132	Estoup et al. 1993

Table 2: Sample size (N), allele frequencies, and expected average heterozygosities (H_s) at seven microsate loci for sixteen westslope cutthroat sample sites in tributaries to Coeur d'Alene Lake.

		Omy 111					*Omy 301*				*Sfo 8*		
SAMPLE SITE	N	*105	*111	*126	*130	*132	*63	*67	*71	*73	*204	*210	*212
Fighting Creek	29	0.000	0.071	0.000	0.821	0.107	0.000	0.981	0.019	0.000	0.531	0.188	0.281
Lake Creek site 1	45	0.000	0.133	0.033	0.800	0.033	0.000	0.967	0.022	0.011	0.357	0.429	0.214
Bozard Creek	25	0.000	0.120	0.000	0.880	0.000	0.000	0.940	0.040	0.020	0.522	0.370	0.109
West Fork Lake C	33	0.000	0.076	0.015	0.894	0.015	0.000	0.939	0.061	0.000	0.359	0.484	0.156
Lake Creek site 2	13	0.000	0.154	0.000	0.808	0.038	0.000	0.962	0.038	0.000	0.500	0.375	0.125
Benewah Creek s	24	0.000	0.167	0.000	0.813	0.021	0.000	0.833	0.146	0.021	0.357	0.595	0.048
Benewah Creek s	10	0.000	0.100	0.000	0.900	0.000	0.000	1.000	0.000	0.000	0.250	0.600	0.150
Bull Creek	30	0.000	0.033	0.000	0.867	0.100	0.000	0.750	0.250	0.000	0.150	0.650	0.200
Windfall Creek	33	0.000	0.106	0.000	0.894	0.000	0.015	0.879	0.106	0.000	0.364	0.455	0.182
Whitetail Creek	17	0.000	0.059	0.000	0.853	0.088	0.000	0.735	0.235	0.029	0.118	0.559	0.324
SE Fork Benewah	19	0.000	0.079	0.000	0.842	0.079	0.000	0.842	0.132	0.026	0.289	0.553	0.058
Hells Gulch Creek	27	0.019	0.093	0.000	0.815	0.074	0.000	0.963	0.000	0.037	0.296	0.500	0.204
Cherry Creek	29	0.000	0.207	0.000	0.759	0.034	0.000	0.741	0.207	0.052	0.345	0.310	0.345
Alder Creek	6	0.000	0.250	0.000	0.750	0.000	0.000	0.833	0.167	0.000	0.333	0.250	0.417
South Fork Evans	22	0.045	0.136	0.000	0.750	0.068	0.000	1.000	0.000	0.000	0.409	0.409	0.182
Evans Creek	33	0.000	0.121	0.000	0.818	0.061	0.000	0.939	0.015	0.045	0.197	0.606	0.197

Table 2 (continued):

e.

		Ssa 311					*Ssa 456*			
SAMPLE SITE	N	*138	*140	*142	*144	*152	*152	*154	*156	*158
Fighting Creek	29	0.268	0.696	0.036	0.000	0.000	0.000	0.148	0.019	0.833
Lake Creek site 1	45	0.344	0.644	0.000	0.011	0.000	0.000	0.360	0.000	0.640
Bozard Creek	25	0.125	0.792	0.021	0.063	0.000	0.000	0.180	0.040	0.780
West Fork Lake (	33	0.250	0.717	0.033	0.000	0.000	0.000	0.203	0.000	0.797
Lake Creek site 2	13	0.308	0.654	0.038	0.000	0.000	0.000	0.155	0.038	0.846
Benewah Creek s	24	0.104	0.813	0.042	0.042	0.000	0.000	0.167	0.042	0.792
Benewah Creek s	10	0.400	0.600	0.000	0.000	0.000	0.000	0.100	0.000	0.900
Bull Creek	30	0.138	0.810	0.000	0.034	0.017	0.000	0.083	0.000	0.917
Windfall Creek	33	0.015	0.985	0.000	0.000	0.000	0.000	0.076	0.000	0.924
Whitetail Creek	17	0.235	0.765	0.000	0.000	0.000	0.000	0.176	0.029	0.794
SE Fork Benewal	19	0.184	0.816	0.000	0.000	0.000	0.000	0.132	0.026	0.842
Hells Gulch Cree	27	0.074	0.889	0.000	0.037	0.000	0.019	0.241	0.000	0.741
Cherry Creek	29	0.069	0.931	0.000	0.000	0.000	0.034	0.155	0.000	0.810
Alder Creek	6	0.167	0.833	0.000	0.000	0.000	0.000	0.000	0.000	1.000
South Fork Evans	22	0.068	0.932	0.000	0.000	0.000	0.000	0.409	0.000	0.591
Evans Creek	33	0.197	0.758	0.000	0.045	0.000	0.000	0.091	0.000	0.909

Table 2 (continued):

		Str 60-1				*Str 60-2*			
SAMPLE SITE	N	*113	*115	*117	*119	*128	*130	*132	H_s
Fighting Creek	29	0.321	0.357	0.286	0.036	0.976	0.000	0.024	0.353
Lake Creek site 1	45	0.489	0.278	0.233	0.000	0.989	0.000	0.011	0.379
Bozard Creek	25	0.543	0.087	0.370	0.000	0.917	0.000	0.083	0.340
West Fork Lake Cr	33	0.391	0.328	0.266	0.016	1.000	0.000	0.000	0.339
Lake Creek site 2	13	0.409	0.273	0.318	0.000	1.000	0.000	0.000	0.352
Benewah Creek site1	24	0.549	0.079	0.342	0.000	0.947	0.000	0.053	0.354
Benewah Creek site2	10	0.400	0.150	0.450	0.000	0.950	0.000	0.050	0.316
Bull Creek	30	0.500	0.217	0.167	0.117	0.983	0.000	0.017	0.390
Windfall Creek	33	0.379	0.045	0.561	0.015	0.909	0.000	0.091	0.277
Whitetail Creek	17	0.412	0.088	0.471	0.029	0.971	0.000	0.029	0.381
SE Fork Benewah	19	0.579	0.105	0.289	0.003	0.947	0.000	0.053	0.349
Hells Gulch Creek	27	0.278	0.111	0.500	0.111	0.981	0.000	0.019	0.324
Cherry Creek	29	0.328	0.103	0.483	0.086	0.931	0.034	0.034	0.388
Alder Creek	6	0.333	0.250	0.417	0.000	0.917	0.000	0.083	0.372
South Fork Evans Cr	22	0.432	0.295	0.250	0.023	1.000	0.000	0.000	0.338
Evans Creek	33	0.455	0.318	0.167	0.061	1.000	0.000	0.000	0.318

Table 3: Number of loci at which allele frequencies are significantly different ($P<0.05$) for samples of westslope cutthroat trout in tributaries to Coeur d'Alene Lake. P values were corrected using the sequencial Bonferroni test (Rice 1989).

SAMPLE SITE	Fight	Lake1	Boz	WFL	Lake2	Ben1	Ben2	Bull	Wind	White	S Ben	Hells	Cherry	Alder	S Evan	Evans
Fighting Creek	—															
Lake Creek site 1	1	—														
Bozard Creek	0	1	—													
West Fork Lake Cree	0	0	1	—												
Lake Creek site 2	0	1	0	0	—											
Benewah Creek site1	1	2	0	0	0	—										
Benewah Creek site2	0	0	0	0	0	0	—									
Bull Creek	2	3	2	0	0	2	0	—								
Windfall Creek	3	3	1	2	2	0	1	3	—							
Whitetail Creek	2	1	1	1	1	1	0	1	1	—						
SE Fork Benewah	1	1	0	0	0	0	0	0	1	0	—					
Hells Gulch Creek	1	2	1	2	1	1	1	2	0	1	0	—				
Cherry Creek	2	4	0	3	1	1	2	3	0	0	0	2	—			
Alder Creek	0	1	0	0	0	0	0	0	0	0	0	0	0	—		
South Fork Evans Cre	1	1	0	1	1	0	1	3	2	2	0	0	0	0	—	
Evans Creek	1	1	2	0	0	1	0	2	2	2	0	1	0	0	1	

Angelo Vitale
Coeur d' Alene Tribe
Natural Resources Department
PO Box 408
Plummer, ID 83851

Angelo,

You may want to add the attached figure and this letter to the final report as an addendum. The dendrogram is based on 6 of the 7 microsatellites we used. These additional data do not change any interpretation in our report, but they do illustrate how little genetic differentiation we observed in the Coeur d' Alene samples.

The additional samples are from the North Fork Clearwater in Idaho (Bostonian and Sawtooth), and a tributary that flows into Lake Koocanusa near the Canadian border (LYoung & UYoung). It was surprising to me that the two sample from Young Creek are almost as genetically divergent as the entire sample set from Coeur d' Alene Lake. Those Young creek samples were probably collected within 6 miles of one another. It is always possible that we are looking at a life history difference there, but the level of differentiation is striking nonetheless.

The Sawtooth sample was virtually fixed at every locus (i.e. there is almost no genetic variation within that sample). I talked to Dana Weigel with the Nez Perce tribe this morning & she is not aware of any barriers on Sawtooth Creek nor anything else that would cause the observed lack of genetic variation. There are a few more fish from a single year class than we normally shoot for but there are definitely 2 or 3 year classes represented in the sample.

Kathy and I are hoping to analyze a few more populations from the Northfork Clearwater to see what patterns emerge. We are a bit surprised by the lack of divergence in Coeur d' Alene.

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SAMPLE SITE	Fight	Lake1	Boz	WFL	Lake2	Ben1	Ben2	Bull	Wind	White	S Ben	Hells	Cherry	Alder	S Evan	Evans
Fighting Creek	—															
Lake Creek site 1	1	—														
Bozard Creek	0	1	—													
West Fork Lake Cree	0	0	1	—												
Lake Creek site 2	0	1	0	0	—											
Benewah Creek site1	1	2	0	0	0	—										
Benewah Creek site2	0	0	0	0	0	0	—									
Bull Creek	2	3	2	0	0	2	0	—								
Windfall Creek	3	3	1	2	2	0	1	3	—							
Whitetail Creek	2	1	1	1	1	1	0	1	1	—						
SE Fork Benewah	1	1	0	0	0	0	0	0	1	0	—					
Hells Gulch Creek	1	2	1	2	1	1	1	2	0	1	0	—				
Cherry Creek	2	4	0	3	1	1	2	3	0	0	0	2	—			
Alder Creek	0	1	0	0	0	0	0	0	0	0	0	0	0	—		
South Fork Evans Cr	1	1	0	1	1	0	1	3	2	2	0	0	0	0	—	
Evans Creek	1	1	2	0	0	1	0	2	2	2	0	1	0	0	1	

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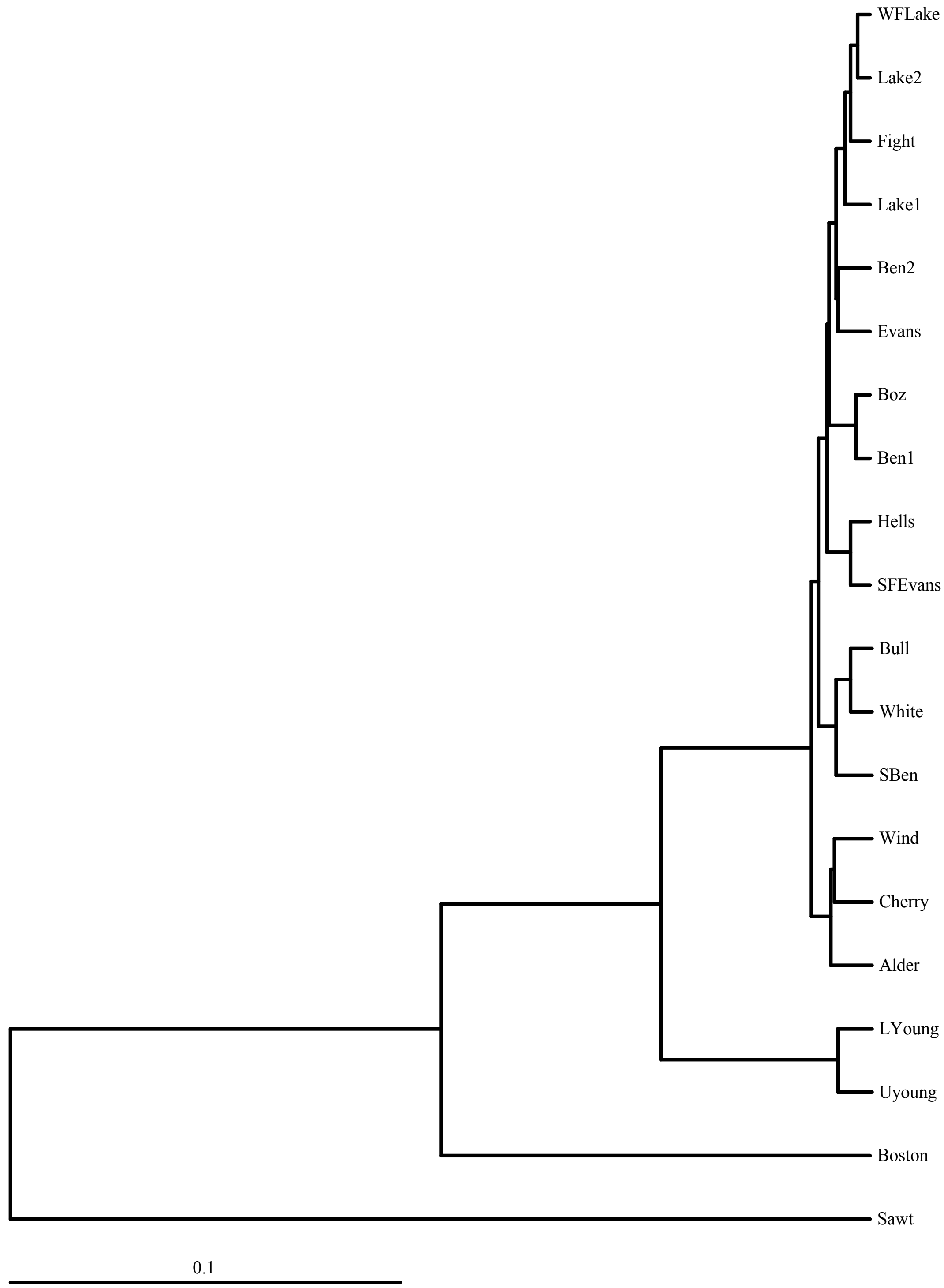
WFLake
Lake2
Fight
Lake1
Ben2
Evans
Boz
Ben1
Hells
SFEvans
Bull
White
SBen
Wind
Cherry
Alder
LYoung
Uyoung
Boston
Sawt
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INTRODUCTION

Historically, native westslope cutthroat trout (*Oncorhynchus clarki lewisi*) and bull trout (*Salvelinus confluentus*) were the dominant salmonids in the Coeur d'Alene system (Scholz et al. 1985; Behnke and Wallace 1986). Bull trout are currently federally listed as a threatened species in the Columbia River Drainage. Anthropogenic causes have had adverse impacts on cutthroat trout populations as they have declined significantly in the past century (Scholz et al. 1985) and are now a species of special concern in Idaho. This decline has been attributed to several factors, including mine pollution from the Coeur d'Alene River system (Ellis 1932), habitat degradation caused by grazing, agriculture, and poor forest management practices (Mallet 1969), overharvest of fish (Rankel 1971), and lake elevation changes that occurred during construction of Post Falls Dam on the Spokane River (Benker 1987).

The Coeur d'Alene Tribe of Indians has proposed that Bonneville Power Administration (BPA) fund a trout production facility on their reservation to mitigate for fish losses due to hydropower development. The overall goal of this hatchery is to increase the production of adfluvial westslope cutthroat trout within the Coeur d'Alene Lake system through supplementation and habitat improvements (Graves et al. 1992; Lillengreen et al. 1994; Peters et al. 1999). Through the BPA process, limiting factors to the success of hatchery reared cutthroat trout have been addressed (Graves et al. 1992; Lillengreen et al. 1993; Lillengreen et al. 1994; Lillengreen et al. 1996; CDA Tribe FWWP 1998; Lillengreen et al. 1998; Knudsen and Spruell 1999; Lillengreen et al. 1999; Peters et al. 1999;Peters and Vitale 1999; Spruell et al. 1999; Vitale et al. 1999; CDA Tribe et al. 2000; Peters et al. 2000).

The Northwest Power Planning Council's Independent Scientific Review Panel (ISRP) has expressed concern that adfluvial westslope cutthroat trout produced by the proposed Coeur d'Alene Tribal Hatchery may be heavily preyed upon by piscivores during outmigration from tributaries into Coeur d'Alene Lake (ISRP 2001). The average age and size of an adfluvial cutthroat trout migrating into the lake is 3 years and 156 mm total length (Lillengreen et al. 1994). An assessment of the annual food habits of piscivorous fishes in the lake was conducted to address this limiting factor concern.

Based upon piscivorous feeding habits and species composition in the south end of the lake (Peters et al. 1999; CDA Tribe unpublished data), northern pikeminnow (*Ptychocheilus oregonensis*), chinook salmon (*O. tshawytscha*), northern pike (*Esox lucius*), largemouth bass (*Micropterus salmoides*), and smallmouth bass (*M. dolomieui*) are presumed to be the principal predators in Coeur d'Alene Lake. The northern pikeminnow is the only species listed above that is native to the Coeur d'Alene Basin. Several studies in the Columbia River Basin have demonstrated the detrimental effects northern pikeminnow predation may have on migrating salmonids (Gray et al. 1984; Poe et al. 1986; Poe and Rieman 1988; Nigro 1989; Petersen et al. 1990a; Petersen et al. 1990b; Willis et al. 1994; Shively et al. 1996; Zimmerman 1999; Petersen 2001).

Although chinook salmon were native to the Spokane River, their migration into Coeur d'Alene Lake was blocked by a migration barrier at Spokane Falls (Scholz et al. 1985). Between 1982 and 2002, 585,597 chinook salmon have been stocked into Coeur d'Alene Lake (Fredericks et al. 2000; IDFG 2002a). Along with extensive stocking, chinook salmon naturally reproduce in the Coeur d'Alene and St. Joe River systems. Optimal numbers of chinook in the system are between 60,000-80,000 (Fredericks et al. 2000), to achieve good kokanee salmon (*O. nerka*) and chinook fishing according to IDFG. Chinook salmon are known to be piscivorous (Scott and

Crossman 1973; Wydoski and Whitney 1979), therefore, it was important that they be studied and considered a potential predator not only to kokanee, but also to cutthroat trout.

Northern pike were first encountered in the Lateral Lakes of the Coeur d'Alene River in 1974 (IDFG 1974; Rich 1992). It is thought that they were illegally introduced from Montana waters by anglers. Since this time, pike populations have increased and spread into Coeur d'Alene Lake. Pike are extremely successful sit and wait predators and spawn in shallow waters in the very early spring, increasing the opportunity for encounters with migrating westslope cutthroat trout.

The United States Fish Commission/Bureau of Fisheries stocked largemouth bass in the late 1800s into the Coeur d'Alene System. Currently, the largemouth bass population in the south end of the lake seems to be quite large. Based on the Coeur d'Alene Tribe's relative abundance data since 1994 (Peters et al. 1999; CDA Tribe unpublished data), largemouth bass accounted for 13.6% of the species composition according to electrofishing surveys. Largemouth bass are also in northern reaches of the lake and the major tributaries to the lake. Largemouth bass move into shallow water with sandy bottoms (like tributary mouths) to spawn (Wydoski and Whitney 1979; Simpson and Wallace 1982) in the spring. The males are very aggressive as they guard the nests and will strike at anything nearby. This hostile behavior has the potential to impact cutthroat trout on their migration from natal tributaries to the lake.

The first confirmed smallmouth bass presence in the lake was in 1990 near the city of Coeur d'Alene (Fredericks et al. 2000). It is thought that they were illegally introduced from nearby Hayden Lake. Smallmouth bass did not occur in the Tribe's relative abundance data until 1997. Since this time, the number captured has steadily increased (CDA Tribe unpublished data).

Smallmouth bass appear to be very successful in this system and their distribution continues to expand.

Another potential cutthroat trout predator in the Coeur d'Alene System is the native bull trout. Populations of bull trout are in decline throughout the Columbia River Basin (Skeesick 1989; NPPC 1991). Once abundant in the Coeur d'Alene System, they are now rarely encountered. For example, since 1994, the Coeur d'Alene Tribe has collected 22,048 fish by electrofishing and gill nets from the south end of the lake and only 2 bull trout were collected (Peters et al. 1999; CDA Tribe unpublished data). Their infrequent occurrence has prompted the United States Fish and Wildlife Service to list bull trout on the Endangered Species list.

Bioenergetics modeling is becoming a standard practice to investigate the impacts of predators on their prey (Boisclair and Leggett 1989; Hansen et al. 1993; Ney 1993; Bowen 1996; Brandt 1996; Madenjian et al. 2000). Bioenergetics models estimate food consumption based upon species specific physiological data such as respiration (basal and active metabolism), specific dynamic action, energy lost to excretion of wastes, and energy converted into somatic or gonadal growth; all of which are functions of temperature (Warren and Davis 1967; Kitchell et al. 1974; Brett and Groves 1979; Stewart et al. 1983; Adams and Breck 1990). Bioenergetics models can be used to determine the impact of predatory fish on specific prey (Kitchell et al. 1974; Kitchell and Breck 1980; Rice 1981; Stewart et al. 1983; Rice and Cochran 1984; Boisclair and Leggett 1989; Petersen and Ward 1999; Hansen et al. 1993; Ney 1993; Petersen and Gadomski 1994; Whitledge and Hayward 1997; Zimmerman and Ward 1999).

Bioenergetics models developed for one species in a particular region of the country often work reasonably well in other regions as well (Rice and Cochran 1984; Boisclair and

Leggett 1989; Hansen et al. 1993; Whitledge and Hayward 1997). Bioenergetics models for predators found in Coeur d'Alene Lake include: 1) northern pikeminnow (Gray et al. 1984; Poe et al. 1986; Vigg and Burley 1989; Petersen and Gadomski 1994; Willis et al. 1994; Petersen and Ward 1999; Zimmerman and Ward 1999), 2) largemouth bass (Rice 1981; Rice and Cochran 1984; Whitledge and Hayward 1997), and 3) northern pike (Niimi and Beamish 1974; Diana 1983; Armstrong 1986; Lucas and Armstrong 1991; Lucas et al. 1993). Models for chinook salmon or smallmouth bass have not been found.

To be useful for determining the impact of a predator on its prey, in addition to requiring specific physiological data, bioenergetics models require information about the population sizes of the predator and prey being modeled (Stewart et al. 1983; Hansen et al. 1993; Ney 1993). This information is not currently available for Coeur d'Alene Lake.

Because models are not developed for all species being considered and population information for both predators and prey were unavailable for Coeur d'Alene Lake, bioenergetics modeling was a practical impossibility with limited funding. (An estimate to collect all of the data required for a bioenergetics model for each predatory species in a system the size of Coeur d'Alene Lake would be approximately $500,000 to $1,000,000). Consequently, the focus of this study was to collect seasonal food habits data as recommended by the American Fisheries Society (Bowen 1996).

The ultimate goal of this project was to determine if westslope cutthroat trout are an important component in the diet of the five principle predators (chinook salmon, largemouth bass, smallmouth bass, northern pikeminnow, and northern pike) in Coeur d'Alene Lake. This project also provides baseline data about the current diets of piscivorous fish that can be used for comparison if stocking of hatchery reared cutthroat trout commences.

METHODS

Study Area

Coeur d'Alene Lake (Figure 1) is located in the panhandle region of north Idaho. The lake lies in a naturally dammed river valley and receives inflow from an area of 9,690 square kilometers. About 90 percent of the surface-water inflow to the lake is from the Coeur d'Alene and St. Joe Rivers. The lake is drained to the north by the Spokane River, a tributary to the Columbia River. The surface elevation of the lake is controlled by Post Falls Dam, which provides hydroelectric power, flood control and irrigation supply. Lake surface elevation at full pool is 648.7 meters above National Geodetic Vertical Datum (NGVD) of 1929. The surface area at full pool is 129 km^2, the maximum depth is 63.7 m just west of Driftwood Bay, and the mean depth is 21.7 m (Woods and Berenbrock 1994).

Coeur d'Alene Lake is unique in that its waters are managed by two separate agencies. Idaho Department of Fish and Game (IDFG) has management jurisdiction north of the Tribal boundary near Harrison (Figure 1). The Coeur d'Alene Tribe of Indians, hereafter referred to as "the Tribe", has absolute management authority of the southern 1/3 of the lake since the Supreme Court ruling in June 2001 (U. S. Supreme Court 2001).

The study area also included Hidden Lake, Round Lake, Benewah Lake, and Chatcolet Lake just south of Coeur d'Alene Lake. Historically they were separate lakes, but impoundment in 1906 has connected them to the Coeur d'Alene Lake and their boundaries are now indistinguishable.

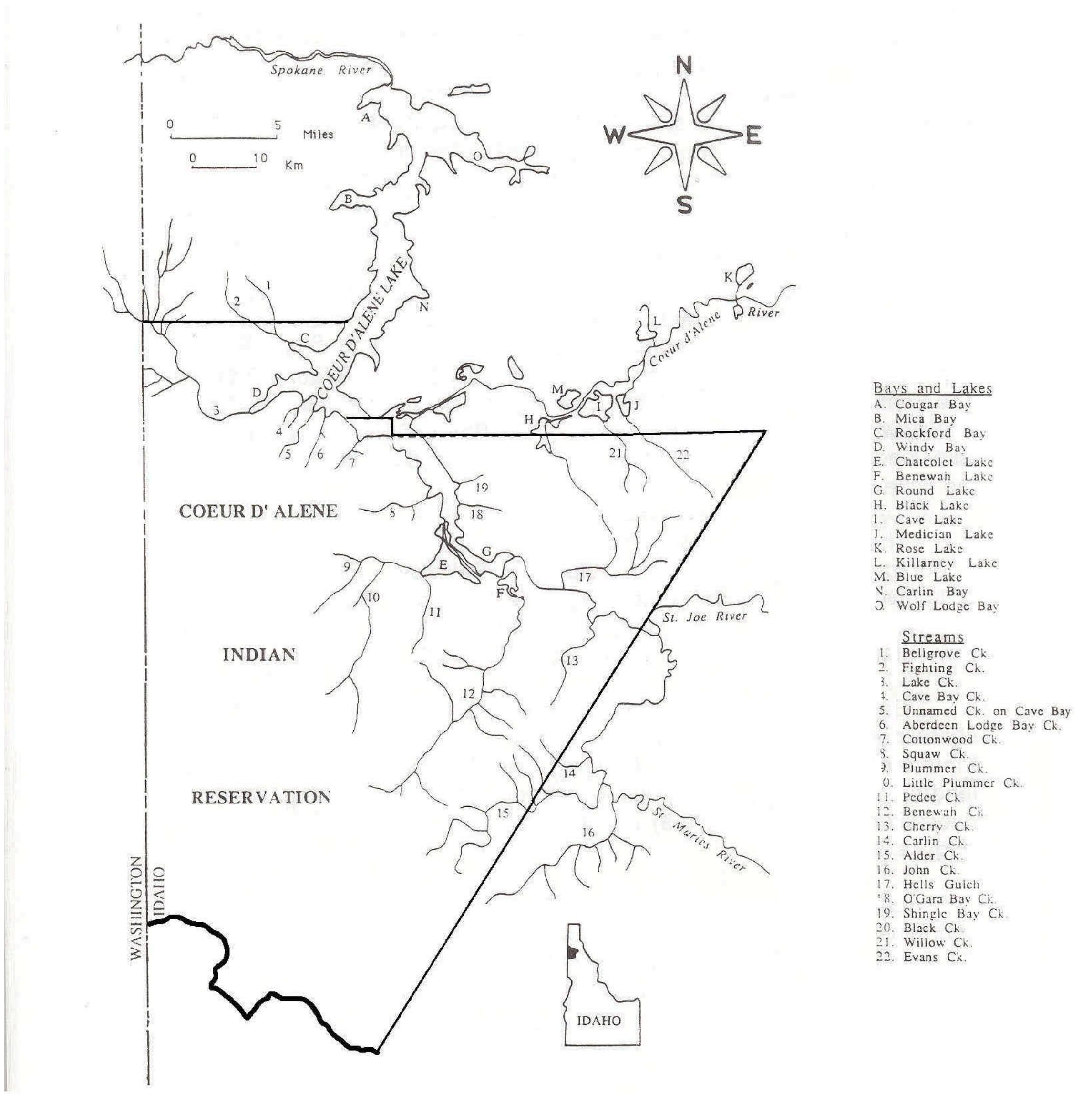

Fig. 1 Coeur d'Alene Lake Basin, modified from Graves et al. (1992).

The lateral lakes of the Coeur d'Alene River upstream to Medicine Lake were also sampled. These include in order from the mouth of the river upstream, Anderson Lake, Thompson Lake, Blue Lake, Black Lake, Swan Lake, Cave Lake, and Medicine Lake.

All of the waters sampled were interconnected, so fish had the opportunity to migrate into any of the above water bodies.

Fish Distribution

A random sampling design was used for quarterly (seasonal) electrofishing and gillnetting surveys from 1 July 2001 to 30 June 2002. The sampling area was divided into 1 km^2 grids (see map, P-1 in pocket), designated into pelagic, shoreline near tributary (tributary), and shoreline not near tributary zones (shoreline) (Table 1). The data was collected seasonally, and summarized in the annual mean and zonal means based on grid designation. Seasonal data are in Appendices A and B. A random number generator selected grids to be sampled each quarter. Boat electrofishing was accomplished with a Smith Root unit generating a DC current at 3-4 amps. Each electrofishing site was sampled for 10 minutes within the selected grid. Gillnets were only set in Tribal waters, south of the boundary near Harrison. The sampling permit for the IDFG waters restricted mesh size to ½ inch at the largest and no longer than one hour net sets. We lacked the appropriate gear and checking nets every hour was not feasible due to the size of area sampled. Horizontal gillnets (12 x 150 ft, 10 x 200 ft, and 8 x 200 ft, each with varied mesh from 1-4 inches) were set in selected grids at various depths. When set near shore, some were placed parallel and others perpendicular in random fashion. Four vertical gillnets (6 x 120 ft with 2.5, 3, 4, and 5 inch stretch research mesh) were set from surface to bottom in clusters in the selected grid. Nets were set for 12 hour periods and checked every 4-6 hours so digestion and regurgitation could be minimized. Electrofishing and gillnetting occurred at least five days each season, with the exception of winter when weather and ice conditions prohibited sampling (Table 2). For all fish captured, total length and weight was recorded.

In August 2001, chinook salmon stomachs were collected from anglers participating in "The Big One" annual chinook fishing derby on Coeur d'Alene Lake.

Feeding Habits

Stomach contents were collected from northern pike, chinook salmon, and largemouth bass over 200 mm. Smallmouth bass and northern pikeminnow stomachs were collected from some fish under 200 mm. Stomach contents were collected via gastric lavage (Goster 1977; Hyslop 1980; Light et al. 1983; Bowen 1996) for live fish. A tube connected to a pump filled with distilled water was inserted into the stomach via the esophagus. Contents were aspirated and collected on a fine mesh screen. Five percent of all fish lavaged were killed and whole stomachs collected to evaluate lavage efficacy. Whole stomachs were removed by cutting anterior to the esophagus and posterior to the pyloric sphincter. Stomach samples were preserved in 10% formalin (Bowen 1996). Efficacy was calculated by dividing the dry weight of the contents removed by lavage by the dry weight of the whole stomach contents (Light et al. 1983).

Table 13. Zone designation for each grid on Coeur d'Alene Lake (see map P-1). Shoreline near tributaries (n=81 grids), shorelines not near a tributary (n=84 grids), and Pelagic grids (n=54). A * denotes a grid that was actually sampled between July 2001 and June 2002. Some grids were sampled more than once.

TRIBUTARY		SHORELINE		PELAGIC	
2*	150*	1*	98	9	130
3*	151*	4	99*	13	143
11*	152*	6*	102*	14	144
24*	153*	7*	103*	15	164*
31*	155*	8*	106*	16	165*
32*	158*	10*	110*	20	166*
33*	159	12*	113	21	172*
34*	160*	17*	119	22	173*
38*	161*	18*	122*	23	180*
39*	162	19*	123*	26	183*
45*	163*	25	124*	27	205*
46*	169*	28*	125*	29	206*
47	181*	30	126	43	
48*	182*	35	131*	51	
55	185*	36	142*	60	
56*	198	37*	145*	61	
57	199*	40*	146*	65	
74	200*	41	154*	68	
79*	201*	42*	156*	72	
87*	202*	44	157*	73	
92*	203*	49*	167*	76	
93*	204*	50*	168*	77	
107	207*	52*	170	80	
108	208*	53*	171*	81	
109*	209*	54*	174*	84	
114*	210*	58	175*	85	
115	211*	59*	176*	86	
116	212	62*	177*	89	
117	213*	63*	178*	90	
118*	214*	64*	179*	95	
132	215*	66*	184	96	
133	216	67*	186*	100	
134*	217	69*	187*	101	
135*	218*	70*	188*	104	
136	220*	75*	189*	105	
138	222*	82*	191*	112	
139*	223*	83*	192*	120	
140	224*	88*	193*	121	
141		91*	194*	127	
148*		94*	195*	128	
149		97	196*	129	

Table 2. Seasonal sampling dates throughout the study.

SUMMER	DERBY	FALL	WINTER	SPRING
19-Jul-01	5-Aug-01	2-Oct-01	5-Mar-02	15-Apr-02
24-Jul-01	6-Aug-01	3-Oct-01	12-Mar-02	16-Apr-02
25-Jul-01	7-Aug-01	9-Oct-01	13-Mar-02	17-Apr-02
31-Jul-01	8-Aug-01	10-Oct-01		24-Apr-02
1-Aug-01	9-Aug-01	16-Oct-01		6-May-02
	10-Aug-01	17-Oct-01		7-May-02
	11-Aug-01	24-Oct-01		30-May-02
	12-Aug-01	24-Oct-01		31-May-02
				4-Jun-02
				5-Jun-02

In the laboratory, prey items were identified using a Nikon SMZ 10 dissecting microscope. For each individual predator, prey items were separated into separate vials and counted. Prey fish were identified to species using taxonomic keys (Wydoski and Whitney 1979; Simpson and Wallace 1982), previously published bone keys (Harrington 1955; Crossman and Casselman 1969; Eastman 1977; Newsome 1977; Scott 1977; McIntyre and Ward 1986; Hansel et al. 1988; Scharf et al. 1997; Zollweg 1998; Frost 2000), and a bone collection at EWU (Appendix D). Prey fish lengths and weights were estimated based on regressions from Appendix D. Macroinvertebrates were keyed to order using Pennak (1989) and Merrit and Cummins (1996). Zooplankton was keyed to genus using Brooks (1957) and Pennak (1989).

The number of each prey item was counted then wet and dry weights were obtained for each as described by Bowen (1996). Weights were measured to the nearest 0.1 g with a Mettler AJ100 analytical balance and larger items with a Mettler PB1501 analytical balance. Dry weights were obtained by allowing the items to dry completely in 105^{o}F oven for 48-72 hours (Busacker et al. 1990; Bowen 1996) depending on the prey item.

For each prey item collected, frequency of occurrence (FOO) was calculated by dividing the number of stomachs containing a particular prey item by the total number of stomachs analyzed (Bowen 1996). FOO data illustrate the uniformity in which fish select their diet, but does not indicate selection or importance of prey items (Bowen 1996). Percent composition by number of prey items was calculated by dividing the number of individuals of a certain prey item in one stomach by the total number of all prey items in the same stomach (Bowen 1996). Percent composition by weight was calculated for both wet and dry weights by dividing the total weight of a certain prey item in one stomach by the total weight of all prey items in the same stomach (Bowen 1996). Each of these indices has biases, to account for these, a relative importance index was calculated (George and Hadley 1979) as follows:

$$R_{ia} = \frac{100 A_{ia}}{\sum_{a=1}^{n} A_{ia}}$$

where: R_{ia} = relative importance of food item a,

A_{ia} = % frequency of occurrence + % total numbers + % total weight; and

n = number of food types.

Each of the three previous indices are included in this index. Values for the relative importance index range from 0-100%; larger numbers were considered more important prey items. Original total lengths and weights of prey fish were calculated using the bone collection and regressions in Appendix D to determine which size prey the predator selected.

Prey selection by predatory fish was determined with selectivity indices (Ivlev 1961; Strauss 1979; Crowder 1990; Bowen 1996). The relative abundance of each prey item in the environment at the time stomach samples were taken was compared to the relative abundance of that prey item in the stomach contents using the following formulas:

$$L = r_i - p_i$$

where: L = Strauss' (1979) measure of food selection,

r_i = relative abundance of prey i in the gut; and

p_i = relative abundance of same prey i in the environment;

and:

$$E = \frac{r_i - p_i}{r_i + p_i}$$

where: E = Ivlev's (1961) measure of food selection;

r_i = relative abundance of prey i in the gut; and

p_i = relative abundance of same prey i in the environment.

Food selection values ranged from –1 to +1. Values near 0 indicated that the predator was eating prey in proportion to its relative abundance in the environment. Values = +0.7 indicated that the predator was selecting for that prey, while values = -0.7 indicated selection against (Strauss 1979).

In Strauss's index, variance can be calculated for sufficiently large sample sizes such that:

$$n_p \geq \frac{3}{p_i(1-p_i)} \quad \text{and} \quad n_r \geq \frac{3}{r_i(1-r_i)}$$

where: n_p = number of i prey items in the environment,

p_i = relative abundance of same prey i in the environment, and

n_r = number of i prey items in the gut, and

r_i = relative abundance of prey i in the gut.

These sample sizes allow the assumption of approximate normal distributions, and since they are both independent, L will be approximately normal as well. The estimated sampling variance is calculated as follows:

$$s^2(L) = \frac{r_i(1-r_i)}{n_r} + \frac{p_i(1-p_i)}{n_p}$$

with $n_r + n_p$ -2 degrees of freedom for use in *t*-statistics comparisons (Strauss 1979).

RESULTS

Annual Fish Distribution

Table 3 is a list of all the species collected in Coeur d'Alene Lake during this study, their scientific names and the abbreviations that will be used in tables from this point forward in this report.

Fish were sampled using horizontal and vertical gillnets along with boat electrofishing in tribal waters and only by electrofishing in waters north of the tribal boundary (Figure 2). A total of 618.6 hours were spent sampling throughout the study in 26 days on the water.

The annual relative abundance and catch per unit effort (fish per hour) are summarized by species for the entire sample area (Table 4). Far more fish were caught using electrofishing than in the horizontal or vertical gillnets. Largescale suckers and northern pikeminnow were the most frequently captured species in gillnets. One bull trout was caught in a horizontal gill net (Shingle Bay, grid 182 P-1) but was quickly cut free and released in excellent condition.

The total annual effort in the pelagic zones was 287.8 hours, using horizontal and vertical gillnets only. The only grids sampled from the pelagic zones were within Tribal waters. Table 5 gives the annual catch per unit effort for each gear type and the total relative abundance of each species collected in the pelagic zone. Kokanee salmon were the most abundant in pelagic zones, followed by northern pikeminnows, largescale suckers, and brown bullhead. It was not unusual to find northern pikeminnow and kokanee together, as kokanee are a major prey item to northern pikeminnow.

Table 3. Species sampled in this study, including scientific names, common names, and abbreviations that will be used in this report.

SCIENTIFIC NAME	COMMON NAME	ABBREVIATION
Ptychocheilus oregonensis	northern pikeminnow	NPM
Tinca tinca	tench	TCH
Catostomus catostomus	longnose sucker	LNS
C. columbianus	bridgelip sucker	BLS
C. macrocheilus	largescale sucker	LSS
Ameiurus nebulosus	brown bullhead	BBH
Esox lucius	northern pike	PIKE
Oncorhynchus clarki lewisi	westslope cutthroat trout	WCT
O. mykiss	rainbow trout	RBT
O. nerka	kokanee salmon	KOK
O. tshawytscha	chinook salmon	CHIN
Prosopium williamsoni	mountain whitefish	MWF
Salvelinus confluentus	bull trout	BT
Cottus spp.	sculpin	COT
Lepomis gibbosus	pumpkinseed sunfish	PS
Micropterus dolomieui	smallmouth bass	SMB
M. salmoides	largemouth bass	LMB
Pomoxis nigromaculatus	black crappie	BC
Perca flavescens	yellow perch	YP

Table 4. The annual catch per unit effort (CPUE), in hours, for each gear type and the total relative abundance (RA) of each species captured in the entire sample area.

SPECIES	ELECTRO n	ELECTRO CPUE	HORIZONTAL NET n	HORIZONTAL NET CPUE	VERTICAL NET n	VERTICAL NET CPUE	TOTAL n	TOTAL CPUE	TOTAL RA
NPM	198	5.1	91	0.3	1	<0.1	290	0.5	7.5
TCH	64	1.6	4	<0.1			68	<0.1	1.8
LNS	11	0.3	12	<0.1			23	<0.1	0.6
BLS	4	0.1	6	<0.1			10	<0.1	0.3
LSS	621	16.0	74	0.2	3	<0.1	698	1.1	17.9
BBH	505	13.0	47	0.1	5	<0.1	557	0.9	14.3
PIKE	21	0.5	5	<0.1			26	<0.1	0.7
WCT	112	2.9	6	<0.1			118	0.2	3.0
RBT	3	0.1					3	<0.1	0.1
KOK	45	1.2	41	0.1			86	0.1	2.2
CHIN*	78	2.0	4	<0.1			82	0.1	2.1
MWF	8	0.2					8	<0.1	0.2
BT			1	<0.1			1	<0.1	<0.1
COT	18	0.5					18	<0.1	0.5
PS	115	3.0	1	<0.1			116	0.2	3.0
SMB	413	10.6					413	0.7	10.6
LMB	252	6.5					252	0.4	6.5
BC	402	10.4	13	<0.1	1	<0.1	416	0.7	10.7
YP	685	17.7	21	0.1			706	1.1	18.1
GRAND TOTALS	**3555**	**91.7**	**326**	**0.9**	**10**	**<0.1**	**3891**	**6.2**	**100.0**

*Chinook n, RA, and CPUE data does not include 46 fish collected during "The Big One" fishing derby.

Table 5. The annual catch per unit effort (CPUE), in hours, for each gear type and the total relative abundance (RA) of each species captured in pelagic zones.

	HORIZONTAL NET		**VERTICAL NET**		**TOTAL**		
SPECIES	**n**	**CPUE**	**n**	**CPUE**	**n**	**CPUE**	**RA**
NPM	21	0.2			21	0.1	19.6
TCH	1	< 0.1			1	< 0.1	0.9
LNS	8	0.1			8	< 0.1	7.5
LSS	19	0.2	1	< 0.1	20	0.1	18.7
BBH	13	0.2	4	< 0.1	17	0.1	15.9
PIKE	1	< 0.1			1	< 0.1	0.9
WCT	4	< 0.1			4	< 0.1	3.7
KOK	26	0.3			26	0.1	24.3
CHIN	2	< 0.1			2	< 0.1	1.9
BC	1	< 0.1	1	< 0.1	2	< 0.1	1.9
YP	5	0.1			5	< 0.1	4.7
GRAND TOTALS	**101**	**1.2**	**6**	**< 0.1**	**107**	**0.4**	**100.0**

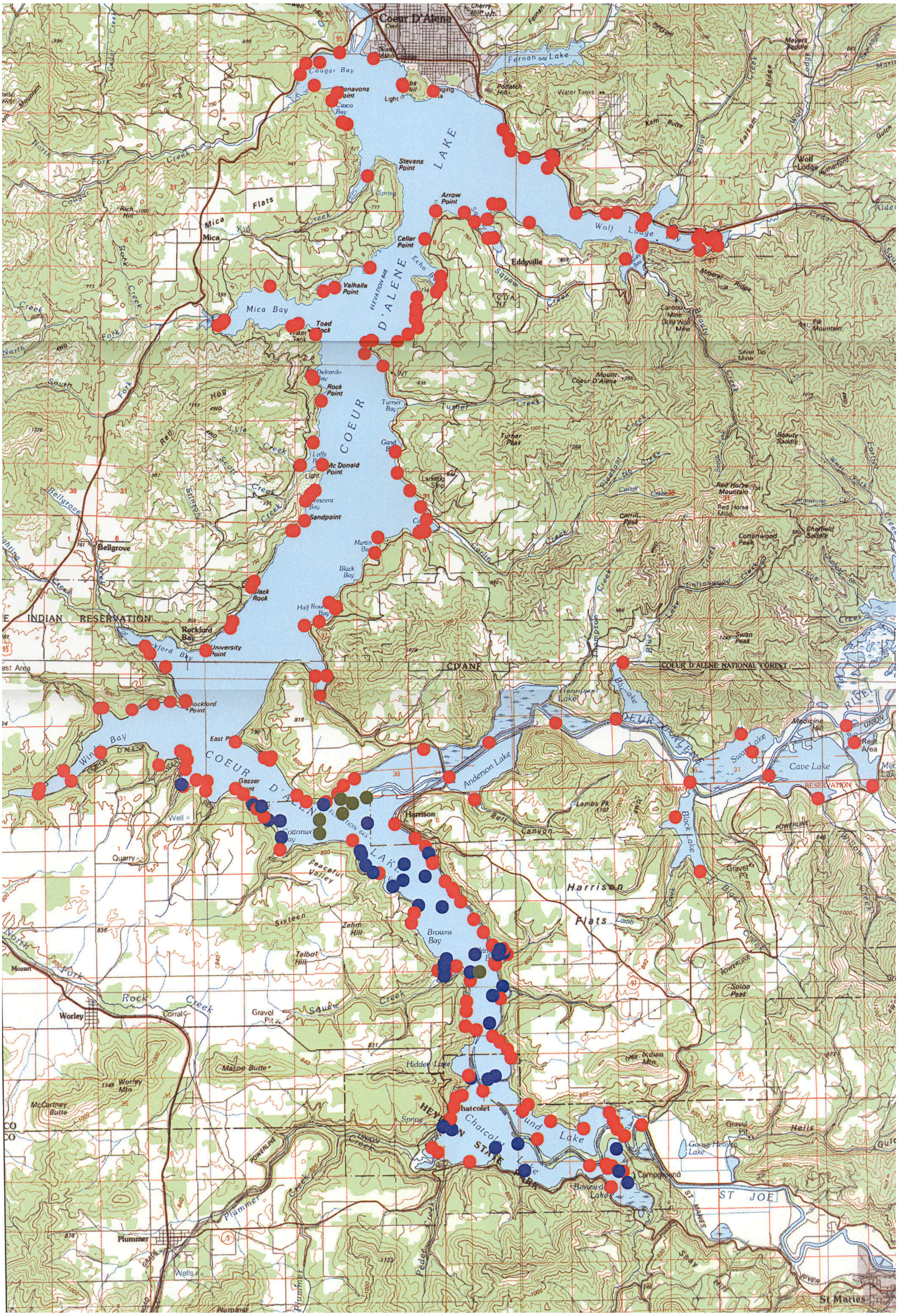

Fig. 2 Annual sites sampled via electrofishing (red), horizontal gillnets (blue), and vertical gillnets (green) on Coeur d'Alene Lake July 2001 to June 2002.

The total annual effort in the shoreline zones for all three gear types was 201.5 hours. Table 6 summarizes the catch for each gear type in the shoreline zones throughout the entire sample period. Largescale suckers were also the most abundant species in shoreline zones followed by smallmouth bass and yellow perch. The majority of the chinook salmon captured in shoreline zones were less than 100 mm in total length, likely smolts from the Coeur d'Alene River. Often, juvenile smallmouth bass were concentrated together. More than half of all pike collected during the course of this study were from shoreline zones, as were more than half of all westslope cutthroat trout. Yellow perch were abundant in most sites that northern pike and bass were present.

Annual tributary sampling consisted of electrofishing and horizontal gillnets. Total effort in tributary zones was 129.3 hours. Table 7 summarizes the annual catch for both gear types in tributary zones. Yellow perch, largescale suckers, and brown bullhead were the most abundant species in tributary zones. Yellow perch and brown bullhead are both important prey items to largemouth bass, which were more abundant in tributary zones than shoreline or pelagic zones. Black crappie were also important prey to largemouth bass and were abundant in tributary zones. Smallmouth bass were also prevalent in tributary zones. Chinook salmon, northern pikeminnow, and northern pike were more abundant in other zones.

Table 6. The annual catch per unit effort (CPUE), in hours, for each gear type and the total relative abundance (RA) of each species captured in shoreline zones.

SPECIES	ELECTRO n	ELECTRO CPUE	HORIZONTAL NET n	HORIZONTAL NET CPUE	VERTICAL NET n	VERTICAL NET CPUE	TOTAL n	TOTAL CPUE	TOTAL RA
NPM	134	6.1	53	0.4	1	< 0.1	188	0.9	9.9
TCH	21	1.0	2	< 0.1			23	0.1	1.2
LNS	1	< 0.1	4	< 0.1			5	< 0.1	0.3
BLS	3	0.1	2	< 0.1			5	< 0.1	0.3
LSS	385	17.7	28	0.2	2	< 0.1	415	2.1	21.9
BBH	178	8.2	30	0.2	1	< 0.1	209	1.0	11.0
PIKE	13	0.6	2	< 0.1			15	0.1	0.8
WCT	74	3.4	2	< 0.1			76	0.4	4.0
RBT	3	0.1					3	< 0.1	0.2
KOK	40	1.8	14	0.1			54	0.3	2.9
CHIN	61	2.8	2	< 0.1			63	0.3	3.3
MWF	3	0.1					3	< 0.1	0.2
COT	13	0.6					13	0.1	0.7
PS	48	2.2	1	< 0.1			49	0.2	2.6
SMB	265	12.2					265	1.3	14.0
LMB	92	4.2					92	0.5	4.9
BC	154	7.1	5	< 0.1			159	0.8	8.4
YP	256	11.7	4	< 0.1			260	1.3	13.7
GRAND TOTALS	**1744**	**80.0**	**149**	**2.0**	**4**	**0.1**	**1897**	**9.4**	**100.0**

Table 7. The annual catch per unit effort (CPUE), in hours, for each gear type and the total relative abundance (RA) of each species captured in tributary zones.

	ELECTRO		HORIZONTAL NET		TOTAL		
SPECIES	**n**	**CPUE**	**n**	**CPUE**	**n**	**CPUE**	**RA**
NPM	64	3.8	17	0.2	81	0.6	4.3
TCH	43	2.5	1	< 0.1	44	0.3	2.3
LNS	10	0.6			10	0.1	0.5
BLS	1	0.1	4	< 0.1	5	< 0.1	0.3
LSS	236	13.9	27	0.2	263	2.0	13.9
BBH	327	19.2	4	< 0.1	331	2.6	17.5
PIKE	8	0.5	2	< 0.1	10	0.1	0.5
WCT	38	2.2			38	0.3	2.0
KOK	5	0.3	1	< 0.1	6	< 0.1	0.3
CHIN	17	1.0			17	0.1	0.9
MWF	5	0.3			5	< 0.1	0.3
BT			1	< 0.1	1	< 0.1	0.1
COT	5	0.3			5	< 0.1	0.3
PS	67	3.9			67	0.5	3.6
SMB	148	8.7			148	1.1	7.8
LMB	160	9.4			160	1.2	8.5
BC	248	14.6	7	0.1	255	2.0	13.5
YP	429	25.2	12	<0.1	441	3.4	23.4
GRAND TOTALS	**1811**	**106.5**	**76**	**0.7**	**1887**	**14.6**	**100.0**

Annual Feeding Habits

Stomach contents were removed from 493 piscivores by gastric lavage and complete removal of the stomach (Table 8). Efficacy tests were performed on 5.8% of all fish subjected to gastric lavage. The efficacy of the lavage technique was 95.2% ± 4.5% (standard deviation) in removing stomach contents.

Invertebrate prey items were identified to order when possible. If they were unidentifiable, they were sorted as "insect parts". Mostly, this category included legs, antennae, and sections of bodies. When a whole or most of an insect head was present, it was counted, and remained separate from the parts. For percent by number calculations, all insect parts from one stomach were counted as one as it was impossible to tell how many insects there were from separate appendages alone. They are included in the tables and calculations however, because their percent by weight gave insight into how important the invertebrate prey were in the diet.

Prey fish were identified to the species level when possible. For many diagnostic bones, the genus level is the lowest taxonomic level obtainable. In such cases, if more than one fish from the genus is present in the system, the prey was only identified to the genus level. For example, bones could often be keyed to the genus *Micropterus*, but not the species level. These are referred to as "bass" in the following tables. If the prey fish was only slightly digested, identification was relatively simple. Chinook salmon and kokanee salmon were not distinguishable from each other if extensive digestion had occurred. When identification was not possible, they were grouped as "salmon". The "Salmonidae" narrows the prey fish down to a chinook salmon, a kokanee salmon, or a westslope cutthroat trout (Appendix D).

Table 8. Number of stomachs taken by species for each technique used. Whole stomachs do not include those that were taken for efficacy after being lavaged.

SPECIES	LAVAGE	WHOLE	GRAND TOTALS
NPM	114	113	227
PIKE	22	4	26
CHIN	2	41	43
SMB	93	9	102
LMB	95	0	95
GRAND TOTALS	**326**	**167**	**493**

Northern pikeminnow

A total of 227 pikeminnow stomachs were analyzed during this study. Thirty-eight stomachs were empty. Stomachs were collected from northern pikeminnow ranging in size from 141 mm to 684 mm. Thirteen fish less than 200 mm were either killed in nets or food items were seen in their mouth and they were sacrificed. Efficacy of lavage extraction was tested on five northern pikeminnow and was 92.9 ± 9.9% (standard deviation) effective in removing stomach contents.

The annual relative importance index for the entire lake is reported in Table 9, along with the indices used to calculate it. Salmon were the most important species in the northern pikeminnow diet. Insect parts and *Daphnia* also were important according to the index of relative importance. Salmon and kokanee were the most important prey items by weight and *Daphnia* were the most important by number. No westslope cutthroat trout were positively identified in the stomachs of northern pikeminnow. There was one unidentified Salmonidae that could have been a cutthroat trout.

Relative importance indices were also calculated for each zone. Table 10 shows the indices used to calculate the importance of each prey item in the pelagic zones throughout Tribal waters. A total of 12 stomachs were examined from this zone and four were empty. Kokanee salmon was the most important prey item in the pelagic zones. Insects and ostracods were also very important in percent by numbers. One Salmonidae was identified and two unknown fish were in the stomach contents. Invertebrate prey items were more important overall than fish.

Table 11 represents the annual relative importance of prey items in the shoreline zones throughout the lake. One hundred forty one stomachs were analyzed from this zone and 24 were empty. Salmon were the most important prey item to northern pikeminnow in shoreline zones annually. *Daphnia* and insect parts were also very important. Twelve fish were too far digested to identify. Given the importance of salmon and kokanee to the diet, it is likely that some of them were salmonids.

The annual relative importance of prey items for northern pikeminnow in tributary sections is summarized in Table 12. Seventy-four stomachs were analyzed and 11 were empty. Insect parts were the most important prey items for northern pikeminnow captured in tributary zones. Salmon were a close second, but in general, northern pikeminnow found in tributary zones presented less piscivory than those captured in pelagic and shoreline zones.

Table 9. The total annual relative importance (RI) of each prey item for northern pikeminnow (n=189) as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Amphipod	6	1.76	0.19	0.00	0.00	0.53	0.53
Annelida	20	2.20	0.65	1.99	1.33	1.14	1.32
Arachnid	5	0.44	0.16	0.01	0.00	0.16	0.17
Bass	1	0.44	0.03	0.32	0.30	0.21	0.22
Coleoptera	19	1.76	0.61	0.05	0.03	0.66	0.66
Collembola	79	1.76	2.55	0.01	0.00	1.18	1.18
Cottidae	2	0.88	0.06	2.48	1.57	0.69	0.93
Decapoda	3	1.32	0.10	1.18	0.99	0.66	0.71
Decapoda parts	6	2.64	0.19	2.45	1.43	1.16	1.44
Cyclopoida	2	0.88	0.06	0.00	0.00	0.26	0.26
Daphnia	1560	2.64	50.34	0.05	0.00	14.46	14.47
Diptera	287	8.81	9.26	0.34	0.06	4.95	5.02
Ephemeroptera	13	0.44	0.42	0.02	0.01	0.24	0.24
Fish eye	9	2.64	0.29	0.01	0.02	0.81	0.80
Gastropods	22	3.08	0.71	0.47	0.15	1.08	1.16
Hemiptera	19	0.88	0.61	0.01	0.00	0.41	0.41
Hymenoptera	19	3.52	0.61	0.03	0.01	1.13	1.14
Insect heads	423	15.86	13.65	0.38	0.05	8.06	8.15
Insect parts	113	49.78	3.65	12.75	3.10	15.42	18.06
Kokanee	3	1.32	0.10	21.21	28.63	8.20	6.17
Nematoda	31	6.61	1.00	0.01	0.00	2.08	2.08
Odonata	281	2.64	9.07	0.33	0.04	3.21	3.28
Orthoptera	5	1.32	0.16	0.00	0.00	0.40	0.41
Ostracoda	40	1.32	1.29	0.00	0.00	0.71	0.71
Plants	70	30.84	2.26	1.35	0.44	9.15	9.40
Salmon	15	6.61	0.48	52.91	60.73	18.50	16.37
Salmonidae	1	0.44	0.03	0.15	0.06	0.14	0.17
Tapeworm	4	1.76	0.13	0.14	0.07	0.53	0.55
Trichoptera	21	3.08	0.68	0.45	0.20	1.08	1.15
Unknown fish	17	7.49	0.55	0.79	0.72	2.39	2.41
Yellow perch	3	1.32	0.10	0.11	0.05	0.40	0.42
GRAND TOTALS	**3099**		**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Table 10. The annual pelagic relative importance (RI) of each prey item for northern pikeminnow (n=8) as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Diptera	1	8.33	4.17	0.02	0.00	3.13	3.13
Hymenoptera	1	8.33	4.17	0.05	0.01	3.13	3.14
Insect heads	6	50.00	25.00	0.22	0.02	18.75	18.81
Insect parts	2	16.67	8.33	5.36	0.44	6.36	7.59
Kokanee	1	8.33	4.17	88.67	97.53	27.51	25.29
Ostracoda	6	50.00	25.00	0.09	0.01	18.75	18.77
Plants	4	33.33	16.67	0.46	0.06	12.52	12.62
Salmonidae	1	8.33	4.17	5.03	1.91	3.60	4.38
Unknown fish	2	16.67	8.33	0.11	0.02	6.25	6.28
GRAND TOTALS	**24**		**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Table 11. The annual shoreline relative importance (RI) of each prey item for northern pikeminnow (n=117) as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Amphipod	5	2.13	0.18	0.00	0.00	0.61	0.61
Annelida	20	3.55	0.70	2.45	1.52	1.52	1.76
Arachnid	5	0.71	0.18	0.01	0.00	0.23	0.23
Bass	1	0.71	0.04	0.39	0.35	0.29	0.30
Coleoptera	17	2.13	0.60	0.03	0.02	0.72	0.73
Collembola	78	2.13	2.74	0.01	0.00	1.28	1.28
Cottidae	2	1.42	0.07	3.05	1.79	0.86	1.19
Decapoda	2	1.42	0.07	0.97	0.85	0.62	0.65
Cyclopoida	2	1.42	0.07	0.00	0.00	0.39	0.39
Daphnia	1560	4.26	54.76	0.06	0.01	15.52	15.54
Diptera	277	9.22	9.72	0.41	0.06	5.00	5.09
Ephemeroptera	13	0.71	0.46	0.03	0.01	0.31	0.31
Fish eye	9	4.26	0.32	0.01	0.02	1.21	1.21
Gastropods	15	4.26	0.53	0.28	0.09	1.28	1.33
Hemiptera	19	1.42	0.67	0.01	0.00	0.55	0.55
Hymenoptera	18	4.96	0.63	0.04	0.01	1.47	1.48
Insect heads	322	17.73	11.30	0.31	0.04	7.65	7.72
Insect parts	71	50.35	2.49	8.92	2.06	14.44	16.25
Kokanee	2	1.42	0.07	22.85	29.21	8.08	6.40
Nematoda	12	6.38	0.42	0.01	0.00	1.79	1.79
Odonata	281	4.26	9.86	0.40	0.05	3.73	3.82
Orthoptera	4	1.42	0.14	0.00	0.00	0.41	0.41
Ostracoda	34	1.42	1.19	0.00	0.00	0.69	0.69
Plants	42	29.79	1.47	0.97	0.32	8.31	8.48
Salmon	9	6.38	0.32	57.29	62.55	18.22	16.83
Tapeworm	4	2.84	0.14	0.17	0.08	0.80	0.83
Trichoptera	10	2.84	0.35	0.26	0.10	0.87	0.91
Unknown fish	12	8.51	0.42	0.95	0.81	2.56	2.60
Yellow perch	3	2.13	0.11	0.13	0.06	0.60	0.62
GRAND TOTALS	**2849**		**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Table 12. The annual tributary zone relative importance (RI) of each prey item for northern pikeminnow (n=63) as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Amphipod	1	1.33	0.44	0.00	0.00	0.51	0.51
Coleoptera	2	1.33	0.88	0.14	0.14	0.68	0.68
Collembola	1	1.33	0.44	0.00	0.00	0.51	0.51
Decapoda	1	1.33	0.44	2.50	2.67	1.28	1.23
Decapoda parts	6	8.00	2.65	15.65	15.68	7.60	7.59
Diptera	9	8.00	3.98	0.07	0.02	3.46	3.48
Gastropods	7	1.33	3.10	1.56	0.82	1.51	1.73
Insect heads	95	13.33	42.04	0.75	0.16	16.02	16.19
Insect parts	40	53.33	17.70	34.03	14.01	24.53	30.31
Nematoda	19	8.00	8.41	0.03	0.01	4.74	4.74
Orthoptera	1	1.33	0.44	0.00	0.00	0.51	0.51
Plants	24	32.00	10.62	3.49	1.69	12.78	13.30
Salmon	6	8.00	2.65	40.15	63.46	21.38	14.66
Trichoptera	11	4.00	4.87	1.51	1.26	2.92	2.99
Unknown fish	3	4.00	1.33	0.12	0.07	1.56	1.57
GRAND TOTALS	**226**		**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Two selection indices were calculated for each prey fish found in the stomachs of northern pikeminnow. Table 13 displays the annual selection values for the entire sample area and each zone that northern pikeminnows had identifiable prey fish in their stomach contents. Ivlev's index indicated selection for Cottidae and salmon in the entire sample area. Bass were selected against according to the same index. Positive selection occurred in shoreline zones for Cottidae and for salmon in tributary zones.

The lengths of prey fish consumed were back calculated using Appendix D. Table 14 gives the back calculated total lengths and weights of all identifiable fish found in northern pikeminnow stomachs. There were 17 unknown fish found in all pikeminnow stomachs. Northern pikeminnow preyed most heavily on salmonid species, ranging in size from 88 mm to 236 mm.

Table 13. Northern pikeminnow annual selection values for the total sample area and each zonal designation using Strauss' (1979) (L) and Ivlev's (1961) (E) methods. Percent by number is the proportion of a fish species in the stomach divided by the total number of prey fish in the stomach (% BY#) and RA is the relative abundance of the prey fish in the environment. Shaded values indicate selection for or against (positive and negative values respectively) a prey item.

PREY SPECIES	TOTAL				PELAGIC				SHORELINE				TRIBUTARY			
	% BY #	RA	L	E	% BY #	RA	L	E	% BY #	RA	L	E	% BY #	RA	L	E
Bass	0.02	0.17	-0.15	-0.76					0.03	0.19	-0.15	-0.69				
Cottidae	0.05	0.00	0.04	0.82					0.07	0.01	0.06	0.82				
Kokanee	0.07	0.02	0.05	0.53	0.25	0.24	0.01	0.01	0.07	0.03	0.04	0.42				
Salmon	0.36	0.04	0.31	0.78					0.31	0.06	0.25	0.67	0.67	0.01	0.65	0.96
Salmonidae	0.02	0.07	-0.05	-0.51	0.25	0.51	-0.26	-0.34								
Yellow Perch	0.07	0.18	-0.11	-0.44					0.10	0.14	-0.03	-0.14				

Table 14. Back calculated original total lengths (mm) and original weights (g) of prey fish consumed by northern pikeminnow. Salmon are considered either chinook or kokanee salmon and Salmonidae are chinook salmon, kokanee salmon, or westslope cutthroat trout.

	ORIGINAL			ORIGINAL	
PREY SPECIES	TL (mm)	WEIGHT (g)	PREY SPECIES	TL (mm)	WEIGHT (g)
BASS	125	30.41	SALMON	178	62.78
COT	93	6.83	SALMON	206	102.14
COT	106	9.55	SALMON	208	105.49
KOK	135	19.06	SALMON	209	107.18
KOK	200	73.62	SALMON	213	114.17
KOK	233	124.48	SALMON	222	131.05
SALMON	88	6.01	SALMON	236	160.66
SALMON	121	17.35	SALMON	88	6.01
SALMON	128	20.93	SALMONIDAE	148	28.99
SALMON	138	26.89	YP	36	0.45
SALMON	138	26.89	YP	37	0.49
SALMON	154	38.75	YP	85	5.99
SALMON	173	57.10			

Chinook salmon

A total of 43 chinook salmon stomachs were analyzed throughout this study. Eleven stomachs were empty. Efficacy of lavage extraction was tested on one chinook salmon (only two lavaged, Table 8) and was 99.5% effective in removing stomach contents. Total lengths of fish whose stomachs were sampled were 204 mm to 885 mm. The annual relative importance index for the entire lake is reported in Table 15, along with the indices used to calculate it. Kokanee, salmon, and Salmonidae are the three most important species to chinook salmon. Chinook salmon exhibit a great deal of piscivory, and a definite preference for salmonids. Two westslope cutthroat trout were positively identified. Eleven Salmonidae were identified in the stomach samples but could not be keyed lower than the family level. Fish from derby anglers were considered to come from the pelagic zone. This was the only zone in which chinook salmon had prey items in their stomach contents.

Two selection indices were calculated for each prey fish found in the stomachs of chinook salmon. Table 16 displays the annual selection values for the entire sample area and the pelagic zone, where chinook salmon had identifiable prey fish in their stomach contents. Kokanee and salmon were selected for throughout the entire sample area according to Ivlev’s index. The relative abundance of salmonids was higher in pelagic zones, so selection is not indicated, however, salmonids were the only family identified in chinook salmon stomach contents.

Table 15. The total annual relative importance (RI) of each prey item for chinook salmon (n=32) as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	%DRY WT	RI DRY	RI WET
Arachnid	4	25.58	2.82	0.00	0.00	8.36	8.37
Fish eye	8	2.33	5.63	0.01	0.04	2.36	2.35
Hemiptera	38	13.95	26.76	0.02	0.01	11.99	12.00
Hymenoptera	8	2.33	5.63	0.01	0.01	2.35	2.35
Insect parts	3	2.33	2.11	0.01	0.00	1.31	1.31
Kokanee	7	6.98	4.93	72.35	42.07	15.90	24.82
Nematoda	47	11.63	33.10	0.02	0.01	13.18	13.18
Plants	2	23.26	1.41	0.22	0.10	7.29	7.33
Salmon	9	2.33	6.34	18.05	38.74	13.96	7.87
Salmonidae	11	16.28	7.75	8.80	18.41	12.50	9.67
Unknown fish	3	25.58	2.11	0.07	0.05	8.17	8.18
Westslope cutthroat	2	6.98	1.41	0.43	0.56	2.63	2.60
GRAND TOTAL	**142**		**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Table 16. Chinook salmon annual selection values for the total sample area and each zonal designation using Strauss' (1979) (L) and Ivlev's (1961) (E) methods. Percent by number is the proportion of a fish species in the stomach divided by the total number of prey fish in the stomach (% BY#) and RA is the relative abundance of the prey fish in the environment. Shaded values indicate selection for or against a prey item (positive and negative values respectively).

PREY SPECIES	TOTAL				PELAGIC			
	% BY #	RA	L	E	% BY #	RA	L	E
Kokanee	0.22	0.02	0.20	0.82	0.22	0.24	-0.02	-0.05
Salmon	0.28	0.04	0.24	0.73	0.28	0.26	0.02	0.04
Salmonidae	0.34	0.07	0.27	0.65	0.34	0.30	0.04	0.07
Westslope Cutthroat	0.06	0.03	0.03	0.35	0.06	0.04	0.03	0.25

The lengths of prey fish consumed were back calculated using Appendix D. Table 17 gives the back calculated total lengths and weights of all identifiable fish found in chinook salmon stomachs. There were 3 unknown fish found in all chinook stomachs. Chinook salmon preyed only on salmonid species. Two westslope cutthroat trout were positively identified from chinook collected during the derby. It is probable that some of the unidentified Salmonidae were also westslope cutthroat trout.

Largemouth bass

A total of 95 largemouth bass stomachs were analyzed throughout this study. Fifteen stomachs were empty. Total length of fish whose stomach contents were analyzed was 209 mm to 550 mm. Efficacy for lavage extraction was tested on six largemouth bass and was 89.3 ± 20.6% (standard deviation) effective in removing stomach contents. The relatively lower efficacy value for largemouth bass, as compared to other species, can be accounted for by the large amount of vegetation in their stomach contents. No fish parts or identifiable invertebrates were left in the stomach by lavage. Plants and a small number of insect parts were all that was left in the gut after gastric lavage.

The annual relative importance index for each prey item in largemouth bass diets for the entire lake is reported in Table 18, along with the indices used to calculate it. Plants were calculated as the most important prey item to largemouth bass, however this is misleading. Plants are abundant in their diets due to the environment in which they live. They prefer vegetated habitats and therefore ingest plant material incidentally when

Table 17. Back calculated original total lengths (mm) and original weights (g) of prey fish consumed by chinook salmon. Salmon were considered either chinook or kokanee salmon and Salmonidae were chinook salmon, kokanee salmon, or westslope cutthroat trout.

	ORIGINAL			ORIGINAL	
PREY SPECIES	TL (mm)	WEIGHT (g)	PREY SPECIES	TL (mm)	WEIGHT (g)
KOK	113	10.34	SALMON	220	127.16
KOK	123	13.84	SALMONIDAE	107	12.07
KOK	127	15.45	SALMONIDAE	156	33.41
KOK	135	19.06	SALMONIDAE	159	35.18
KOK	137	20.04	SALMONIDAE	168	40.82
KOK	140	21.59	SALMONIDAE	169	41.48
KOK	159	33.45	SALMONIDAE	200	65.36
SALMON	113	13.82	SALMONIDAE	204	68.95
SALMON	125	19.34	SALMONIDAE	205	69.86
SALMON	126	19.86	SALMONIDAE	212	76.49
SALMON	131	22.61	SALMONIDAE	236	102.19
SALMON	136	25.61	SALMONIDAE	258	129.99
SALMON	136	25.61	WCT	134	27.89
SALMON	136	25.61	WCT	152	37.43
SALMON	172	56.01			

Table 18. The total annual relative importance (RI) of each prey item of largemouth bass (n=80) as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Amphipod	2	2.11	0.70	0.003	0.001	0.72	0.72
Annelida	4	2.11	1.41	0.35	0.43	1.01	0.99
Arachnid	4	4.21	1.41	0.13	0.10	1.46	1.47
Bass	1	1.05	0.35	0.07	0.04	0.37	0.38
Black crappie	12	8.42	4.23	32.62	38.37	13.03	11.56
Brown bullhead	11	11.58	3.87	29.63	27.28	10.91	11.51
Coelenterata	1	1.05	0.35	0.00	0.00	0.36	0.36
Coleoptera	3	3.16	1.06	0.67	0.72	1.26	1.25
Cottidae	1	1.05	0.35	0.05	0.03	0.37	0.37
Decapoda	1	1.05	0.35	2.22	2.94	1.11	0.92
Decapoda parts	1	1.05	0.35	0.11	0.09	0.38	0.39
Diptera	19	8.42	6.69	0.01	0.01	3.86	3.86
Ephemeroptera	4	2.11	1.41	0.00	0.00	0.90	0.90
Fish eye	1	1.05	0.35	0.00	0.00	0.36	0.36
Hemiptera	11	2.11	3.87	0.07	0.03	1.54	1.54
Insect heads	15	3.16	5.28	0.02	0.00	2.16	2.16
Insect parts	23	24.21	8.10	0.28	0.09	8.27	8.32
Nematoda	1	1.05	0.35	0.00	0.00	0.36	0.36
Neuroptera	2	1.05	0.70	0.00	0.00	0.45	0.45
Northern pikeminnow	1	1.05	0.35	0.72	0.79	0.56	0.54
Odonata	62	7.37	21.83	0.14	0.07	7.47	7.49
Plants	57	60.00	20.07	3.62	1.92	20.94	21.37
Pumpkinseed	1	1.05	0.35	0.81	0.62	0.52	0.56
Rodent	1	1.05	0.35	3.91	2.81	1.08	1.36
Tapeworm	1	1.05	0.35	0.06	0.09	0.38	0.37
Unknown fish	23	24.21	8.10	2.31	1.42	8.61	8.84
Yellow perch	21	15.79	7.39	22.22	22.15	11.58	11.59
GRAND TOTALS	**284**		**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

eating other prey items. Black crappie, yellow perch and brown bullhead the most important prey items (after plants). This shows that largemouth bass exhibit a great deal of piscivory. Several invertebrates were also important to the diet. No salmonids were identified in the largemouth bass stomach samples analyzed in this study.

No largemouth bass were captured in the pelagic zones during this study. Table 19 displays the relative importance of the prey items found in the 25 stomachs from shoreline zones throughout the study period. Four of these stomachs were empty. In shoreline zones, plants again were calculated as the most important prey item. For reasons discussed before, this is discounted. Yellow perch and brown bullhead are the most important prey items followed by unidentified fish. Odonata were the most important invertebrate prey item to largemouth bass in shoreline zones.

Sixty-nine largemouth bass stomachs were analyzed from tributary sections throughout the sample period. Eleven of these stomachs were empty. Table 20 summarizes the relative importance of each prey item from largemouth bass caught in tributary zones. Black crappie, yellow perch and brown bullhead were also the most important prey items in tributary zones for largemouth bass. There were 15 unidentified fish from largemouth bass in tributary zones, none could be identified as salmonids.

Two selection indices were calculated for each prey fish found in the stomachs of largemouth bass. Table 21 displays the annual selection values for the entire sample area and each zone that largemouth bass had identifiable prey fish in their stomach contents. Largemouth bass selected against other bass in tributary zones and throughout the study area. In tributary zones, they Ivlev’s index indicates selection for Cottidae.

Table 19. The annual relative importance (RI) of each prey item for largemouth bass (n= 1) from shoreline zones as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Amphipod	1	4.00	1.05	0.00	0.00	1.30	1.30
Annelida	4	8.00	4.21	1.20	1.41	3.51	3.46
Black crappie	5	12.00	5.26	19.93	20.21	9.66	9.58
Brown bullhead	1	4.00	1.05	39.04	42.99	12.38	11.37
Coelenterata	1	4.00	1.05	0.00	0.00	1.30	1.30
Coleoptera	1	4.00	1.05	1.17	1.43	1.67	1.60
Diptera	3	12.00	3.16	0.01	0.00	3.91	3.91
Hemiptera	10	4.00	10.53	0.21	0.09	3.77	3.80
Insect heads	2	4.00	2.11	0.03	0.01	1.58	1.58
Insect parts	6	24.00	6.32	0.35	0.12	7.85	7.90
Nematoda	1	4.00	1.05	0.00	0.00	1.30	1.30
Odonata	31	8.00	32.63	0.12	0.03	10.48	10.50
Plants	12	48.00	12.63	2.13	0.87	15.85	16.17
Unknown fish	8	32.00	8.42	4.79	2.66	11.10	11.65
Yellow perch	9	16.00	9.47	31.02	30.17	14.34	14.56
GRAND TOTALS	**95**		**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Table 20. The annual relative importance (RI) of each prey item for largemouth bass (n= 8) from tributary zones as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Amphipod	1	1.45	0.53	0.003	0.002	0.50	0.50
Arachnid	4	5.80	2.12	0.19	0.14	2.04	2.05
Bass	1	1.45	0.53	0.09	0.05	0.51	0.52
Black crappie	7	7.25	3.70	37.78	46.37	14.49	12.32
Brown bullhead	10	14.49	5.29	25.80	20.35	10.14	11.52
Coleoptera	2	2.90	1.06	0.46	0.41	1.10	1.12
Cottidae	1	1.45	0.53	0.07	0.04	0.51	0.52
Decapoda	1	1.45	0.53	3.12	4.23	1.57	1.29
Decapoda parts	1	1.45	0.53	0.16	0.13	0.53	0.54
Diptera	16	7.25	8.47	0.02	0.01	3.97	3.98
Ephemeroptera	4	2.90	2.12	0.006	0.002	1.27	1.27
Fish eye	1	1.45	0.53	0.0002	0.0005	0.50	0.50
Hemiptera	1	1.45	0.53	0.01	0.01	0.50	0.50
Insect heads	13	2.90	6.88	0.011	0.001	2.47	2.47
Insect parts	17	24.64	8.99	0.25	0.07	8.52	8.56
Neuroptera	2	1.45	1.06	0.003	0.001	0.63	0.63
Northern pikeminnow	1	1.45	0.53	1.01	1.13	0.79	0.75
Odonata	31	7.25	16.40	0.15	0.08	6.00	6.02
Plants	45	65.22	23.81	4.22	2.38	23.10	23.57
Pumpkinseed	1	1.45	0.53	1.13	0.90	0.73	0.79
Rodent	1	1.45	0.53	5.49	4.05	1.52	1.89
Tapeworm	1	1.45	0.53	0.09	0.14	0.53	0.52
Unknown fish	15	21.74	7.94	1.30	0.87	7.72	7.83
Yellow perch	12	15.94	6.35	18.64	18.62	10.34	10.35
GRAND TOTALS	**189**		**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Table 21. Largemouth bass annual selection values for the total sample area and each zonal designation using Strauss' (1979) (L) and Ivlev's (1961) (E) methods. Percent by number is the proportion of a fish species in the stomach divided by the total number of prey fish in the stomach (% BY#) and RA is the relative abundance of the prey fish in the environment. Shaded values indicate selection for or against a prey item (positive and negative values respectively).

PREY SPECIES	TOTAL AREA				SHORELINE				TRIBUTARY			
	% BY #	RA	L	E	% BY #	RA	L	E	% BY #	RA	L	E
Bass	0.01	0.17	-0.16	-0.85					0.02	0.16	-0.14	-0.77
Black crappie	0.17	0.11	0.06	0.23	0.22	0.08	0.13	0.44	0.15	0.14	0.01	0.04
Brown bullhead	0.15	0.14	0.01	0.04	0.04	0.11	-0.07	-0.43	0.21	0.18	0.03	0.09
Cottidae	0.01	0.00	0.01	0.51					0.02	0.00	0.02	0.77
Northern Pikeminnow	0.01	0.07	-0.06	-0.68					0.02	0.04	-0.02	-0.35
Pumpkinseed	0.01	0.03	-0.02	-0.36					0.02	0.04	-0.01	-0.26
Yellow perch	0.30	0.18	0.11	0.24	0.39	0.14	0.25	0.48	0.25	0.23	0.02	0.03

The lengths of prey fish consumed were back calculated using Appendix D. Table 22 gives the back calculated total lengths and weights of all identifiable fish found in largemouth bass stomachs. There were 23 unknown fish found in all largemouth bass stomachs. No salmonids were identified in largemouth bass stomach contents. This does not however, mean that largemouth bass are selecting against salmonids. It is likely that they eat more yellow perch, black crappie and brown bullhead because they are most abundant in the environment.

Table 22. Back calculated original total lengths (mm) and original weights (g) of prey fish consumed by largemouth bass.

PREY SPECIES	ORIGINAL TL (mm)	ORIGINAL WEIGHT (g)	PREY SPECIES	ORIGINAL TL (mm)	ORIGINAL WEIGHT (g)
Bass	73	7.36	COT	22	0.17
BBH	59	3.24	NPM	123	10.87
BBH	59	3.24	PS	101	20.00
BBH	60	3.39	YP	39	0.57
BBH	61	3.56	YP	51	1.28
BBH	62	3.72	YP	65	2.66
BBH	67	4.64	YP	71	3.48
BBH	68	4.84	YP	73	3.78
BBH	111	19.50	YP	75	4.10
BBH	175	71.09	YP	76	4.27
BBH	179	75.81	YP	78	4.62
BBH	183	80.72	YP	78	4.62
BC	45	1.92	YP	80	4.99
BC	64	5.02	YP	90	7.11
BC	67	5.69	YP	90	7.11
BC	67	5.69	YP	112	13.77
BC	74	7.46	YP	118	16.11
BC	88	11.96	YP	123	18.26
BC	89	12.33	YP	123	18.26
BC	89	12.33	YP	132	22.60
BC	105	19.35	YP	134	23.65
BC	109	21.43	YP	144	29.39
BC	158	58.93	YP	145	30.01
BC	197	107.52	YP	152	34.60

Smallmouth bass

A total of 102 smallmouth bass stomachs were analyzed throughout this study. Seven stomachs were empty. Total lengths of fish whose stomach contents were analyzed ranged from 155 to 407 mm. Forty fish under 200 mm were analyzed because we saw food items in their mouths. Efficacy of lavage extraction was tested on five smallmouth bass and was 94.3 ± 8.1% (standard deviation) effective in removing stomach contents.

The annual relative importance index of each prey item in the diet of smallmouth bass for the entire lake is reported in Table 23, along with the indices used to calculate it. Smallmouth bass had more prey items found in their stomach contents than the other species. Insect parts and heads were among the most important items. Overall, invertebrates were more important by number and fish prey was more important by weight. Cottidae were the most important fish in smallmouth bass diets. One kokanee and one westslope cutthroat trout were found in smallmouth bass stomachs. Smallmouth bass appeared to be opportunists and eat what prey is available.

No smallmouth bass were captured in the pelagic zones during this study. Table 24 displays the relative importance of the prey items found in the 70 stomachs from shoreline zones throughout the study period. Four of these stomachs were empty. Unidentified insect parts and heads were the most important prey items to smallmouth bass in shoreline zones. Invertebrates were more important by numbers, but by weight, fish were the most important. Cottidae, yellow perch, and kokanee were the most important species by weight to smallmouth bass. Two salmonids were found in stomachs of smallmouth bass collected in shoreline zones.

Table 23. The total annual relative importance (RI) of each prey item of smallmouth bass (n=95) as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Amphipod	27	6.86	4.02	0.15	0.05	2.19	2.21
Annelida	4	1.96	0.60	7.01	7.66	2.04	1.91
Arachnid	33	6.86	4.91	0.56	0.43	2.44	2.47
Bass	4	3.92	0.60	2.24	1.75	1.25	1.35
Black crappie	4	3.92	0.60	6.18	6.11	2.13	2.14
Bosmina	1	0.98	0.15	0.00	0.00	0.23	0.23
Coleoptera	7	5.88	1.04	0.10	0.11	1.41	1.41
Cottidae	11	10.78	1.64	16.73	17.69	6.02	5.83
Decapoda	1	0.98	0.15	1.50	2.45	0.72	0.53
Decapoda parts	5	4.90	0.74	0.41	0.40	1.21	1.21
Cyclopoida	27	0.98	4.02	0.02	0.00	1.00	1.00
Daphnia	72	6.86	10.71	0.19	0.01	3.52	3.55
Diptera	41	14.71	6.10	0.12	0.06	4.17	4.19
Ephemeroptera	25	6.86	3.72	0.52	0.46	2.21	2.22
Fish eye	13	7.84	1.93	0.05	0.11	1.98	1.97
Hemiptera	3	1.96	0.45	0.03	0.03	0.49	0.49
Hymenoptera	34	10.78	5.06	0.37	0.26	3.22	3.24
Insect heads	115	22.55	17.11	0.57	0.29	7.99	8.05
Insect parts	62	60.78	9.23	14.83	7.69	15.54	16.97
Kokanee	1	0.98	0.15	11.07	16.02	3.43	2.44
Largemouth bass	1	0.98	0.15	1.13	1.24	0.47	0.45
Lepidoptera	2	1.96	0.30	0.16	0.08	0.47	0.48
Megaloptera	9	2.94	1.34	0.08	0.07	0.87	0.87
Nematoda	4	3.92	0.60	0.01	0.01	0.90	0.91
Neuroptera	8	4.90	1.19	0.05	0.02	1.22	1.23
Odonata	62	22.55	9.23	1.64	1.05	6.57	6.68
Orthoptera	11	2.94	1.64	0.10	0.08	0.93	0.94
Plants	44	43.14	6.55	1.32	0.62	10.06	10.20
Plecoptera	2	0.98	0.30	0.24	0.20	0.30	0.30
Pumpkinseed	5	4.90	0.74	12.55	15.26	4.18	3.64
Tapeworm	3	2.94	0.45	0.04	0.06	0.69	0.69
Trichoptera	3	2.94	0.45	0.03	0.03	0.68	0.68
Unknown fish	21	18.63	3.13	3.57	2.91	4.93	5.07
Westslope cutthroat	1	0.98	0.15	1.58	1.24	0.47	0.54
Yellow perch	6	3.92	0.89	14.82	15.57	4.08	3.93
GRAND TOTALS	**672**		**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Table 24. The annual relative importance (RI) of each prey item for smallmouth bass (n=66) from shoreline zones as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Amphipod	24	7.14	6.37	0.16	0.05	2.83	2.85
Annelida	4	2.86	1.06	9.08	9.87	2.87	2.71
Arachnid	3	1.43	0.80	0.07	0.03	0.47	0.48
Bass	3	4.29	0.80	2.43	2.03	1.48	1.57
Black crappie	4	5.71	1.06	8.00	7.87	3.05	3.08
Coleoptera	4	4.29	1.06	0.10	0.12	1.14	1.14
Cottidae	11	15.71	2.92	21.67	22.80	8.63	8.40
Decapoda	1	1.43	0.27	1.94	3.16	1.01	0.76
Decapoda parts	2	2.86	0.53	0.13	0.04	0.71	0.73
Daphnia	5	5.71	1.33	0.02	0.00	1.47	1.47
Diptera	32	14.29	8.49	0.11	0.06	4.76	4.77
Ephemeroptera	24	8.57	6.37	0.67	0.59	3.23	3.25
Fish eye	10	8.57	2.65	0.04	0.08	2.36	2.35
Hymenoptera	21	8.57	5.57	0.33	0.26	3.00	3.02
Insect heads	78	20.00	20.69	0.58	0.26	8.53	8.60
Insect parts	43	61.43	11.41	13.60	7.06	16.64	18.01
Kokanee	1	1.43	0.27	14.33	20.64	4.65	3.34
Largemouth bass	1	1.43	0.27	1.47	1.59	0.68	0.66
Lepidoptera	2	2.86	0.53	0.20	0.10	0.73	0.75
Megaloptera	1	1.43	0.27	0.04	0.03	0.36	0.36
Nematoda	3	4.29	0.80	0.01	0.01	1.06	1.06
Neuroptera	4	4.29	1.06	0.03	0.01	1.12	1.12
Odonata	45	20.00	11.94	1.55	1.04	6.87	6.98
Plants	31	44.29	8.22	1.25	0.46	11.03	11.20
Pumpkinseed	3	4.29	0.80	3.59	3.91	1.87	1.81
Tapeworm	2	2.86	0.53	0.05	0.06	0.72	0.72
Trichoptera	2	2.86	0.53	0.02	0.03	0.71	0.71
Unknown fish	8	11.43	2.12	1.51	1.02	3.04	3.14
Westslope cutthroat	1	1.43	0.27	2.05	1.60	0.69	0.78
Yellow perch	4	4.29	1.06	14.97	15.22	4.28	4.23
GRAND TOTAL	**377**		**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Thirty-two smallmouth bass stomachs were analyzed from tributary sections throughout the sample period. Three of these stomachs were empty. Table 25 summarizes the relative importance of each prey item from largemouth bass caught in tributary zones. Insect parts were also very important in tributary zones. Many stomachs contained one or more unidentifiable insect parts. Pumpkinseed sunfish were the most important prey item following unidentified insects. There were also thirteen unidentified fish that were very important to smallmouth bass diets in tributary zones. Salmonids were not identified in smallmouth bass stomachs from tributary zones.

Two selection indices were calculated for each prey fish found in the stomachs of smallmouth bass. Table 26 displays the annual selection values for the entire sample area and each zone that smallmouth bass had identifiable prey fish in their stomach contents. Ivlev's index indicates selection for Cottidae in shoreline zones and in the whole study area. Sculpins were poorly represented in the relative abundance data (Table 4), and this selection is likely a product of that.

The lengths of prey fish consumed were back calculated using Appendix D. Table 27 gives the back calculated total lengths and weights of all identifiable fish found in smallmouth bass stomachs. There were 19 unknown fish found in all largemouth bass stomachs. Both salmonids from smallmouth bass stomachs were greater than 100 mm in total length. It is likely that the cutthroat consumed was migrating to the lake for the first time based on its' back calculated length.

Table 25. The annual relative importance (RI) of each prey item for smallmouth bass (n=29) from tributary zones as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Amphipod	3	6.25	1.02	0.14	0.02	1.34	1.36
Arachnid	30	18.75	10.17	2.23	1.84	5.66	5.73
Bass	1	3.13	0.34	1.60	0.75	0.78	0.93
Bosmina	1	3.13	0.34	0.00	0.00	0.64	0.64
Coleoptera	3	9.38	1.02	0.10	0.07	1.92	1.93
Decapoda parts	3	9.38	1.02	1.37	1.64	2.21	2.16
Cyclopoida	27	3.13	9.15	0.10	0.01	2.26	2.28
Daphnia	67	9.38	22.71	0.78	0.05	5.91	6.04
Diptera	9	15.63	3.05	0.16	0.08	3.45	3.46
Ephemeroptera	1	3.13	0.34	0.01	0.02	0.64	0.64
Fish eye	3	6.25	1.02	0.06	0.20	1.37	1.35
Hemiptera	3	6.25	1.02	0.11	0.11	1.36	1.36
Hymenoptera	13	15.63	4.41	0.51	0.30	3.74	3.78
Insect heads	37	28.13	12.54	0.52	0.40	7.55	7.57
Insect parts	19	59.38	6.44	19.04	9.85	13.92	15.60
Megaloptera	8	6.25	2.71	0.22	0.19	1.68	1.69
Nematoda	1	3.13	0.34	0.01	0.01	0.64	0.64
Neuroptera	4	6.25	1.36	0.10	0.04	1.41	1.42
Odonata	17	28.13	5.76	1.94	1.08	6.43	6.59
Orthoptera	11	9.38	3.73	0.43	0.34	2.47	2.49
Plants	13	40.63	4.41	1.58	1.19	8.50	8.57
Plecoptera	2	3.13	0.68	1.07	0.89	0.86	0.90
Pumpkinseed	2	6.25	0.68	42.97	54.62	11.32	9.18
Tapeworm	1	3.13	0.34	0.01	0.05	0.65	0.64
Trichoptera	1	3.13	0.34	0.06	0.02	0.64	0.65
Unknown fish	13	34.38	4.41	10.57	9.45	8.87	9.08
Yellow perch	2	3.13	0.68	14.29	16.80	3.79	3.33
GRAND TOTALS	**295**		**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Table 26. Smallmouth bass's annual selection values for the total sample area and each zonal designation using Strauss' (1979) (L) and Ivlev's (1961) (E) methods. Percent by number is the proportion of a fish species in the stomach divided by the total number of prey fish in the stomach (% BY#) and RA is the relative abundance of the prey fish in the environment. Shaded values indicate selection for or against a prey item (positive and negative values respectively).

PREY SPECIES	TOTAL				SHORELINE				TRIBUTARY			
	% BY #	RA	L	E	% BY #	RA	L	E	% BY #	RA	L	E
Bass	0.07	0.17	-0.10	-0.40	0.08	0.19	-0.10	-0.39	0.06	0.16	-0.11	-0.49
Black crappie	0.07	0.11	-0.03	-0.18	0.11	0.08	0.03	0.14				
Cottidae	0.20	0.00	0.20	0.96	0.31	0.01	0.30	0.96				
Kokanee	0.02	0.02	0.00	-0.09	0.03	0.03	0.00	-0.01				
Largemouth bass	0.02	0.06	-0.05	-0.56	0.03	0.05	-0.02	-0.27				
Pumpkinseed	0.09	0.03	0.06	0.51	0.08	0.03	0.06	0.53	0.11	0.04	0.08	0.52
Westslope Cutthroat	0.02	0.03	-0.01	-0.24	0.03	0.04	-0.01	-0.18				
Yellow Perch	0.11	0.18	-0.07	-0.24	0.11	0.14	-0.03	-0.10	0.11	0.23	-0.12	-0.36

Table 27. Back calculated original total lengths (mm) and original weights (g) of prey fish consumed by smallmouth bass.

	ORIGINAL			ORIGINAL	
PREY SPECIES	TL (mm)	WEIGHT (g)	PREY SPECIES	TL (mm)	WEIGHT (g)
Bass	54	3.33	COT	96	7.41
Bass	64	5.20	COT	104	9.10
Bass	86	11.34	KOK	125	14.63
Bass	88	12.05	LMB	52	3.11
BC	43	1.70	PS	51	2.96
BC	59	4.02	PS	57	4.04
BC	62	4.60	PS	64	5.59
BC	66	5.46	PS	66	6.09
COT	29	0.34	PS	93	15.88
COT	44	1.00	WCT	147	34.62
COT	44	1.00	YP	81	5.18
COT	65	2.72	YP	83	5.57
COT	75	3.93	YP	85	5.99
COT	77	4.20	YP	89	6.88
COT	82	4.94	YP	99	9.49
COT	91	6.46	YP	102	10.38
COT	93	6.83			

Northern pike

A total of 26 northern pike stomachs were collected throughout the study area. Two of the stomachs analyzed contained no prey items. Total lengths of fish whose stomachs were analyzed ranged from 293 mm to 740 mm. Efficacy of lavage extraction was tested on two northern pike and was 100.0 ± 0.1% (standard deviation) effective in removing stomach contents.

The relative importance of each prey item throughout the study is shown in Table 28. Westslope cutthroat trout were the most important prey item to northern pike in this study. The second most important prey item was vegetation, however this is likely a product of the habitat in which northern pike resided. Yellow perch were the second most important prey item, followed by unidentified fish. Pike were very piscivorous and preyed heavily on cutthroat trout and yellow perch.

One northern pike was collected from the pelagic zone. The relative importance of each prey item for the fish collected in the pelagic zone is displayed in Table 29. Two fish were found in this stomach, one was identified as a cutthroat and the other was not identifiable. The cutthroat trout was the most important prey item.

Fifteen pike stomachs were collected from all shoreline zones throughout the project. None of these fish had empty stomachs. Table 30 shows the relative importance of prey items to northern pike in shoreline zones over the entire sample time. Westslope cutthroat trout were the most important prey item in shoreline zones. Coleopterans were the most important invertebrate prey item. Yellow perch and black crappie were the next most important prey fish to northern pike.

Table 28. The total annual relative importance (RI) of each prey item of northern pike (n=24) as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Annelida	1	3.85	1.47	0.13	0.07	1.33	1.35
Bait fish and hook	1	3.85	1.47	2.24	8.32	3.38	1.87
Bass	1	3.85	1.47	0.52	0.31	1.39	1.45
Black crappie	3	11.54	4.41	1.30	0.52	4.08	4.27
Brown bullhead	1	3.85	1.47	2.22	1.66	1.73	1.87
Coleoptera	7	3.85	10.29	0.07	0.05	3.51	3.52
Diptera	1	3.85	1.47	0.00	0.00	1.32	1.32
Fish eye	2	3.85	2.94	0.00	0.00	1.68	1.68
Feathers	1	3.85	1.47	0.16	0.02	1.32	1.36
Gastropods	1	3.85	1.47	0.00	0.00	1.32	1.32
Hymenoptera	1	3.85	1.47	0.00	0.00	1.32	1.32
Insect heads	1	3.85	1.47	0.00	0.00	1.32	1.32
Insect parts	4	15.38	5.88	1.06	0.50	5.39	5.53
Mountain whitefish	1	3.85	1.47	6.92	5.19	2.60	3.03
Northern pikeminnow	1	3.85	1.47	0.79	0.40	1.42	1.51
Odonata	1	3.85	1.47	0.01	0.01	1.32	1.32
Plants	14	53.85	20.59	3.55	0.66	18.59	19.31
Pumpkinseed	3	3.85	4.41	1.65	0.85	2.26	2.45
Unknown fish	6	23.08	8.82	3.33	8.98	10.12	8.72
Westslope cutthroat	6	23.08	8.82	62.78	62.48	23.37	23.44
Yellow perch	11	19.23	16.18	13.26	9.98	11.24	12.05
GRAND TOTAL	**68**		**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Table 29. The annual relative importance (RI) of prey items for northern pike (n=1) from a pelagic zone as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Unknown fish	1	100.00	50.00	0.19	0.10	37.52	37.55
Westslope cutthroat	1	100.00	50.00	99.81	99.90	62.48	62.45
GRAND TOTALS	**2**		**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Table 30. The annual relative importance (RI) of each prey item for northern pike (n=15) from shoreline zones as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Bass	1	6.67	2.38	0.87	0.55	2.00	2.07
Black crappie	3	20.00	7.14	2.17	0.91	5.84	6.11
Brown bullhead	1	6.67	2.38	3.70	2.89	2.49	2.66
Coleoptera	7	46.67	16.67	0.12	0.08	13.21	13.22
Diptera	1	6.67	2.38	0.00	0.00	1.88	1.89
Fish eye	2	13.33	4.76	0.01	0.01	3.77	3.77
Feathers	1	6.67	2.38	0.26	0.03	1.89	1.94
Hymenoptera	1	6.67	2.38	0.00	0.00	1.89	1.89
Insect heads	1	6.67	2.38	0.00	0.00	1.88	1.89
Insect parts	3	20.00	7.14	1.69	0.87	5.84	6.01
Northern pikeminnow	1	6.67	2.38	1.32	0.70	2.03	2.16
Odonata	1	6.67	2.38	0.02	0.01	1.89	1.89
Plants	10	66.67	23.81	1.47	0.37	18.93	19.16
Unknown fish	2	13.33	4.76	0.35	0.13	3.80	3.84
Westslope cutthroat	4	26.67	9.52	87.26	93.14	26.94	25.72
Yellow perch	3	20.00	7.14	0.76	0.31	5.72	5.81
GRAND TOTALS	**42**		**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Over the year, 10 pike stomachs were analyzed from tributary zones. Two of these were empty. Table 31 gives the annual relative importance of each prey item to pike within the tributary zones. Yellow perch were the most important prey item in tributary zones. Three unidentified fish were the next most important prey item. Pumpkinseed sunfish, mountain whitefish, and westslope cutthroat trout were also important to their diet. Two salmonid species were important prey items to northern pike from tributary zones.

Two selection indices were calculated for each prey fish found in the stomachs of northern pike. Table 32 displays the annual selection values for the entire sample area and each zone that northern pike had identifiable prey fish in their stomach contents. Ivlev's index was the only one which indicated any selection by northern pike. Bass were selected against throughout the whole study area. One mountain whitefish was found in the stomach contents and indicated to be selected for in tributary zones. Westslope cutthroat trout were selected for by northern pike in all zones except tributary zones.

The lengths of prey fish consumed were back calculated using Appendix D. Table 33 gives the back calculated total lengths and weights of all identifiable fish found in northern pike stomachs. Westslope cutthroat trout back calculated lengths range from 164 mm to 332 mm. These fish are likely to be adult spawners and fish migrating to the lake for the first time from natal tributaries.

Table 31. The annual relative importance (RI) of each prey item for northern pike (n=8) from tributary zones as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Annelida	1	10.00	4.17	0.38	0.18	3.88	3.93
Bait fish and hook	1	10.00	4.17	6.59	22.52	9.92	5.61
Gastropods	1	10.00	4.17	0.01	0.01	3.83	3.83
Insect parts	1	10.00	4.17	0.12	0.01	3.83	3.86
Mountain whitefish	1	10.00	4.17	20.36	14.04	7.62	9.33
Plants	4	40.00	16.67	7.85	1.22	15.64	17.44
Pumpkinseed	3	10.00	12.50	4.86	2.30	6.70	7.39
Unknown fish	3	30.00	12.50	9.14	24.07	17.99	13.96
Westslope cutthroat	1	10.00	4.17	13.04	9.14	6.30	7.35
Yellow perch	8	30.00	33.33	37.66	26.51	24.28	27.30
GRAND TOTAL	**24**		**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Table 32. Northern pike annual selection values for the total sample area and each zonal designation using Strauss' (1979) (L) and Ivlev's (1961) (E) methods. Percent by number is the proportion of a fish species in the stomach divided by the total number of prey fish in the stomach (% BY#) and RA is the relative abundance of the prey fish in the environment. Shaded values indicate selection for or against a prey item (positive and negative values respectively).

PREY SPECIES	TOTAL % BY #	TOTAL RA	TOTAL L	TOTAL E	PELAGIC % BY #	PELAGIC RA	PELAGIC L	PELAGIC E	SHORELINE % BY #	SHORELINE RA	SHORELINE L	SHORELINE E	TRIBUTARY % BY #	TRIBUTARY RA	TRIBUTARY L	TRIBUTARY E
Bass	0.03	0.17	-0.14	-0.71					0.07	0.19	-0.12	-0.48				
Black crappie	0.09	0.11	-0.02	-0.10					0.20	0.08	0.12	0.41				
Brown bullhead	0.03	0.14	-0.11	-0.66					0.07	0.11	-0.04	-0.25				
Mountain whitefish	0.03	0.00	0.03	0.87									0.06	0.00	0.06	0.92
Northern pikeminnow	0.03	0.07	-0.05	-0.43					0.07	0.10	-0.03	-0.20				
Pumpkinseed	0.09	0.03	0.06	0.49									0.19	0.04	0.15	0.68
Westslope cutthroat	0.18	0.03	0.15	0.71	0.50	0.04	0.46	0.86	0.27	0.04	0.23	0.74	0.06	0.02	0.04	0.51
Yellow perch	0.32	0.18	0.14	0.28					0.20	0.14	0.06	0.19	0.50	0.23	0.27	0.36

Table 33. Back calculated original total lengths (mm) and original weights (g) of prey fish consumed by northern pike.

PREY SPECIES	ORIGINAL TL (mm)	ORIGINAL WEIGHT (g)	PREY SPECIES	ORIGINAL TL (mm)	ORIGINAL WEIGHT (g)
Bass	167	65.26	WCT	220	88.78
BBH	190	89.81	WCT	332	232.14
BC	55	3.32	YP	56	1.70
BC	62	4.60	YP	76	4.27
BC	135	38.39	YP	78	4.62
MWF	131	18.96	YP	85	5.99
NPM	271	161.09	YP	85	5.99
PS	59	4.45	YP	89	6.88
PS	64	5.59	YP	99	9.49
PS	76	9.03	YP	107	11.99
WCT	164	44.70	YP	111	13.40
WCT	180	55.56	YP	139	26.42
WCT	196	67.79	YP	140	26.99
WCT	205	75.28			

APPENDICES

APPENDIX A: SEASONAL FISH DISTRIBUTION

The seasonal fish sampling data were combined to describe the annual fish distribution (in main report). Here, I describe the results by season. The methods used are the same as described in the methods.

Summer

During the summer season, horizontal and vertical gillnets were set in the pelagic zone for a total of 58.0 hours of effort. Table A-1 summarizes the catch during summer in the pelagic zone, no fish were captured in vertical gillnets. In the shoreline sections, 52.8 hours were spent electrofishing and with horizontal net sets. Table A-2 shows the catch per unit effort and abundance of fish collected in the shoreline zones during the summer quarter. Tributary zones received 31.1 hours of sampling effort in the summer. Table A-3 shows the catch per unit effort and relative abundance of fish collected during the summer quarter from tributary sections. In the summer quarter, largescale sucker, brown bullhead, yellow perch and black crappie were the most abundant species encountered.

Fall

During the fall season, horizontal and vertical nets were set in the pelagic zones for a total of 145.8 hours of effort. Table A-4 summarizes the catch during fall in the pelagic zones. In the shoreline sections, 114.6 hours were spent electrofishing and with horizontal and vertical net sets. Table A-5 shows the catch per unit effort and abundance of fish collected in the shoreline zones during the fall quarter. Tributary zones received 34.3 hours of sampling effort in the fall. Table A-6 shows the catch per unit effort and relative abundance of fish collected during the fall quarter from tributary sections.

Yellow perch were the most abundant species in the fall followed by brown bullhead, smallmouth bass, and black crappie. Smallmouth bass were the most abundant predator species, followed by largemouth bass.

Winter

During the winter season, horizontal nets were set in the pelagic zone for a total of 21.8 hours of effort. A longnose sucker and a largescale sucker were the only fish captured. Each had a relative abundance of 50% and a catch per unit effort of <0.1 fish per hour. In the shoreline sections, 3.7 hours were spent electrofishing. Table A-7 shows the catch per unit effort and relative abundance of species collected in the shoreline zones during the winter quarter. Tributary zones received 11.4 hours of sampling effort in the winter. Table A-8 shows the catch per unit effort and relative abundance of fish collected during the winter quarter from tributary sections. Largescale suckers and brown bullhead were the most abundant species sampled in the winter quarter. Other than brown bullhead, yellow perch were the most abundant prey fish sampled. It was difficult to sample in many parts of the lake as ice covered the southern end up to Conkling Park and northern bays were also iced over. One bull trout was captured in a horizontal gill net in a tributary zone. This fish was cut from the net immediately, measured and weighed and released in good condition.

Spring

During the spring season, horizontal nets were set in the pelagic zone for a total of 13.1 hours of effort. Table A-9 summarizes the catch during spring in the pelagic zone. In the shoreline sections, 30.5 hours were spent electrofishing and with horizontal net sets. Table A-10 shows the catch per unit effort and abundance of fish collected in the shoreline zones during the spring quarter. Tributary zones received 52.4 hours of sampling effort in the fall. Table A-11 shows the catch per unit effort and relative abundance of fish collected during the spring quarter from tributary sections. Largescale suckers, yellow perch and smallmouth bass were the most abundant species in the spring sampling quarter. Smallmouth bass again were found where yellow perch were abundant. More than half of the total northern pike sampled annually were captured in the spring. The same is true for westslope cutthroat trout, an important prey item to northern pike.

Table A-1. The summer catch per unit effort (CPUE), in hours, and the total relative abundance (RA) of each species captured in pelagic zones.

	HORIZONTAL NET		TOTAL
SPECIES	**n**	**CPUE**	**RA**
NPM	9	0.2	14.5
LSS	6	0.1	9.7
BBH	13	0.3	21.0
WCT	4	0.1	6.5
KOK	24	0.5	38.7
CHIN	2	< 0.1	3.2
BC	1	< 0.1	1.6
YP	3	0.1	4.8
GRAND TOTALS	**62**	**1.3**	**100.0**

Table A-2. The summer catch per unit effort (CPUE) for all gear types, in hours, and the total relative abundance (RA) of each species captured in shoreline zones.

	ELECTRO		HORIZONTAL NET		TOTAL		
SPECIES	**n**	**CPUE**	**n**	**CPUE**	**n**	**CPUE**	**RA**
NPM	33	14.3	30	0.6	63	1.2	13.4
TCH	7	3.0	1	< 0.1	8	0.2	1.7
LSS	135	58.7	9	0.2	144	2.7	30.6
BBH	57	24.8	27	0.5	84	1.6	17.8
PIKE	4	1.7			4	0.1	0.9
WCT	4	1.7	2	< 0.1	6	0.1	1.3
KOK			6	0.1	6	0.1	1.3
CHIN			1	< 0.1	1	< 0.1	0.2
MWF	1	0.4			1	< 0.1	0.2
COT	3	1.3			3	0.1	0.6
PS	12	5.2			12	0.2	2.6
SMB	44	19.1			44	0.8	9.3
LMB	3	1.3			3	0.1	0.6
BC	52	22.6	1	< 0.1	53	1.0	11.3
YP	38	16.5	1	< 0.1	39	0.7	8.3
GRAND TOTALS	**393**	**170.9**	**78**	**1.5**	**471**	**8.9**	**100.0**

Table A-3. The summer catch per unit effort (CPUE) for all gear types, in hours, and the total relative abundance (RA) of each species captured in tributary zones.

	ELECTRO		HORIZONTAL NET		TOTAL		
SPECIES	**n**	**CPUE**	**n**	**CPUE**	**n**	**CPUE**	**RA**
NPM	28	10.4	5	0.2	33	1.1	6.6
TCH	10	3.7			10	0.3	2.0
LSS	116	43.0	7	0.2	123	4.0	24.6
BBH	94	34.8	3	0.1	97	3.1	19.4
PIKE	1	0.4			1	< 0.1	0.2
WCT	3	1.1			3	0.1	0.6
KOK	1	0.4	1	< 0.1	2	0.1	0.4
COT	2	0.7			2	0.1	0.4
PS	17	6.3			17	0.5	3.4
SMB	14	5.2			14	0.5	2.8
LMB	31	11.5			31	1.0	6.2
BC	69	25.6	2	0.1	71	2.3	14.2
YP	95	35.2	2	0.1	97	3.1	19.4
GRAND TOTALS	**481**	**178.1**	**20**	**0.7**	**501**	**16.1**	**100.0**

Table A-4. The fall catch per unit effort (CPUE) for all gear types, in hours, and the total relative abundance (RA) of each species captured in pelagic zones.

	HORIZONTAL NET		VERTICAL NET		TOTAL		
SPECIES	**n**	**CPUE**	**n**	**CPUE**	**n**	**CPUE**	**RA**
NPM	10	0.5			10	0.1	28.6
LNS	7	0.4			7	0.1	20.0
LSS	9	0.5	1	< 0.1	10	0.1	28.6
BBH			4	< 0.1	4	< 0.1	11.4
KOK	2	0.1			2	< 0.1	5.7
BC			1	< 0.1	1	< 0.1	2.9
YP	1	0.1			1	< 0.1	2.9
GRAND TOTALS	**29**	**1.5**	**6**	**< 0.1**	**35**	**0.2**	**100.0**

Table A-5. The fall catch per unit effort (CPUE) for all gear types, in hours, and the total relative abundance (RA) of each species captured in shoreline zones.

	ELECTRO		HORIZONTAL NET		VERTICAL NET		TOTAL		
SPECIES	**n**	**CPUE**	**n**	**CPUE**	**n**	**CPUE**	**n**	**CPUE**	**RA**
NPM	52	7.2	21	0.3	1	< 0.1	74	0.6	8.2
TCH	1	0.1	1	< 0.1			2	< 0.1	0.2
LNS			4	0.1			4	< 0.1	0.4
BLS	1	0.1					1	< 0.1	0.1
LSS	109	15.1	19	0.3	2	< 0.1	130	1.1	14.4
BBH	81	11.3	3	< 0.1	1	< 0.1	85	0.7	9.4
PIKE	5	0.7	1	< 0.1			6	0.1	0.7
WCT	12	1.7					12	0.1	1.3
RBT	2	0.3					2	0.2	0.2
KOK	13	1.8	8	0.1			21	0.1	2.3
CHIN	1	0.1					1	< 0.1	0.1
MWF	1	0.1					1	< 0.1	0.1
COT	10	1.4					10	0.1	1.1
PS	35	4.9	1	< 0.1			36	0.3	4.0
SMB	159	22.1					159	1.4	17.6
LMB	75	10.4					75	0.7	8.3
BC	96	13.3	3	< 0.1			99	0.9	10.9
YP	188	26.1					188	1.6	20.8
GRAND TOTALS	**841**	**116.8**	**61**	**0.9**	**4**	**0.1**	**906**	**7.9**	**100.0**

Table A-6. The fall catch per unit effort (CPUE) for all gear types, in hours, and the total relative abundance (RA) of each species captured in tributary zones.

	ELECTRO		HORIZONTAL NET		TOTAL		
SPECIES	**n**	**CPUE**	**n**	**CPUE**	**n**	**CPUE**	**RA**
NPM	15	3.0	6	0.2	21	0.6	2.6
TCH	9	1.8			9	0.3	1.1
LNS	3	0.6			3	0.1	0.4
LSS	50	10.0	13	0.4	63	1.8	7.9
BBH	152	30.4			152	4.4	19.1
PIKE	2	0.4			2	0.1	0.3
WCT	3	0.6			3	0.1	0.4
CHIN	1	0.2			1	< 0.1	0.1
COT	3	0.6			3	0.1	0.4
PS	44	8.8			44	1.3	5.5
SMB	81	16.2			81	2.4	10.2
LMB	71	14.2			71	2.1	8.9
BC	134	26.8			134	3.9	16.8
YP	210	131.3			210	6.1	26.4
GRAND TOTALS	**778**	**155.6**	**19**	**0.6**	**797**	**23.2**	**100.0**

Table A-7. The winter catch per unit effort (CPUE), in hours, and the total relative abundance (RA) of each species captured in shoreline zones.

SPECIES	ELECTRO n	ELECTRO CPUE	TOTAL RA
TCH	2	0.5	3.5
LSS	17	4.6	29.8
BBH	29	7.8	50.9
KOK	1	0.3	1.8
LMB	3	0.8	5.3
YP	5	1.4	8.8
GRAND TOTALS	**57**	**15.4**	**100.0**

Table A-8. The winter catch per unit effort (CPUE) for all gear types, in hours, and the total relative abundance (RA) of each species captured in tributary zones.

	ELECTRO		HORIZONTAL NET		TOTAL		
SPECIES	**n**	**CPUE**	**n**	**CPUE**	**n**	**CPUE**	**RA**
NPM			3	0.3	3	0.3	8.3
TCH			1	0.1	1	0.1	2.8
BLS			4	0.4	4	0.4	11.1
LSS	11	6.1	4	0.4	15	1.3	41.7
BBH	2	1.1			2	0.2	5.6
KOK	2	1.1			2	0.2	5.7
MWF	4	2.2			4	0.4	11.1
BT			1	0.1	1	0.1	2.8
YP	3	1.7	1	0.1	4	0.4	11.1
GRAND TOTALS	**22**	**12.2**	**14**	**1.5**	**36**	**3.2**	**100.0**

Table A-9. The spring catch per unit effort (CPUE), in hours, and the total relative abundance (RA) of each species captured in pelagic zones.

	HORIZONTAL NET		TOTAL
SPECIES	**n**	**CPUE**	**RA**
NPM	2	0.2	25.0
TCH	1	0.1	12.5
LSS	3	0.2	37.5
PIKE	1	0.1	12.5
YP	1	0.1	12.5
GRAND TOTALS	**8**	**0.6**	**100.0**

Table A-10. The spring catch per unit effort (CPUE), in hours, and the total relative abundance (RA) of each species captured in shoreline zones.

	ELECTRO		HORIZONTAL NET		TOTAL		
SPECIES	**n**	**CPUE**	**n**	**CPUE**	**n**	**CPUE**	**RA**
NPM	49	5.6	2	0.1	51	1.7	11.0
TCH	11	1.3			11	0.4	2.4
LNS	1	0.1			1	< 0.1	0.2
BLS	2	0.2	2	0.1	4	0.1	0.9
LSS	124	14.2			124	4.1	26.8
BBH	11	1.3			11	0.4	2.4
PIKE	4	0.5	1	< 0.1	5	0.2	1.1
WCT	58	6.7			58	1.9	12.5
RBT	1	0.1			1	< 0.1	0.2
KOK	26	3.0			26	0.9	5.6
CHIN	60	6.9	1	< 0.1	61	2.0	13.2
MWF	1	0.1			1	< 0.1	0.2
PS	1	0.1			1	< 0.1	0.2
SMB	62	7.1			62	2.0	13.4
LMB	11	1.3			11	0.4	2.4
BC	6	0.7	1	< 0.1	7	0.2	1.5
YP	25	2.9	3	0.1	28	0.9	6.1
GRAND TOTALS	**453**	**52.1**	**3**	**0.5**	**463**	**15.2**	**100.0**

Table A-11. The spring catch per unit effort (CPUE), in hours, and the total relative abundance (RA) of each species captured in tributary zones.

	ELECTRO		HORIZONTAL NET		TOTAL		
SPECIES	**n**	**CPUE**	**n**	**CPUE**	**n**	**CPUE**	**RA**
NPM	21	2.8	3	0.1	24	0.5	4.3
TCH	24	3.2			24	0.5	4.3
LNS	7	0.9			7	0.1	1.3
BLS	1	0.1			1	< 0.1	0.2
LSS	59	7.9	3	0.1	62	1.2	11.2
BBH	79	10.5	1	< 0.1	80	1.5	14.5
PIKE	5	0.7	2	< 0.1	7	0.1	1.3
WCT	32	4.3			32	0.6	5.8
KOK	2	0.3			2	< 0.1	0.4
CHIN	16	2.1			16	0.3	2.9
MWF	1	0.1			1	< 0.1	0.2
PS	6	0.8			6	0.1	1.1
SMB	53	7.1			53	1.0	9.6
LMB	58	7.7			58	1.1	10.5
BC	45	6.0	5	0.1	50	1.0	9.0
YP	121	16.1	9	0.2	130	2.5	23.5
GRAND TOTALS	**530**	**70.7**	**23**	**0.5**	**553**	**10.6**	**100.0**

APPENDIX B: SEASONAL FEEDING HABITS

The seasonal food habits data were combined to describe the annual food habits described in the main report. Here, I report on the seasonal food habits. The methods used were the same as described in the main report.

Northern pikeminnow

Summer

During the summer sampling period, 76 northern pikeminnow stomachs were collected throughout the sampling area, five of which were empty. Table B-1 summarizes the relative importance of summer prey items to their diet. Insect parts were found frequently in northern pikeminnow stomachs, and were important to the diets of northern pikeminnow in the summer. Salmon were very important to their diets as were kokanee. Many *Daphnia* were found in a few stomachs, but the high numbers present increased the importance to the summer feeding of northern pikeminnow. A preference for salmonid prey is evident.

Six northern pikeminnow stomachs were collected from the pelagic zone during the summer sampling period, two of which were empty. Table B-2 displays the relative importance of prey items to northern pikeminnow in the pelagic zone during the summer. Kokanee were more than twice as important as any other predator in this zone. Ostracods were abundant in stomach samples also. Insects remained an important diet item.

During the summer sampling period, the shoreline produced 41 northern pikeminnow stomachs, 3 were empty. Table B-3 summarizes the importance of each prey item for the shoreline zone during summer. Insects were very important to northern pikeminnow in shoreline zones in the summer. They were found in 85% of all stomachs.

Kokanee and salmon once again were the most important prey fish to northern pikeminnow.

Twenty-nine northern pikeminnow stomachs from tributary zone were analyzed from the summer sampling effort. No stomachs were empty from this zone. Table B-4 displays the relative importance of prey items to northern pikeminnow in tributary zones for the summer. Insects seem to be the most important diet item to northern pikeminnow in tributary zones. They make up very little of the weight composition of the diet, but are abundant in numbers. Salmon were the only fish found in northern pikeminnow diets. Decapoda parts were also present in the stomach contents.

Table B-5 displays the summer selection values for the entire sample area and each zone where northern pikeminnow were sampled and had prey fish in their stomach contents. Ivlev's index indicated selection for kokanee and salmon in shoreline zones and the entire system. Salmon were selected for in tributary zones.

Fall

In the fall, 75 northern pikeminnow stomachs were collected from the entire sampling area, nine were empty. Table B-6 summarizes the relative importance of prey items found in their stomachs during the fall. Salmon were the most important prey item to northern pikeminnow in the fall. Insect parts, plants and diptera were also important, making up a larger numerical percent than fish, but fish account for a higher percentage by weight. One bass and one yellow perch were consumed, however salmonids were the dominant type of fish eaten. No cutthroat trout were identified in pikeminnow stomachs, but their preference for salmonids is evident.

Only four northern pikeminnow stomachs were collected from the pelagic zone in the fall sampling period, two of these were empty. Table B-7 summarizes the relative importance of the prey items found in their stomachs. One unknown fish was found in the stomach contents of fall pelagic fish. Plants were the most important prey item to northern pikeminnow.

The shoreline produced 52 stomachs during the fall season. Five of these stomachs were empty. Table B-8 shows the relative importance of each prey item for the shoreline in fall. Salmon were the most important prey item for the shoreline zone in fall. Plants and insects were found in several stomachs, indicating importance as well. Salmonids are the most important prey fish to northern pikeminnow.

In the tributary zones in fall, 19 stomachs were analyzed and three were empty. Table B-9 summarizes the importance of prey items found in these stomachs. As in shoreline and pelagic zones, salmon were the most important prey item followed by plants and insect parts. Two unidentifiable fish were also found in stomach samples from fall tributary zones. No cutthroat trout were identified.

Table B-10 displays the fall selection values for the entire sample area and each zone where northern pikeminnow were sampled and had prey fish in their stomach contents. Salmon were selected for in each zone and the sample area. No fish were identifiable from the pelagic zone in the fall.

Winter

During the winter sampling period, three northern pikeminnow stomachs were collected from tributary zones. All three were empty.

Spring

The spring sampling period yielded 73 stomachs throughout the sampling area. Of these stomachs, 21 were empty. Table B-11 displays the relative importance of each prey item during the spring quarter. Salmon were important prey items to pikeminnow in the spring. Plants, annelids, and insect parts were frequently encountered in northern pikeminnow stomachs in the spring.

Two stomachs were collected from the pelagic zone in the spring, neither of which was empty. Table B-12 displays the importance of prey items found in pikeminnow from the pelagic zones in spring. Dipterans and plants were the only prey items found in pelagic stomachs in the spring. This could be attributed to a small sample size.

Forty-eight stomachs were analyzed from shoreline zones in the spring. Sixteen of these stomachs were empty. Table B-13 shows the relative importance of each prey item from the shoreline zones in the spring. Annelida, insect parts and plants were the most important prey items from shoreline zones. Gastropods were more prevalent in the stomachs of spring pikeminnow than any other season. Six unknown fish and a salmon accounted for about 17% of the relative importance.

Tributary zones in the spring yielded 23 northern pikeminnow stomachs, five were empty. Table B-14 shows the relative importance of prey items during the spring for tributary zones. Salmon was the most important prey item in tributary zones. Plants, insect parts and trichoptera were all very important as well. A total of four fish were found in the stomach contents of northern pikeminnow from tributary zones in the spring.

Table B-15 displays the spring selection values for the entire sample area and each zone where northern pikeminnow were sampled and had prey fish in their stomach contents. Ivlev's index indicates selection for Cottidae in the whole sample area and tributary zones. The relative abundance of sculpins was zero from the environment in the spring (Tables A-9, 10, 11). The only value for which Strauss's index indicates selection for a prey item was for salmon in tributary zones during spring quarter. Both indices indicate selection for salmon.

Table B-1. The total summer relative importance (RI) of each prey item for northern pikeminnow (n=71) as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Annelida	1	1.3	< 0.1	< 0.1	< 0.1	0.3	0.3
Coleoptera	2	1.3	0.1	0.1	< 0.1	0.3	0.4
Decapoda	1	1.3	< 0.1	0.7	0.5	0.5	0.5
Decapoda parts	5	6.6	0.2	5.2	3.4	2.4	2.9
Daphnia	1559	6.6	59.9	0.1	< 0.1	16.0	16.0
Diptera	200	13.2	7.7	0.8	0.1	5.4	5.2
Fish eye	3	4.0	0.1	< 0.1	< 0.1	1.0	1.0
Hymenoptera	4	4.0	0.2	< 0.1	< 0.1	1.0	1.0
Insect heads	398	40.8	15.3	0.9	0.1	13.5	13.7
Insect parts	63	82.9	2.4	26.8	7.2	22.2	27.0
Kokanee	2	2.6	0.1	29.7	43.5	11.1	7.8
Nematoda	24	11.8	0.9	< 0.1	< 0.1	3.1	3.1
Odonata	281	7.9	10.8	0.8	0.1	4.5	4.7
Orthoptera	2	2.6	0.1	< 0.1	< 0.1	0.7	0.7
Ostracoda	40	4.0	1.5	< 0.1	< 0.1	1.3	1.3
Plants	11	14.5	0.4	1.1	0.3	3.7	3.8
Salmon	2	2.6	0.1	33.3	44.4	11.3	8.7
Salmonidae	1	1.3	< 0.1	0.4	0.2	0.4	0.4
Unknown fish	3	4.0	0.1	< 0.1	< 0.1	1.0	1.0
Yellow perch	2	2.6	0.1	0.2	0.1	0.7	0.7
GRAND TOTALS	**2604**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-2. The relative importance (RI) of each prey item for northern pikeminnow (n=4) in pelagic zones during the summer sampling period as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Hymenoptera	1	16.7	5.3	0.1	< 0.1	6.3	6.3
Insect heads	6	16.7	31.6	0.2	< 0.1	13.8	13.9
Insect parts	2	33.3	10.5	5.4	0.4	12.7	14.1
Kokanee	1	16.7	5.3	89.0	97.6	34.2	31.7
Ostracoda	6	16.7	31.6	0.1	< 0.1	13.8	13.8
Plants	1	16.7	5.3	0.1	< 0.1	6.3	6.3
Salmonidae	1	16.7	5.3	5.1	1.9	6.8	7.7
Unknown fish	1	16.7	5.3	0.1	< 0.1	6.3	6.3
GRAND TOTALS	**19**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-3. The relative importance (RI) of each prey item for northern pikeminnow (n=38) in the shoreline zones during the summer sampling period as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Annelida	1	2.4	< 0.1	< 0.1	< 0.1	0.6	0.6
Decapoda	1	2.4	< 0.1	1.0	0.6	0.7	0.8
Daphnia	1559	12.2	64.2	0.2	< 0.1	17.5	17.5
Diptera	193	14.6	8.0	1.1	0.2	5.2	5.4
Fish eye	3	7.3	0.1	< 0.1	0.1	1.7	1.7
Hymenoptera	3	4.9	0.1	< 0.1	< 0.1	1.2	1.2
Insect heads	301	51.2	12.4	0.9	0.1	14.6	14.8
Insect parts	35	85.4	1.4	20.04	4.8	21.0	24.5
Kokanee	1	2.4	< 0.1	33.89	45.1	10.9	8.3
Nematoda	7	12.2	0.3	< 0.1	< 0.1	2.9	2.9
Odonata	281	14.6	11.6	1.2	0.2	6.0	6.3
Orthoptera	1	2.4	< 0.1	< 0.1	< 0.1	0.6	0.6
Ostracoda	34	4.9	1.4	< 0.1	< 0.1	1.4	1.4
Plants	3	7.3	0.1	< 0.1	< 0.1	1.7	1.7
Salmon	1	2.4	< 0.1	41.3	48.9	11.8	10.0
Unknown fish	2	4.9	0.1	< 0.1	< 0.1	1.1	1.1
Yellow perch	2	4.9	0.1	0.2	0.1	1.2	1.2
GRAND TOTALS	**2428**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-4. The relative importance (RI) of each prey item for northern pikeminnow (n=29) in the tributary zones during the summer sampling period as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Coleoptera	2	3.3	1.3	0.2	0.3	1.2	1.2
Decapoda parts	5	16.7	3.2	21.1	24.4	11.2	10.4
Diptera	7	13.3	4.5	0.1	< 0.1	4.5	4.5
Insect heads	91	30.0	58.0	1.2	0.3	22.4	22.7
Insect parts	26	86.7	16.6	51.8	24.9	32.6	39.4
Nematoda	17	13.3	10.8	< 0.1	< 0.1	6.2	6.2
Orthoptera	1	3.3	0.6	< 0.1	< 0.1	1.0	1.0
Plants	7	23.3	4.5	4.2	2.4	7.7	8.1
Salmon	1	3.3	0.6	21.3	47.8	13.2	6.4
GRAND TOTALS	**157**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-5. Northern pikeminnow summer selection values for the total sample area and each zonal designation using Strauss' (1979) (L) and Ivlev's (1961) (E) methods. Percent by number is the proportion of a fish species in the stomach divided by the total number of prey fish in the stomach (% BY#) and RA is the relative abundance of the prey fish in the environment.

	TOTAL				PELAGIC				SHORELINE				TRIBUTARY			
PREY SPECIES	% BY #	RA	L	E	% BY #	RA	L	E	% BY #	RA	L	E	% BY #	RA	L	E
Kokanee	0.20	0.03	0.17	0.73	0.33	0.39	-0.05	-0.07	0.17	0.01	0.15	0.86				
Salmon	0.20	0.03	0.17	0.71					0.17	0.01	0.15	0.84	1.00	0.00	1.00	0.99
Salmonidae	0.10	0.05	0.05	0.37	0.33	0.48	-0.15	-0.18								
Yellow Perch	0.20	0.13	0.07	0.20					0.33	0.08	0.25	0.60				

Table B-6. The total fall relative importance (RI) of each prey item for northern pikeminnow (n=66) as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Amphipod	4	2.7	1.2	< 0.1	< 0.1	1.1	1.1
Arachnid	5	1.3	1.4	< 0.1	< 0.1	0.8	0.8
Bass	1	1.3	0.3	0.6	0.5	0.6	0.6
Coleoptera	17	4.0	4.9	0.1	< 0.1	2.4	2.5
Collembola	79	5.3	22.8	< 0.1	< 0.1	7.8	7.7
Decapoda	1	1.3	0.3	0.8	0.4	0.7	0.7
Decapoda parts	1	1.3	0.3	0.9	0.5	0.6	0.7
Cyclopoida	2	2.7	0.6	< 0.1	< 0.1	0.9	0.9
Daphnia	1	1.3	0.3	< 0.1	< 0.1	0.4	0.4
Diptera	83	9.3	23.9	0.1	< 0.1	9.1	9.1
Fish eye	6	4.0	1.7	< 0.1	< 0.1	1.6	1.6
Hemiptera	19	2.7	5.5	< 0.1	< 0.1	2.2	2.2
Hymenoptera	15	6.7	4.3	< 0.1	< 0.1	3.0	3.0
Insect heads	23	5.3	6.6	< 0.1	< 0.1	3.3	3.3
Insect parts	29	38.7	8.4	3.5	0.8	13.1	13.8
Kokanee	1	1.3	0.3	19.3	23.6	6.9	5.7
Nematoda	6	6.7	1.7	< 0.1	< 0.1	2.3	2.3
Orthoptera	3	1.3	0.9	< 0.1	< 0.1	0.6	0.6
Plants	34	45.3	9.8	0.4	0.1	15.1	15.2
Salmon	9	12.0	2.6	73.2	73.2	24.0	24.0
Unknown fish	7	9.3	2.0	1.1	0.8	3.3	3.4
Yellow perch	1	1.3	0.3	0.1	0.1	0.5	0.5
GRAND TOTALS	**347**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-7. The relative importance (RI) of each prey item for northern pikeminnow (n=2) collected in the pelagic zones in fall as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Plants	2	50.0	66.7	76.4	54.6	62.3	70.2
Unknown fish	1	25.0	33.3	23.6	45.5	37.7	29.8
GRAND TOTALS	**3**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-8. The relative importance (RI) of each prey item for northern pikeminnow collected in the shoreline zones in fall as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Amphipod	4	3.9	1.3	< 0.1	< 0.1	1.3	1.3
Arachnid	5	1.9	1.6	< 0.1	< 0.1	0.9	0.9
Bass	1	1.9	0.3	0.7	0.6	0.7	0.8
Coleoptera	17	5.8	5.4	0.1	< 0.1	2.9	2.9
Collembola	78	5.8	24.7	< 0.1	< 0.1	7.9	7.9
Cyclopoida	2	3.9	0.6	< 0.1	< 0.1	1.2	1.2
Daphnia	1	1.9	0.3	< 0.1	< 0.1	0.6	0.6
Diptera	82	11.5	26.0	0.1	< 0.1	9.8	9.8
Fish eye	6	5.8	1.9	< 0.1	< 0.1	2.0	2.0
Hemiptera	19	3.9	6.0	< 0.1	< 0.1	2.6	2.6
Hymenoptera	15	9.6	4.8	< 0.1	< 0.1	3.7	3.8
Insect heads	19	5.8	6.0	< 0.1	< 0.1	3.1	3.1
Insect parts	23	44.2	7.3	3.6	0.8	13.6	14.3
Kokanee	1	1.9	0.3	21.0	25.0	7.1	6.1
Nematoda	4	5.8	1.3	< 0.1	< 0.1	1.8	1.8
Orthoptera	3	1.9	1.0	< 0.1	< 0.1	0.8	0.8
Plants	24	46.2	7.6	0.3	0.1	14.0	14.1
Salmon	7	13.5	2.2	72.9	72.6	23.0	23.0
Unknown fish	4	7.7	1.3	1.1	0.8	2.6	2.6
Yellow perch	1	1.9	0.3	0.1	0.1	0.6	0.6
GRAND TOTALS	**316**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-9. The relative importance (RI) of each prey item for northern pikeminnow (n=16) collected in the tributary zones in fall as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Collembola	1	5.3	3.6	< 0.1	< 0.1	2.7	2.7
Decapoda	1	5.3	3.6	9.8	7.4	4.9	5.6
Decapoda parts	1	5.3	3.6	10.7	8.4	5.2	5.9
Diptera	1	5.3	3.6	0.1	< 0.1	2.7	2.7
Insect heads	4	5.3	14.3	0.1	< 0.1	5.9	5.9
Insect parts	6	31.6	21.4	2.3	0.4	16.1	16.7
Nematoda	2	10.5	7.1	< 0.1	< 0.1	5.3	5.3
Plants	8	42.1	28.6	0.8	0.2	21.4	21.6
Salmon	2	10.5	7.1	76.2	83.5	30.5	28.3
Unknown fish	2	10.5	7.1	0.1	0.1	5.4	5.4
GRAND TOTALS	**28**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-10. Northern pikeminnow fall selection values for the total sample area and each zonal designation using Strauss' (1979) (L) and Ivlev's (1961) (E) methods. Percent by number is the proportion of a fish species in the stomach divided by the total number of prey fish in the stomach (% BY#) and RA is the relative abundance of the prey fish in the environment. Shaded values indicate selection for or against (positive and negative values, respectively) a specific prey.

	TOTAL				SHORELINE				TRIBUTARY			
PREY SPECIES	% BY #	RA	L	E	% BY #	RA	L	E	% BY #	RA	L	E
Bass	0.05	0.22	-0.17	-0.62	0.07	0.26	-0.19	-0.57				
Kokanee	0.05	0.01	0.04	0.60	0.07	0.02	0.05	0.51				
Salmon	0.47	0.01	0.46	0.94	0.50	0.02	0.48	0.91	0.50	0.00	0.50	0.99
Yellow Perch	0.05	0.23	-0.18	-0.63	0.07	0.21	-0.14	-0.49				

Table B-11. The total spring relative importance (RI) of each prey item for northern pikeminnow (n=52) as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Amphipod	2	2.7	1.4	< 0.1	< 0.1	1.3	1.3
Annelida	19	5.5	12.8	17.8	17.6	11.1	11.2
Cottidae	2	2.7	1.4	22.2	20.7	7.7	8.1
Decapoda	1	1.4	0.7	4.7	7.6	3.0	2.1
Diptera	4	4.1	2.7	< 0.1	< 0.1	2.1	2.1
Ephemeroptera	13	1.4	8.8	0.2	0.1	3.2	3.2
Gastropods	22	9.6	14.9	4.2	2.0	8.2	8.9
Insect heads	2	1.4	1.4	< 0.1	< 0.1	0.8	0.9
Insect parts	21	28.8	14.2	5.2	2.5	14.1	14.9
Nematoda	1	1.4	0.7	< 0.1	< 0.1	0.6	0.6
Plants	25	34.3	16.9	6.8	3.8	17.0	17.9
Salmon	4	5.5	2.7	31.2	38.7	14.5	12.2
Tapeworm	4	5.5	2.7	1.2	0.9	2.8	2.9
Trichoptera	21	9.6	14.2	4.0	2.7	8.2	8.6
Unknown fish	7	9.6	4.7	2.3	3.3	5.4	5.2
GRAND TOTALS	**148**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-12. The relative importance (RI) of each prey item for northern pikeminnow (n=2) collected in the pelagic zones in spring as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Diptera	1	50.0	50.0	4.6	4.2	34.7	34.9
Plants	1	50.0	50.0	95.4	95.8	65.3	65.1
GRAND TOTALS	**2**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-13. The relative importance (RI) of each prey item for northern pikeminnow (n=32) collected in the shoreline zones in spring as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Amphipod	1	2.1	1.0	< 0.1	< 0.1	0.9	0.9
Annelida	19	8.3	18.1	21.9	20.6	14.4	14.8
Cottidae	2	4.2	1.9	27.2	24.3	9.3	10.2
Decapoda	1	2.1	1.0	5.8	8.9	3.7	2.7
Diptera	2	2.1	1.9	< 0.1	< 0.1	1.2	1.2
Ephemeroptera	13	2.1	12.4	0.2	0.1	4.5	4.5
Gastropods	15	12.5	14.3	2.50	1.2	8.6	9.0
Insect heads	2	2.1	1.9	< 0.	< 0.1	1.2	1.2
Insect parts	13	27.1	12.4	3.5	1.7	12.6	13.1
Nematoda	1	2.1	1.0	< 0.1	< 0.1	0.9	0.9
Plants	15	31.3	14.3	7.1	3.8	15.1	16.1
Salmon	1	2.1	1.0	25.2	33.2	11.1	8.6
Tapeworm	4	8.3	3.8	1.5	1.1	4.0	4.2
Trichoptera	10	8.3	9.5	2.4	1.4	5.9	6.2
Unknown fish	6	12.5	5.7	2.7	3.8	6.7	6.4
GRAND TOTALS	**105**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-14. The relative importance (RI) of each prey item for northern pikeminnow collected in the tributary zones in spring as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Amphipod	1	4.4	2.4	< 0.1	< 0.1	2.1	2.2
Diptera	1	4.4	2.4	< 0.1	< 0.1	2.1	2.1
Gastropods	7	4.4	17.1	11.8	6.8	8.9	10.5
Insect parts	8	34.8	19.5	13.0	7.7	19.5	21.2
Plants	9	39.1	22.0	5.3	3.3	20.3	20.9
Salmon	3	13.0	7.3	57.7	71.5	28.9	24.6
Trichoptera	11	13.0	26.8	11.4	10.5	15.9	16.2
Unknown fish	1	4.4	2.4	0.8	0.3	2.2	2.4
GRAND TOTALS	**41**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-15. Northern pikeminnow spring selection values for the total sample area and each zonal designation using Strauss' (1979) (L) and Ivlev's (1961) (E) methods. Percent by number is the proportion of a fish species in the stomach divided by the total number of prey fish in the stomach (% BY#) and RA is the relative abundance of the prey fish in the environment. Shaded values indicate selection for or against (positive and negative values, respectively) for a specific prey item.

PREY SPECIES	TOTAL				SHORELINE				TRIBUTARY			
	% BY #	RA	L	E	% BY #	RA	L	E	% BY #	RA	L	E
Cottidae	0.15	0.00	0.15	1.00	0.22	0.00	0.22	1.00				
Salmon	0.31	0.10	0.21	0.50	0.11	0.19	-0.08	-0.26	0.75	0.03	0.72	0.92

Chinook salmon

Summer

During our summer sampling effort, two chinook salmon (total lengths 280 mm and 367 mm) were caught and their stomachs analyzed, both had prey items in them. The relative importance of these prey items are shown in Table B-16. One unidentified fish was twice as important to the chinook as the other prey items were. Insect parts and one nematode were also identified.

Thirty-nine stomachs were collected from derby fish (“The Big Ones” annual chinook salmon derby on Coeur d’Alene Lake) during the summer quarter. Eleven derby fish were empty. These fish were not included in the relative abundance data. Table B-17 gives the relative importance of prey items found in derby fish stomachs. Salmonids were by far the most important prey items to chinook salmon, and no other types of fish were identified in their stomach contents. Kokanee, salmon, and Salmonidae were all abundant in stomach contents. Two westslope cutthroat trout were positively identified from two chinook salmon stomachs.

All of the chinook salmon from summer whose stomachs were analyzed were caught in the pelagic zones. Two came from gillnets and 39 from the fishing derby. Derby fish were considered to come from the pelagic zone as most anglers reported catching them from 12-27 m deep. Table B-18 displays the relative importance of prey items to chinook salmon captured in pelagic zones. Salmonids were the most important prey items in chinook stomachs. Two fish from the derby had westslope cutthroat trout in their stomachs.

All chinook salmon stomachs that contained identifiable prey fish were collected in the summer quarter and during the derby from fish collected in the pelagic zone. Table B-19 displays the summer selection values for the pelagic zones, derby fish were considered part of the pelagic sampling so the relative abundance of prey fish in the environment is that which was collected during the summer sampling period. Ivlev's index indicates selection for all types of salmonids. This was the only type of prey found in their stomach contents. This selection for salmonids poses a serious threat to westslope cutthroat trout, especially when utilizing the pelagic zone.

Fall

During the fall, two chinook stomachs were analyzed and both had prey items in them. Table B-20 displays the relative importance of the prey items to these fish during the fall. No fish remains were found in the stomach contents of chinook salmon caught in the fall. Hemiptera and plants were the most important items.

One chinook stomach was taken from a shoreline zone in the fall. The relative importance of prey items found in this stomach are reported in Table B-21. The total length of this fish was 204 mm. Hemiptera were the most important prey item. Hymenoptera and arachnids were the next most important.

The other fall chinook stomach was from a tributary zone. This fish's total length was 885 mm. Plants were the only items in its stomach. This fish was preparing to spawn when captured in Anderson Lake (grid 161, P-1).

Table B-16. The total summer relative importance (RI) of each prey item for chinook salmon (n=2) as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Insect parts	1	50.0	33.3	5.5	2.6	24.6	25.4
Unknown fish	1	50.0	33.3	93.4	94.8	50.9	50.5
Nematoda	1	50.0	33.3	1.1	2.6	24.6	24.1
GRAND TOTALS	**3**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-17. The relative importance (RI) of each prey item for chinook salmon (n=28) collected in the fishing derby during August 2001, as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Fish eye	8	15.4	9.3	< 0.1	< 0.1	8.0	8.0
Insect parts	1	2.6	1.2	< 0.1	< 0.1	1.2	1.2
Kokanee	7	12.8	8.1	72.6	42.1	20.3	30.2
Nematoda	46	23.1	53.5	< 0.1	< 0.1	24.7	24.7
Salmon	9	18.0	10.5	18.1	38.8	21.7	15.0
Salmonidae	11	28.2	12.8	8.8	18.4	19.2	16.1
Unknown fish	2	5.1	2.3	< 0.1	< 0.1	2.4	2.4
Westslope cutthroat	2	5.1	2.3	0.4	0.6	2.6	2.5
GRAND TOTALS	**86**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-18. The relative importance (RI) of each prey item for chinook salmon (n=30) collected in the pelagic zones, including derby fish, as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Fish eye	8	14.0	9.0	< 0.1	< 0.1	7.5	7.5
Insect parts	2	4.7	2.3	< 0.1	< 0.1	2.3	2.3
Kokanee	7	11.633	7.9	72.5	42.1	20.1	30.0
Nematoda	47	23.3	52.8	< 0.1	< 0.1	24.8	24.8
Salmon	9	16.3	10.1	18.1	38.8	21.2	14.5
Salmonidae	11	25.6	12.4	8.8	18.4	18.4	15.2
Unknown fish	3	7.0	3.4	0.1	0.1	3.4	3.4
Westslope cutthroat	2	4.7	2.3	0.4	0.6	2.4	2.3
GRAND TOTALS	**89**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-19. Chinook salmon summer selection values for the pelagic zones using Strauss' (1979) (L) and Ivlev's (1961) (E) methods. Percent by number is the proportion of a fish species in the stomach divided by the total number of prey fish in the stomach (% BY#) and RA is the relative abundance of the prey fish in the environment.

PREY SPECIES	PELAGIC			
	%BY #	RA	L	E
Kokanee	0.22	0.00	0.21	0.96
Salmon	0.28	0.00	0.28	0.97
Salmonidae	0.34	0.01	0.33	0.94
Westslope Cutthroat	0.06	0.01	0.06	0.82

Table B-20. **The relative importance (RI) of each prey item for chinook salmon (n=2) collected in fall throughout the entire sample area as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).**

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Arachnid	4	50.0	7.6	1.9	1.1	13.0	13.2
Hemiptera	38	50.0	71.7	8.3	8.3	28.9	28.9
Hymenoptera	8	50.0	15.1	5.0	7.5	16.1	15.6
Insect parts	1	50.0	1.9	1.0	0.9	11.7	11.8
Plants	2	50.0	3.8	83.8	82.2	30.2	30.6
GRAND TOTALS	**53**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-21. **The relative importance (RI) of prey items for the chinook salmon collected in fall from a shoreline zone as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).**

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Arachnid	4	100.0	7.8	11.8	6.0	19.0	19.9
Hemiptera	38	100.0	74.5	51.2	46.6	36.9	37.6
Hymenoptera	8	100.0	15.7	30.7	42.1	26.3	24.4
Insect parts	1	100.0	2.0	6.3	5.3	17.9	18.1
GRAND TOTALS	**51**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Largemouth bass

<u>Summer</u>

A total of nine largemouth bass stomachs were analyzed in the summer quarter, one was empty. Table B-22 details the relative importance of prey items to the diet of largemouth bass in the summer. Insect parts and plants were the most important prey items to largemouth bass. Plants were likely present as a product of the environment largemouth bass prefer. Black crappie were the most abundant prey fish in their diets. Diptera and odonata were both important prey items and had high frequencies of occurrence. One northern pikeminnow was identified, three yellow perch, and two unknown fish. Relative piscivory was somewhat low.

Three largemouth bass stomachs were collected from shoreline zones in the summer. None of them were empty. Table B-23 shows the relative importance of each prey item to these shoreline fish in the summer. Odonata, diptera, and other insect parts were the most important prey items to largemouth bass from shoreline zones in the summer. One unknown fish was found in the stomach contents.

Six stomachs were also collected from tributary zones in the summer, one of which was empty. The relative importance for each prey item consumed by largemouth bass in tributary zones in the summer are given in Table B-24. Black crappie and insect parts were the two most important prey items to largemouth bass from tributary sections. Dipterans and yellow perch were also main prey items.

Table B-25 displays the summer selection values for the entire sample area and each zone where largemouth bass were sampled and had prey fish in their stomach contents. Overall, largemouth bass seem to eat prey as it is available. Ivlev’s index indicates selection for Cottidae, however few Cottidae were recruited to the sampling gear for relative abundance in the environment.

<u>Fall</u>

Twenty-five largemouth bass stomachs were collected in the fall sampling period, two were empty. Table B-26 displays the relative importance of each prey item to these fish. Plants and unknown fish had about equal importance to the diets of largemouth bass in the fall. It is likely that plants were ingested incidentally with the prey fish. Yellow perch and black crappie were the next most important prey items. Piscivory increased in the fall relative to summer quarter. No salmonids were identified in largemouth bass stomachs.

In the fall, eight stomachs were analyzed from shoreline zones, one of which was empty. Table B-27 shows the relative importance of each prey item for these fish. In shoreline zones, black crappie, yellow perch and unknown fish were by far the most important prey items. Largemouth bass stomach contents consisted almost entirely of fish remains.

The relative importance of each prey item from the fall tributary zones is displayed in Table B-28. Fall sampling in tributary zones produced 17 largemouth bass stomachs, one was empty. Unidentified fish were the most important prey item in tributary zones. Black crappie and decapoda (crayfish) were the next most important prey items.

Table B-29 displays the fall selection values for the entire sample area and each zone where largemouth bass were sampled and had prey fish in their stomach contents.

Selection for or against fish prey was not indicated during the fall. Largemouth bass seem to eat what is available to them in the environment.

Winter

All three largemouth bass stomachs collected during the winter came from shoreline zones, none were empty. Table B-30 shows the relative importance of each prey item from the winter. Fish were the only prey items found in the stomach contents. Yellow perch were the most important prey.

Table B-31 displays the winter selection values for prey fish found in largemouth bass stomachs. All largemouth bass stomach samples from winter quarter were collected in shoreline zones. Yellow perch were selected for according to Ivlev's index.

Spring

Fifty-eight largemouth bass stomachs were analyzed from spring collection, 12 were empty. Table B-32 details the relative importance of prey items to the diet of all largemouth bass analyzed from the spring. Brown bullhead, yellow perch, and black crappie were the most important prey items in the spring. Piscivory was relatively high in the spring compared to other seasons. Several types of invertebrate prey were also present, but fish remains were by far the most important items. No salmonids were identified, however there were seven fish too far digested to identify.

Eleven stomachs were collected from shoreline zones in the spring, three were empty. Table B-33 shows the relative importance of each prey item to largemouth bass in shoreline zones in the spring. Brown bullhead were the most important prey item in the stomach contents. Yellow perch, hemiptera and insect parts were also very important.

Nine of 47 largemouth bass stomachs were empty from tributary zones in the spring. Table B-34 gives the relative importance of each prey item from these fish. Brown bullhead, black crappie, and yellow perch were the three most abundant prey species, respectively. Odonata were the most important invertebrate prey item in largemouth bass stomachs.

Table B-35 displays the spring selection values for the entire sample area and each zone where largemouth bass were sampled and had prey fish in their stomach contents. Cannibalism was avoided in largemouth according to Ivlev's index. Black crappie, brown bullhead, and yellow perch were all selected for in shoreline zones in the spring according to Ivlev's index.

Table B-22. The relative importance (RI) of each prey item for largemouth bass (n=8) collected in summer throughout the entire sample area as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Amphipod	1	11.1	1.0	< 0.1	< 0.1	1.9	1.9
Black crappie	3	11.1	3.0	68.1	77.3	13.9	12.5
Coelenterata	1	11.1	1.0	< 0.1	< 0.1	1.9	1.9
Cottidae	1	11.1	1.0	0.7	0.4	1.9	2.0
Decapoda parts	1	11.1	1.0	1.6	1.2	2.0	2.1
Diptera	17	66.7	17.0	0.2	0.1	12.8	12.8
Ephemeroptera	4	22.2	4.0	0.1	< 0.1	4.0	4.0
Fish eye	1	11.1	1.0	< 0.1	< 0.1	1.9	1.9
Insect heads	14	22.2	14.0	0.2	< 0.1	5.5	5.6
Insect parts	7	77.8	7.0	1.6	0.2	13.0	13.2
Nematoda	1	11.1	1.0	< 0.1	< 0.1	1.9	1.9
Neuroptera	2	11.1	2.0	< 0.1	< 0.1	2.0	2.0
Northern pikeminnow	1	11.1	1.0	9.9	10.2	3.4	3.4
Odonata	33	33.3	33.0	0.6	0.2	10.2	10.2
Plants	8	88.9	8.0	4.4	0.8	15.0	15.5
Unknown fish	2	22.2	2.0	3.5	1.8	4.0	4.2
Yellow perch	3	22.2	3.0	9.1	7.7	5.0	5.2
GRAND TOTALS	**100**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-23. The relative importance (RI) of prey items for largemouth bass (n=3) collected in the summer from shoreline zones as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Amphipod	1	33.3	2.2	0.6	0.3	5.1	5.2
Coelenterata	1	33.3	2.2	< 0.1	0.1	5.1	5.1
Diptera	3	100.0	6.7	1.2	0.9	15.4	15.4
Insect heads	2	33.3	4.4	3.5	2.4	5.7	5.9
Insect parts	2	66.7	4.4	12.3	3.9	10.7	11.9
Nematoda	1	33.3	2.2	0.4	0.4	5.1	5.1
Odonata	31	66.7	68.9	16.8	12.4	21.1	21.8
Plants	3	100.0	6.7	25.5	15.5	17.4	18.9
Unknown fish	1	33.3	2.2	39.9	64.2	14.3	10.8
GRAND TOTALS	**45**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-24. The relative importance (RI) of prey items for largemouth bass (n=5) collected in the summer from tributary zones as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Black crappie	3	16.7	5.5	70.2	78.1	15.8	14.6
Cottidae	1	16.7	1.8	0.7	0.4	3.0	3.0
Decapoda parts	1	16.7	1.8	1.6	1.2	3.1	3.2
Diptera	14	50.0	25.5	0.1	0.1	11.9	11.9
Ephemeroptera	4	33.3	7.3	0.1	< 0.1	6.4	6.4
Fish eye	1	16.7	1.8	< 0.1	< 0.1	2.9	2.9
Insect heads	12	16.7	21.8	0.1	< 0.1	6.1	6.1
Insect parts	5	83.3	9.1	1.3	0.2	14.6	14.8
Neuroptera	2	16.7	3.6	< 0.1	< 0.1	3.2	3.2
Northern pikeminnow	1	16.7	1.8	10.2	10.3	4.6	4.5
Odonata	2	16.7	3.6	0.2	0.1	3.2	3.2
Plants	5	83.3	9.1	3.7	0.6	14.7	15.2
Unknown fish	1	16.7	1.8	2.4	1.1	3.1	3.3
Yellow perch	3	33.3	5.5	9.4	7.8	7.4	7.6
GRAND TOTALS	**55**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-25. Largemouth bass summer selection values for the total sample area and tributary zones using Strauss' (1979) (L) and Ivlev's (1961) (E) methods. Percent by number is the proportion of a fish species in the stomach divided by the total number of prey fish in the stomach (% BY#) and RA is the relative abundance of the prey fish in the environment.

PREY SPECIES	TOTAL				TRIBUTARY			
	% BY #	RA	L	E	% BY #	RA	L	E
Bass								
Black crappie	0.30	0.12	0.18	0.42	0.33	0.14	0.19	0.40
Brown bullhead								
Cottidae	0.10	0.00	0.10	0.91	0.11	0.00	0.11	0.93
Northern Pikeminnow	0.10	0.10	0.00	-0.01	0.11	0.07	0.05	0.26
Pumpkinseed								
Yellow perch	0.30	0.13	0.17	0.38	0.33	0.19	0.14	0.27

Table B-26. The relative importance (RI) of each prey item for largemouth bass (n=23) collected in fall throughout the entire sample area as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Black crappie	5	12.0	11.1	42.3	41.1	17.6	18.0
Decapoda	1	4.0	2.2	13.3	17.1	6.4	5.4
Insect heads	1	4.0	2.2	< 0.1	< 0.1	1.7	1.7
Insect parts	7	28.0	15.6	0.3	0.1	12.0	12.0
Plants	14	56.0	31.1	3.5	1.8	24.4	24.9
Unknown fish	13	52.0	28.9	11.6	7.2	24.2	25.4
Yellow perch	4	8.0	8.9	29.2	32.7	13.6	12.7
GRAND TOTALS	**45**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-27. The relative importance (RI) of prey items for largemouth bass (n=7) collected in the fall from shoreline zones as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Black crappie	3	12.5	18.8	42.9	46.6	22.3	21.2
Insect Parts	1	12.5	6.3	0.3	0.1	5.4	5.4
Plants	3	37.5	18.8	0.8	0.2	16.1	16.3
Unknown fish	6	75.0	37.5	15.0	7.7	34.3	36.4
Yellow perch	3	12.5	18.8	41.1	45.5	21.9	20.7
GRAND TOTALS	**16**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-28. The relative importance (RI) of prey items for largemouth bass collected in the fall from tributary zones as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Black crappie	2	11.8	6.9	41.6	33.6	14.1	16.3
Decapoda	1	5.9	3.5	27.5	40.3	13.4	9.9
Insect heads	1	5.9	3.5	< 0.1	< 0.1	2.5	2.5
Insect parts	6	35.9	20.7	0.2	0.1	15.1	15.2
Plants	11	64.7	37.9	6.3	4.0	28.8	29.4
Unknown fish	7	41.2	24.1	7.9	6.5	19.4	19.8
Yellow perch	1	5.9	3.5	16.4	15.4	6.7	6.9
GRAND TOTALS	**29**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-29. Largemouth bass fall selection values for the total sample area and each zonal designation using Strauss' (1979) (L) and Ivlev's (1961) (E) methods. Percent by number is the proportion of a fish species in the stomach divided by the total number of prey fish in the stomach (% BY#) and RA is the relative abundance of the prey fish in the environment.

	TOTAL				SHORELINE				TRIBUTARY			
PREY SPECIES	% BY #	RA	L	E	%BY #	RA	L	E	%BY #	RA	L	E
Black crappie	0.23	0.13	0.09	0.26	0.25	0.11	0.14	0.39	0.20	0.17	0.03	0.09
Yellow perch	0.18	0.23	-0.05	-0.12	0.25	0.21	0.04	0.09	0.10	0.26	-0.16	-0.45

Table B-30. The relative importance (RI) of prey items for largemouth bass (n=3) collected in the winter from shoreline zones as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Unknown fish	1	33.3	25.0	2.3	0.8	19.7	20.2
Yellow perch	3	66.7	75.0	97.8	99.2	80.3	79.8
GRAND TOTALS	**4**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-31. Largemouth bass winter selection values for shoreline zones using Strauss' (1979) (L) and Ivlev's (1961) (E) methods. Percent by number is the proportion of a fish species in the stomach divided by the total number of prey fish in the stomach (% BY#) and RA is the relative abundance of the prey fish in the environment. Shaded values indicate selection for or against (positive and negative values, respectively) for a specific prey.

	SHORELINE			
PREY SPECIES	%BY #	RA	L	E
Yellow Perch	0.75	0.09	0.66	0.79

Table B-32. The relative importance (RI) of each prey item for largemouth bass (n=12) collected in spring throughout the entire sample area as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Amphipod	1	1.7	0.7	< 0.1	< 0.1	0.7	0.7
Annelida	4	3.5	3.0	0.5	0.6	1.9	1.9
Arachnid	4	6.9	3.0	0.2	0.1	2.7	2.7
Bass	1	1.7	0.7	0.1	0.1	0.7	0.7
Black crappie	4	6.9	3.0	27.3	33.8	11.9	10.1
Brown bullhead	11	19.0	8.2	39.1	36.4	17.3	18.0
Coleoptera	3	5.2	2.2	0.9	1.0	2.3	2.3
Diptera	2	3.5	1.5	< 0.1	< 0.1	1.3	1.3
Hemiptera	11	3.5	8.2	0.1	< 0.1	3.2	3.2
Insect parts	9	15.5	6.7	0.2	0.1	6.1	6.1
Odonata	29	6.9	21.5	0.1	0.1	7.7	7.8
Plants	35	60.3	25.9	3.6	2.1	24.1	24.5
Pumpkinseed	1	1.7	0.7	1.1	0.8	0.9	1.0
Rodent	1	1.7	0.7	5.2	3.7	1.7	2.1
Tapeworm	1	1.7	0.7	0.1	0.1	0.7	0.7
Unknown fish	7	12.1	5.2	0.2	0.1	4.7	4.7
Yellow perch	11	15.5	8.2	21.6	21.1	12.2	12.3
GRAND TOTALS	**135**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-33. **The relative importance (RI) of prey items for largemouth bass (n=8) collected in the spring from shoreline zones as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).**

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Annelida	4	18.2	13.3	1.8	2.1	9.5	9.4
Black crappie	2	18.2	6.7	10.4	7.7	9.2	10.0
Brown bullhead	1	9.1	3.3	57.3	64.2	21.6	19.7
Coleoptera	1	9.1	3.3	1.7	2.1	4.1	4.0
Hemiptera	10	9.1	33.3	0.3	0.1	12.0	12.1
Insect parts	3	27.3	10.0	0.3	0.1	10.6	10.6
Plants	6	54.6	20.0	2.5	1.2	21.4	21.7
Yellow perch	3	9.1	10.0	25.7	22.5	11.7	12.6
GRAND TOTALS	**30**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-34. The relative importance (RI) of prey items for largemouth bass (n=38) collected in the spring from tributary zones as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Amphipod	1	2.1	1.0	< 0.1	< 0.1	0.8	0.8
Arachnid	4	8.5	3.8	0.2	0.2	3.4	3.4
Bass	1	2.1	1.0	0.1	0.1	0.9	0.9
Black crappie	2	4.3	1.9	33.2	43.6	13.5	10.6
Brown bullhead	10	21.3	9.5	32.7	25.9	15.3	17.2
Coleoptera	2	4.3	1.9	0.6	0.5	1.8	1.8
Diptera	2	4.3	1.9	< 0.1	< 0.1	1.7	1.7
Hemiptera	1	2.1	1.0	< 0.1	< 0.1	0.8	0.8
Insect parts	6	12.8	5.7	0.1	0.1	5.0	5.0
Odonata	29	8.5	27.6	0.2	0.1	9.8	9.8
Plants	29	61.7	27.6	4.0	2.4	24.8	25.2
Pumpkinseed	1	2.1	1.0	1.4	1.1	1.1	1.2
Rodent	1	2.1	1.0	7.0	5.2	2.2	2.7
Tapeworm	1	2.1	1.0	0.1	0.2	0.9	0.9
Unknown fish	7	14.9	6.7	0.2	0.1	5.9	5.9
Yellow perch	8	17.0	7.6	20.1	20.6	12.2	12.1
GRAND TOTALS	**105**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-35. Largemouth bass spring selection values for the total sample area and each zonal designation using Strauss' (1979) (L) and Ivlev's (1961) (E) methods. Percent by number is the proportion of a fish species in the stomach divided by the total number of prey fish in the stomach (% BY#) and RA is the relative abundance of the prey fish in the environment. Shaded values indicate selection for or against (positive and negative values, respectively) specific prey items.

PREY SPECIES	TOTAL				SHORELINE				TRIBUTARY			
	% BY #	RA	L	E	% BY #	RA	L	E	% BY #	RA	L	E
Bass	0.03	0.18	-0.15	-0.72					0.03	0.20	-0.17	-0.71
Black crappie	0.11	0.06	0.06	0.35	0.33	0.02	0.32	0.91	0.07	0.09	-0.02	-0.13
Brown bullhead	0.31	0.09	0.22	0.55	0.17	0.02	0.14	0.75	0.34	0.14	0.20	0.41
Pumpkinseed	0.03	0.01	0.02	0.57					0.03	0.02	0.02	0.30
Yellow perch	0.31	0.15	0.16	0.34	0.50	0.06	0.44	0.78	0.28	0.24	0.04	0.08

Smallmouth bass

Summer

A total of 35 smallmouth bass stomachs were analyzed for the summer quarter, one was empty. Table B-36 details the relative importance of prey items to the diet of smallmouth bass in the summer. Insect parts and heads were the most abundant prey items in smallmouth bass stomachs. One kokanee salmon was identified in the stomach contents. Cottidae and pumpkinseed sunfish were the most important fish prey to smallmouth. There were more kinds of prey items found in smallmouth bass stomachs than any other predator.

Twenty-six smallmouth bass stomachs were collected from shoreline zones in the summer, one was empty. Table B-37 shows the relative importance of each prey item to these shoreline fish in the summer. Insect heads and parts were important to smallmouth bass stomachs in shoreline zones. One kokanee salmon was identified and was an important prey to smallmouth bass. Odonata were the most abundant invertebrate prey item after unidentified insect parts and heads.

Nine stomachs were collected from tributary zones in the summer; none were empty. The relative importance for each prey item consumed by smallmouth bass in tributary zones in the summer is given in Table B-38. Unidentifiable insect parts and heads were the most important prey items in tributary zones. Pumpkinseed sunfish were the most important prey fish, followed by unknown fish.

Table B-39 displays the summer selection values for the entire sample area and each zone where smallmouth bass were sampled and had prey fish in their stomach contents. Sculpins were selected for by smallmouth bass in the entire sample area according to Ivlev's index. Kokanee salmon were selected for in shoreline zones.

Fall

Fifty-four smallmouth bass stomachs were collected during the fall, five were empty. Table B-40 displays the relative importance of each prey item of smallmouth bass during the fall. Insect parts were the most important prey. Yellow perch were the most abundant fish prey, followed by Cottidae and unknown fish. No salmonids were identified in the fall.

In the fall, 34 stomachs were collected from shoreline zones, two were found to be empty upon analysis. Table B-41 displays the relative importance of each prey item for smallmouth bass in shoreline zones. Insect parts wee once again the most important prey item to smallmouth bass. Yellow perch and Cottidae were the most important prey fish. Pumpkinseed and bass were the next two most abundant prey fish. No salmonids were identified.

Twenty smallmouth bass stomachs were collected from tributary zones in the fall, three were empty. Table B-42 shows the relative importance of each prey item for these fish. Insects and arachnids were the most important prey items from tributary zones. Unknown fish and pumpkinseed sunfish were the most important prey fish, followed by bass species.

Table B-43 displays the fall selection values for the entire sample area and each zone where smallmouth bass were sampled and had prey fish in their stomach contents.

Cottidae were selected for in shoreline zones and the total sample area. In general, smallmouth bass seem to eat prey as it is available in the environment.

Winter

There were no smallmouth bass stomachs collected winter quarter.

Spring

Thirteen smallmouth bass stomachs were collected during the spring throughout the sample area, one was empty. Table B-44 gives the relative importance of each smallmouth bass prey item during the spring. *Daphnia* and annelida were the most important prey items. Cottidae were the most important fish prey. Yellow perch were the second most important prey fish. One westslope cutthroat trout was identified in the stomach contents of a smallmouth bass in the spring.

In the shoreline zones during spring, 10 smallmouth bass stomachs were analyzed; one was empty. Table B-45 gives the relative importance of prey items to smallmouth bass in the shoreline zones during spring. Ephemeroptera were the most important prey items in shoreline zones. Annelids were the next most important, followed by Cottidae. Black crappie and westslope cutthroat trout were the only other prey fish identified in the stomach contents.

Three stomachs were analyzed from the tributary zones in the spring, all had prey items in them. Table B-46 shows the relative importance of each prey item to these fish. *Daphnia* were the most important prey to smallmouth bass in tributary zones, they had a high numerical percentage. Unknown fish and yellow perch were the only fish found in stomach contents, and together were more important than invertebrate prey.

Table B-47 displays the spring selection values for the entire sample area and each zone where smallmouth bass were sampled and had prey fish in their stomach contents. Cottidae were selected for in shoreline zones and throughout the study area. Selection for black crappie was indicated in shoreline zones.

Table B-36. The relative importance (RI) of each prey item for smallmouth bass (n=34) collected in summer throughout the entire sample area as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Amphipod	14	5.7	5.6	0.2	0.1	2.1	2.2
Arachnid	6	2.9	2.4	0.5	0.5	1.1	1.1
Bass	1	2.9	0.4	0.5	0.2	0.7	0.7
Black crappie	2	5.7	0.8	7.3	8.1	2.8	2.6
Coleoptera	3	5.7	1.2	0.1	0.1	1.3	1.3
Cottidae	3	8.6	1.2	10.5	12.1	4.1	3.8
Decapoda parts	3	8.6	1.2	0.4	0.6	2.0	1.9
Diptera	11	17.1	4.4	0.1	< 0.1	4.1	4.1
Fish eye	10	20.0	4.0	0.1	0.2	4.6	4.6
Hymenoptera	21	17.1	8.3	0.5	0.4	4.9	4.9
Insect heads	77	34.3	30.6	0.9	0.4	12.3	12.4
Insect parts	30	85.7	11.9	26.2	13.4	21.0	23.4
Kokanee	1	2.9	0.4	22.4	31.3	6.5	4.9
Lepidoptera	1	2.9	0.4	0.2	0.1	0.6	0.7
Nematoda	1	2.9	0.4	< 0.1	< 0.1	0.6	0.6
Neuroptera	3	8.6	1.2	< 0.1	< 0.1	1.9	1.9
Odonata	38	25.7	15.1	3.1	2.0	8.1	8.3
Plants	15	42.9	6.0	0.7	0.3	9.3	9.4
Pumpkinseed	2	5.7	0.8	20.7	25.1	6.0	5.1
Tapeworm	1	2.9	0.4	< 0.1	< 0.1	0.6	0.6
Trichoptera	1	2.9	0.4	< 0.1	< 0.1	0.6	0.6
Unknown fish	7	14.3	2.8	2.0	1.2	3.4	3.6
Yellow perch	1	2.9	0.4	3.6	3.9	1.4	1.3
GRAND TOTALS	**252**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-37. The relative importance (RI) of prey items for smallmouth bass (n=25) collected in the summer from shoreline zones as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Amphipod	14	7.7	6.7	0.3	0.1	2.7	2.8
Bass	1	3.9	0.5	0.7	0.3	0.9	0.9
Black crappie	2	7.7	1.0	10.4	11.5	3.8	3.6
Coleoptera	3	7.7	1.5	0.1	0.2	1.8	1.8
Cottidae	3	11.5	1.5	14.8	17.1	5.7	5.2
Decapoda parts	1	3.9	0.5	< 0.1	< 0.1	0.8	0.8
Diptera	9	15.4	4.4	0.1	< 0.1	3.7	3.7
Fish eye	7	19.2	3.4	0.1	0.2	4.3	4.3
Hymenoptera	20	19.2	9.7	0.7	0.5	5.5	5.6
Insect heads	66	34.6	31.9	1.1	0.5	12.6	12.7
Insect parts	22	84.6	10.6	26.5	13.6	20.5	22.9
Kokanee	1	3.9	0.5	31.8	44.2	9.2	6.8
Lepidoptera	1	3.9	0.5	0.3	0.2	0.9	0.9
Nematoda	1	3.9	0.5	< 0.1	< 0.1	0.8	0.8
Neuroptera	2	7.7	1.0	0.1	< 0.1	1.6	1.6
Odonata	37	30.8	17.9	3.4	2.2	9.6	9.8
Plants	12	46.2	5.8	0.8	0.4	9.9	9.9
Pumpkinseed	1	3.9	0.5	3.0	3.0	1.4	1.4
Trichoptera	1	3.9	0.5	< 0.1	< 0.1	0.8	0.8
Unknown fish	2	7.7	1.0	0.8	0.6	1.7	1.8
Yellow perch	1	3.9	0.5	5.0	5.5	1.9	1.8
GRAND TOTALS	**207**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-38. The relative importance (RI) of prey items for smallmouth bass (n=9) collected in the summer from tributary zones as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Arachnid	6	11.1	13.3	1.8	1.6	5.0	5.0
Decapoda parts	2	22.2	4.4	1.3	2.1	5.5	5.4
Diptera	2	22.2	4.4	< 0.1	0.0	5.1	5.1
Fish eye	3	22.2	6.7	0.1	0.3	5.6	5.6
Hymenoptera	1	11.1	2.2	0.1	0.1	2.6	2.6
Insect heads	11	33.3	24.4	0.4	0.2	11.1	11.1
Insect parts	8	88.9	17.8	25.4	13.0	22.9	25.3
Neuroptera	1	11.1	2.2	< 0.1	< 0.1	2.6	2.6
Odonata	1	11.1	2.2	2.6	1.4	2.8	3.0
Plants	3	33.3	6.7	0.2	0.1	7.7	7.7
Pumpkinseed	1	11.1	2.2	63.1	78.6	17.6	14.6
Tapeworm	1	11.1	2.2	< 0.1	0.1	2.6	2.6
Unknown fish	5	33.3	11.1	5.0	2.5	9.0	9.5
GRAND TOTAL	**45**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-39. Smallmouth bass summer selection values for the total sample area and each zonal designation using Strauss' (1979) (L) and Ivlev's (1961) (E) methods. Percent by number is the proportion of a fish species in the stomach divided by the total number of prey fish in the stomach (% BY#) and RA is the relative abundance of the prey fish in the environment. Shaded values indicate selection for or against (positive and negative values, respectively) a specific prey.

PREY SPECIES	TOTAL				SHORELINE				TRIBUTARY			
	% BY #	RA	L	E	% BY #	RA	L	E	% BY #	RA	L	E
Bass	0.06	0.09	-0.03	-0.20	0.09	0.10	-0.01	-0.05				
Black crappie	0.12	0.12	0.00	-0.01	0.18	0.11	0.07	0.24				
Cottidae	0.18	0.00	0.17	0.95	0.27	0.64	-0.36	-0.40				
Kokanee	0.06	0.03	0.03	0.31	0.09	0.01	0.08	0.75				
Pumpkinseed	0.12	0.03	0.09	0.61	0.09	0.03	0.07	0.56	0.17	0.03	0.13	0.66
Yellow Perch	0.06	0.13	-0.08	-0.39	0.09	0.08	0.01	0.05				

Table B-40. The relative importance (RI) of each prey item for smallmouth bass (n=49) collected in the fall throughout the entire sample area as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Amphipod	12	7.4	3.8	0.2	< 0.1	2.3	2.3
Arachnid	27	11.1	8.5	1.0	0. 7	4.1	4.1
Bass	3	5.6	1.0	7.0	6.0	2.5	2.7
Black crappie	1	1.9	0.3	2.8	2.6	1.0	1.0
Bosmina	1	1.9	0.3	< 0.1	< 0.1	0.4	0.4
Coleoptera	4	7.4	1.3	0.2	0.2	1.8	1.8
Cottidae	5	9.3	1.6	23.1	24.8	7.1	6.8
Decapoda	1	1.9	0.3	5.2	8.9	2.2	1.5
Decapoda parts	2	3.7	0.6	0.7	0.3	0.9	1.0
Cyclopoida	27	1.9	8.5	0.1	< 0.1	2.1	2.1
Daphnia	20	11.1	6.3	0.5	< 0.1	3.5	3.6
Diptera	27	14.8	8.5	0.3	0.2	4.7	4.7
Ephemeroptera	3	5.6	1.0	< 0.1	< 0.1	1.3	1.3
Fish eye	3	1.9	1.0	< 0.1	< 0.1	0.6	0.6
Hemiptera	3	3.7	1.0	0.1	0.1	1.0	1.0
Hymenoptera	13	9.3	4.1	0.4	0.3	2.7	2.8
Insect heads	38	20.4	12.0	0.4	0.3	6.5	6.6
Insect parts	29	53.7	9.2	4.9	1.8	12.9	13.7
Largemouth bass	1	1.9	0.3	3.9	4.5	1.3	1.2
Lepidoptera	1	1.9	0.3	0.2	< 0.1	0.4	0.5
Megaloptera	9	5.6	2.9	0.3	0.3	1.7	1.7
Nematoda	3	5.6	1.0	< 0.1	< 0.1	1.3	1.3
Neuroptera	5	3.7	1.6	0.1	< 0.1	1.1	1.1
Odonata	21	22.2	6.7	0.3	0.1	5.8	5.8
Orthoptera	11	5.6	3.5	0.3	0.3	1.9	1.9
Plants	23	42.6	7.3	1.8	1.2	10.2	10.3
Plecoptera	2	1.9	0.6	0.9	0.7	0.6	0.7
Pumpkinseed	3	5.6	1.0	8.1	8.7	3.0	2.9
Tapeworm	1	1.9	0.3	0.1	0.1	0.4	0.4
Trichoptera	2	3.7	0.6	0.1	0.1	0.9	0.9
Unknown fish	12	22.2	3.8	3.2	2.2	5.6	5.9
Yellow perch	3	3.7	1.0	33.9	35.7	8.1	7.7
GRAND TOTALS	**316**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-41. The relative importance (RI) of prey items for smallmouth bass (n=32) collected in the fall from shoreline zones as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Amphipod	10	8.8	8.0	0.1	< 0.1	3.7	3.7
Arachnid	3	2.9	2.4	0.2	0.1	1.2	1.2
Bass	2	5.9	1.6	6.4	5.7	2.9	3.0
Black crappie	1	2.9	0.8	3.1	2.8	1.4	1.5
Coleoptera	1	2.9	0.8	0.1	0.1	0.9	0.8
Cottidae	5	14.7	4.0	26.0	26.6	9.9	9.7
Decapoda	1	2.9	0.8	5.8	9.6	2.9	2.1
Decapoda parts	1	2.9	0.8	0.4	0.1	0.8	0.9
Daphnia	5	11.8	4.0	0.1	< 0.1	3.4	3.5
Diptera	20	14.7	16.0	0.2	0.1	6.7	6.7
Ephemeroptera	2	5.9	1.6	< 0.1	< 0.1	1.6	1.6
Fish eye	3	2.9	2.4	< 0.1	< 0.1	1.2	1.2
Hymenoptera	1	2.9	0.8	0.1	0.1	0.8	0.8
Insect heads	12	14.7	9.6	0.2	0.1	5.3	5.3
Insect parts	18	52.9	14.4	3.1	0.9	14.9	15.4
Largemouth bass	1	2.9	0.8	4.4	4.8	1.9	1.8
Lepidoptera	1	2.9	0.8	0.2	< 0.1	0.8	0.9
Megaloptera	1	2.9	0.8	0.1	0.1	0.8	0.8
Nematoda	2	5.9	1.6	< 0.1	< 0.1	1.6	1.6
Neuroptera	2	2.9	1.6	< 0.1	< 0.1	1.0	1.0
Odonata	5	11.8	4.0	< 0.1	< 0.1	3.4	3.4
Plants	15	44.1	12.0	1.0	0.3	12.3	12.5
Pumpkinseed	2	5.9	1.6	6.8	7.6	3.3	3.1
Tapeworm	1	2.9	0.8	0.1	0.1	0.8	0.8
Trichoptera	1	2.9	0.8	< 0.1	< 0.1	0.8	0.8
Unknown fish	6	17.7	4.8	3.4	2.3	5.4	5.6
Yellow perch	3	5.9	2.4	38.1	38.3	10.2	10.1
GRAND TOTALS	**125**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-42. The relative importance (RI) of prey items for smallmouth bass (n=17) collected in the fall from tributary zones as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Amphipod	2	5.0	1.1	0.6	0.1	1.1	1.2
Arachnid	24	25.0	12.6	7.6	9.0	8.2	7.9
Bass	1	5.0	0.5	11.4	9.1	2.6	3.0
Bosmina	1	5.0	0.5	< 0.1	< 0.1	1.0	1.0
Coleoptera	3	15.0	1.6	0.7	0.8	3.1	3.0
Decapoda parts	1	5.0	0.5	3.6	2.7	1.4	1.6
Cyclopoida	27	5.0	14.1	0.7	0.1	3.4	3.5
Daphnia	15	10.0	7.9	4.0	0.2	3.2	3.8
Diptera	7	15.0	3.7	1.0	0.8	3.4	3.4
Ephemeroptera	1	5.0	0.5	0.1	0.2	1.0	1.0
Hemiptera	3	10.0	1.6	0.8	1.4	2.3	2.2
Hymenoptera	12	20.0	6.3	3.3	3.0	5.1	5.2
Insect heads	26	30.0	13.6	2.0	3.1	8.2	8.0
Insect parts	11	55.0	5.8	19.8	13.8	13.1	14.1
Megaloptera	8	10.0	4.2	1.6	2.2	2.9	2.8
Nematoda	1	5.0	0.5	0.1	0.1	1.0	1.0
Neuroptera	3	5.0	1.6	0.7	0.4	1.2	1.3
Odonata	16	40.0	8.4	2.2	1.6	8.8	8.9
Orthoptera	11	15.0	5.8	3.1	4.0	4.4	4.2
Plants	8	40.0	4.2	8.5	13.0	10.0	9.2
Plecoptera	2	5.0	1.1	7.6	10.7	2.9	2.4
Pumpkinseed	1	5.0	0.5	18.5	22.9	5.0	4.2
Trichoptera	1	5.0	0.5	0.4	0.2	1.0	1.0
Unknown fish	6	30.0	3.1	1.7	0.8	6.0	6.1
GRAND TOTALS	**191**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-43. Smallmouth bass fall selection values for the total sample area and each zonal designation using Strauss' (1979) (L) and Ivlev's (1961) (E) methods. Percent by number is the proportion of a fish species in the stomach divided by the total number of prey fish in the stomach (% BY#) and RA is the relative abundance of the prey fish in the environment. Shaded values indicate selection (positive and negative values, respectively) for specific prey.

PREY SPECIES	TOTAL				SHORELINE				TRIBUTARY			
	% BY #	RA	L	E	% BY #	RA	L	E	% BY #	RA	L	E
Bass	0.11	0.22	-0.12	-0.35	0.10	0.26	-0.16	-0.44	0.13	0.19	-0.07	-0.21
Black crappie	0.04	0.13	-0.10	-0.58	0.05	0.11	-0.06	-0.37				
Cottidae	0.18	0.01	0.17	0.92	0.25	0.01	0.24	0.92				
Largemouth bass	0.04	0.08	-0.05	-0.40	0.05	0.08	-0.03	-0.25				
Pumpkinseed	0.11	0.05	0.06	0.40	0.10	0.04	0.06	0.43	0.13	0.06	0.07	0.39
Yellow Perch	0.11	0.23	-0.12	-0.36	0.15	0.21	-0.06	-0.16				

Table B-44. The relative importance (RI) of each prey item for smallmouth bass (n=12) collected in the spring throughout the entire sample area as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Amphipod	1	7.7	1.0	0.1	< 0.1	2.1	2.1
Annelida	4	15.4	3.9	32.4	36.0	13.1	12.2
Black crappie	1	7.7	1.0	8.1	5.7	3.4	4.0
Cottidae	3	23.1	2.9	22.6	22.0	11.3	11.5
Daphnia	52	7.7	50.0	0.2	< 0.1	13.6	13.7
Diptera	3	7.	2.9	< 0.1	< 0.1	2.5	2.5
Ephemeroptera	22	30.8	21.2	2.4	2.1	12.8	12.8
Insect parts	3	23.1	2.9	2.2	1.6	6.5	6.6
Odonata	3	15.4	2.9	< 0.1	< 0.1	4.3	4.3
Plants	6	46.2	5.8	2.2	0.7	12.4	12.8
Tapeworm	1	7.7	1.0	0.1	0.1	2.1	2.1
Unknown fish	2	15.4	1.9	7.5	8.2	6.0	5.9
Westslope cutthroat	1	7.7	1.0	7.3	5.8	3.4	3.8
Yellow perch	2	7.7	1.9	15.0	17.7	6.5	5.8
GRAND TOTALS	**104**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-45. The relative importance (RI) of prey items for smallmouth bass (n=9) collected in the spring from shoreline zones as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Annelida	4	20.0	8.9	42.1	48.6	18.5	16.9
Black crappie	1	10.0	2.2	10.5	7.7	4.8	5.4
Cottidae	3	30.0	6.7	29.4	29.7	15.8	15.7
Diptera	3	10.0	6.7	< 0.1	< 0.1	4.0	4.0
Ephemeroptera	22	40.0	48.9	3.1	2.9	21.9	21.9
Insect parts	3	30.0	6.7	2.8	2.1	9.2	9.4
Odonata	3	20.0	6.7	0.1	< 0.1	6.4	6.4
Plants	4	40.0	8.9	2.5	0.8	11.8	12.2
Tapeworm	1	10.0	2.2	0.1	0.2	3.0	2.9
Westslope cutthroat	1	10.0	2.2	9.5	7.9	4.8	5.2
GRAND TOTALS	**45**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-46. The relative importance (RI) of prey items for smallmouth (n=3) bass collected in the spring from tributary zones as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Amphipod	1	33.3	1.7	0.3	0.1	8.1	8.1
Daphnia	52	33.3	88.1	1.0	0.1	28.1	28.3
Plants	2	66.7	3.4	1.2	0.3	16.2	16.4
Unknown fish	2	66.7	3.4	32.5	31.4	23.4	23.7
Yellow perch	2	33.3	3.4	65.1	68.1	24.2	23.5
GRAND TOTAL	**59**		**100.0**	**100. 0**	**100.0**	**100.0**	**100.0**

Table B-47. Smallmouth bass spring selection values for the total sample area and each zonal designation using Strauss' (1979) (L) and Ivlev's (1961) (E) methods. Percent by number is the proportion of a fish species in the stomach divided by the total number of prey fish in the stomach (% BY#) and RA is the relative abundance of the prey fish in the environment. Shaded values indicate selection for or against (positive and negative values, respectively) for a specific prey.

PREY SPECIES	TOTAL				SHORELINE				TRIBUTARY			
	% BY #	RA	L	E	% BY #	RA	L	E	% BY #	RA	L	E
Black crappie	0.11	0.06	0.06	0.33	0.20	0.02	0.18	0.86				
Cottidae	0.33	0.00	0.33	1.00	0.60	0.00	0.60	1.00				
Westslope Cutthroat	0.11	0.09	0.02	0.12	0.20	0.13	0.07	0.23				
Yellow Perch	0.22	0.15	0.07	0.18					0.50	0.24	0.26	0.36

Northern Pike

Summer

During the summer quarter, five northern pike stomachs were analyzed. One summer stomach, from a tributary zone was empty. All stomachs with prey were caught in shoreline zones. Table B-48 shows the relative importance of each prey item found in their stomachs during the summer. Westslope cutthroat trout were the most important prey item for northern pike in the summer. Insect parts and brown bullhead were the next most important prey items. A westslope cutthroat trout was the only salmonid identified in these stomachs.

Table B-49 displays the summer selection values for the entire sample area and each zone where northern pike were sampled and had prey fish in their stomach contents. Ivlev's index indicated selection for westslope cutthroat trout n the shoreline zone.

Fall

Eight northern pike stomachs were collected during the fall sampling period. All of these fish had prey items in their stomachs. Table B-50 gives the relative importance of each prey item to northern pike in the fall. Plants were the most important item in the diet of northern pike, however this is a product of the environment in which they live. Yellow perch were the most abundant item, followed by black crappie. Two fish were unidentifiable and one westslope cutthroat trout was found in the stomach contents.

Six northern pike stomachs were collected from shoreline zones in the fall. All of these fish had prey items in them. Table B-51 gives the relative importance of each prey item to northern pike from shoreline zones in the fall. Black crappie, northern pikeminnow, and bass were the most important prey items to northern pike in shoreline zones. One westslope cutthroat trout was identified in the stomach contents.

Two pike stomachs were collected from the tributaries in the fall. Both had prey items in them. Table B-52 shows the relative importance of each prey item for northern pike from tributary zones in the fall. Yellow perch were the most important prey item. Plants and an unidentifiable fish were also in the stomach contents.

Table B-53 displays the fall selection values for the entire sample area and each zone where northern pike were sampled and had prey fish in their stomach contents. Ivlev's index indicates selection for westslope cutthroat trout in the shoreline zones and in the entire sample area.

Winter

No northern pike were collected during the winter.

Spring

Thirteen northern pike stomachs were collected from all zones in the spring. One fish was empty. Table B-54 gives the relative importance of each prey item found in the stomachs of northern pike during the spring. Westslope cutthroat trout were the most important prey item to northern pike in the spring, followed by yellow perch and unidentified fish. Cutthroat trout are most important by weight and yellow perch are most important by numbers.

One northern pike was collected from the pelagic zone in the spring as reported in the annual feeding habits. The relative importance of each prey item is displayed in

Table B-55. Of two prey items, the westslope cutthroat trout was the most important. The other item was an unidentifiable fish.

Five pike stomachs, each with prey items, were collected from the shoreline zones in the spring. The relative importance of each prey item is shown in Table B-56. Westslope cutthroat trout were the most important prey item in shoreline zones. About half as important were yellow perch and coleopterans.

Seven stomachs were collected from tributary zones during the spring; one was empty. Table B-57 gives the relative importance of prey items in northern pike diets for the tributary zones in the spring. Yellow perch were the most important prey item, followed by unidentifiable fish. Two salmonid species were found in tributary stomachs, a mountain whitefish and a westslope cutthroat trout.

Table B-58 displays the spring selection values for the entire sample area and each zone where northern pike were sampled and had prey fish in their stomach contents. Black crappie were selected for in the shoreline zones according to Ivlev's index. Mountain whitefish were selected for in tributary zones and the entire sample zone. Ivlev's index shows that cutthroat trout were being selected for in pelagic zones, and yellow perch in shoreline zones.

Table B-48. The relative importance (RI) of each prey item for northern pike (n=4) collected in the summer in shoreline zones as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Brown bullhead	1	20.0	12.5	11.5	8.2	11.3	12.2
Feathers	1	20.0	12.5	0.8	0.1	9.1	9.3
Insect heads	1	20.0	12.5	< 0.1	< 0.1	9.0	9.0
Insect parts	2	40.0	25.0	4.4	2.2	18.7	19.3
Odonata	1	20.0	12.5	0.1	< 0.1	9.0	9.0
Plants	1	20.0	12.5	0.3	0.2	9.1	9.1
Westslope cutthroat	1	20.0	12.5	83.0	89.2	33.8	32.1
GRAND TOTALS	**8**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-49. Northern pike summer selection values for shoreline zones using Strauss' (1979) (L) and Ivlev's (1961) (E) methods. Percent by number is the proportion of a fish species in the stomach divided by the total number of prey fish in the stomach (% BY#) and RA is the relative abundance of the prey fish in the environment. Shaded values indicate selection for or against (positive and negative values, respectively) for specific prey.

PREY SPECIES	SHORELINE			
	% BY #	RA	L	E
Brown bullhead	0.50	0.18	0.32	0.47
Westslope cutthroat	0.50	0.01	0.49	0.95

Table B-50. The relative importance (RI) of each prey item for northern pike (n=8) collected in the fall throughout the entire sample area as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Bass	1	12.5	5.0	3.7	3.70	5.1	5.1
Black crappie	2	25.0	10.0	8.0	5.4	9.8	10.4
Diptera	1	12.5	5.0	< 0.1	< 0.1	4.2	4.2
Fish eye	2	12.5	10.0	< 0.1	0.1	5.5	5.5
Northern pikeminnow	1	12.5	5.0	5.6	4.7	5.4	5.6
Plants	7	87.5	35.0	21.3	6.0	31.1	34.9
Unknown fish	2	25.0	10.0	5.4	4.7	9.6	9.8
Westslope cutthroat	1	12.5	5.0	2.1	1.3	4.6	4.8
Yellow perch	3	12.5	15.0	53.7	74.2	24.7	19.7
GRAND TOTAL	**20**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-51. The relative importance (RI) of prey items for northern pike (n=6) collected in the fall from shoreline zones as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Bass	1	16.7	7.1	15.1	21.4	10.8	9.3
Black crappie	2	33.3	14.3	32.8	31.3	18.9	19.3
Diptera	1	16.7	7.1	0.0	< 0.1	5.7	5.7
Fish eye	2	16.7	14.3	0.1	0.3	7.5	7.5
Northern pikeminnow	1	16.7	7.1	23.0	27.3	12.3	11.2
Plants	5	83.3	35.7	14.8	7.5	30.4	32.1
Unknown fish	1	16.7	7.1	5.4	5.0	6.9	7.0
Westslope cutthroat	1	16.7	7.1	8.6	7.3	7.5	7.8
GRAND TOTALS	**14**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-52. The relative importance (RI) of prey items for northern pike (n=2) collected in the fall from tributary zones as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Plants	2	100	33.3	23.4	5.6	34.7	39.2
Unknown fish	1	50	16.7	5.4	4.6	17.8	18.0
Yellow Perch	3	50	50	71.1	89.7	47.4	42.8
GRAND TOTALS	**6**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-53. Northern pike fall selection values for the total sample area and each zonal designation using Strauss' (1979) (L) and Ivlev's (1961) (E) methods. Percent by number is the proportion of a fish species in the stomach divided by the total number of prey fish in the stomach (% BY#) and RA is the relative abundance of the prey fish in the environment. Shaded values indicate selection for or against (positive and negative values, respectively) for a specific prey.

PREY SPECIES	TOTAL				SHORELINE				TRIBUTARY			
	% BY #	RA	L	E	% BY #	RA	L	E	% BY #	RA	L	E
Bass	0.10	0.22	-0.12	-0.38	0.17	0.26	-0.09	-0.22				
Black crappie	0.20	0.13	0.07	0.20	0.33	0.11	0.22	0.51				
Northern pikeminnow	0.10	0.06	0.04	0.25	0.17	0.08	0.08	0.34				
Westslope cutthroat	0.10	0.01	0.09	0.84	0.17	0.01	0.15	0.85				
Yellow perch	0.30	0.23	0.07	0.13					0.75	0.26	0.49	0.48

Table B-54. The relative importance (RI) of each prey item for northern pike (n=12) collected in the spring throughout the entire sample area as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Annelida	1	7.7	2.5	0.2	0.1	2.5	2.5
Bait fish and hook	1	7.7	2.5	3.4	11.7	5.3	3.3
Black crappie	1	7.7	2.5	0.3	0.1	2.5	2.5
Coleoptera	7	7.7	17.5	0.1	0.1	6.1	6.1
Gastropods	1	7.7	2.5	0.0	< 0.1	2.5	2.5
Hymenoptera	1	7.7	2.5	0.0	< 0.1	2.5	2.5
Insect parts	2	15.4	5.0	0.3	0.1	4.9	5.0
Mountain whitefish	1	7.7	2.5	10.4	7.3	4.2	5.0
Plants	6	46.2	15.0	0.8	0.2	14.8	14.9
Pumpkinseed	3	7.7	7.5	2.5	1.2	3.9	4.3
Unknown fish	4	30.8	10.0	3.9	12.0	12.7	10.7
Westslope cutthroat	4	30.8	10.0	69.7	62.2	24.8	26.6
Yellow perch	8	30.8	20.0	8.6	5.2	13.5	14.3
GRAND TOTALS	**40**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-55. The relative importance (RI) of prey items for northern pike (n=1) collected in the spring from a pelagic zone as calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Unknown fish	1	100.0	50.0	0.2	0.1	37.5	37.6
Westslope cutthroat	1	100.0	50.0	99.8	99.9	62.5	62.5
GRAND TOTALS	**2**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-56. The relative importance (RI) of prey items for northern pike (n=5) collected in the spring from the shoreline zones was calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Black crappie	1	20.0	5.0	0.5	0.2	5.5	5.5
Coleoptera	7	20.0	35.0	0.2	0.1	12.0	12.0
Hymenoptera	1	20.0	5.0	< 0.1	< 0.1	5.4	5.4
Insect parts	1	20.0	5.0	0.4	0.2	5.5	5.5
Plants	4	80.0	20.0	0.9	0.2	21.8	21.9
Unknown fish	1	20.0	5.0	0.1	< 0.1	5.4	5.5
Westslope cutthroat	2	40.0	10.0	96.8	98.9	32.4	31.9
Yellow perch	3	40.0	15.0	1.2	0.5	12.1	12.2
GRAND TOTALS	**20**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-57. The relative importance (RI) of prey items for northern pike (n=6) collected in the spring from the tributary zones was calculated from the frequency of its occurrence (FOO), the percent composition by number (% BY #), and the percent composition by wet and dry weights (% WET WT and % DRY WT, respectively).

PREY	n	FOO	% BY #	% WET WT	% DRY WT	RI DRY	RI WET
Annelida	1	14.3	5.6	0.6	0.2	5.2	5.3
Bait fish and hook	1	14.3	5.6	9.6	27.8	12.4	7.6
Gastropods	1	14.3	5.6	< 0.1	< 0.1	5.2	5.2
Insect parts	1	14.3	5.6	0.2	< 0.1	5.2	5.2
Mountain whitefish	1	14.3	5.6	29.6	17.3	9.6	12.8
Plants	2	28.6	11.1	0.8	0.2	10.3	10.5
Pumpkinseed	3	14.3	16.7	7.1	2.8	8.8	9.9
Unknown fish	2	28.6	11.1	10.8	28.6	17.7	13.1
Westslope cutthroat	1	14.6	5.6	19.0	11.3	8.1	10.1
Yellow perch	5	28.6	27.8	22.5	11.8	17.7	20.4
GRAND TOTALS	**18**		**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table B-58. Northern pike spring selection values for the total sample area and each zonal designation using Strauss' (1979) (L) and Ivlev's (1961) (E) methods. Percent by number is the proportion of a fish species in the stomach divided by the total number of prey fish in the stomach (% BY#) and RA is the relative abundance of the prey fish in the environment. Shaded values indicate selection for or against (positive and negative values, respectively) for specific prey.

PREY SPECIES	TOTAL				PELAGIC				SHORELINE				TRIBUTARY			
	% BY #	RA	L	E	% BY #	RA	L	E	% BY #	RA	L	E	% BY #	RA	L	E
Black crappie	0.05	0.06	-0.01	-0.10					0.14	0.02	0.13	0.81				
Mountain whitefish	0.05	0.00	0.04	0.92									0.08	0.00	0.08	0.96
Pumpkinseed	0.14	0.01	0.13	0.89									0.25	0.01	0.24	0.92
Westslope cutthroat	0.18	0.09	0.09	0.35	0.50	0.00	0.50	1.00	0.29	0.13	0.16	0.39	0.08	0.06	0.03	0.18
Yellow perch	0.36	0.15	0.21	0.40					0.43	0.06	0.37	0.75	0.42	0.24	0.18	0.28

APPENDIX C: AGE AND GROWTH

Methods

Scales were taken from all fish whose stomach contents were collected. Scales were analyzed by placing them on slides and magnifying them with an Eyecom 3000 microfiche reader. The age of each fish was determined by counting the number of annuli on the scale as in Devries and Frie (1996). The distances from the focus to each annulus and to the outer margin of the scale were measured. From these data, the growth of the fish was back-calculated (Lux 1971; Anderson and Neumann 1996) to estimate the length of the fish at each age. For most species, the Fraser-Lee back calculation method (Devries and Frie 1996) was used;

$$L_i = \frac{L_c - a}{S_c} S_i + a$$

where: L_i = back calculated length of the fish when the *i*th annulus was formed,

$L_c - a/S_c$ = slope of a two point regression line to estimate L_i,

a = intercept parameter,

L_c = length of the fish at capture,

S_c = radius of the scale at capture, and

S_i = radius of the scale at the *i*th annulus.

The intercept value, a, is the length at which the species scales become visible. For northern pikeminnow, an intercept value was unavailable, therefore, the direct proportion method (Devries and Frie 1996) was used to back calculate the lengths of these fish;

$$L_i = \frac{S_i}{S_c} L_c$$

where L_i = back calculated length of the fish when the *i*th annulus was formed

L_c = length of the fish at capture

S_c = radius of the scale at capture, and

S_i = radius of the scale at the *i*th annulus.

Fulton type condition factors were calculated for all species collected during sampling. This serves as an indication of the rate at which the fish puts on weight with length, and the overall condition of the fish. The following equation was used to calculate Fulton type condition factors (Anderson and Neumann 1996):

$$K_{TL} = \frac{W}{L^3} \times 100{,}000$$

where: K_{TL} = Fulton type condition factor based on the total length of the fish,

W = weight of the fish in grams, and

L = total length of the fish in millimeters.

Results

The mean lengths, weights, and Fulton type condition factors for every species collected are given in Table C-1. This includes chinook salmon collected in the derby. The mean values reflect some degree of gear bias as relatively few fish under 100 mm were captured.

<u>Northern pikeminnow</u>

Scales were collected from 204 northern pikeminnow and aged from 2 to 11. The mean back calculated lengths are given in Table C-2.

The age frequency distribution for northern pikeminnow (Figure C-1) shows how many fish were collected for stomach analysis from each age class. The absence of ages zero and one is probably because they do not fully recruit to the sampling gear until about age three.

The length frequency distribution (Figure C-2) illustrates how the population is structured according to length intervals. Fish under 200 mm were seldomly captured in this study. This is likely do to gear bias.

The mean condition factor for all northern pikeminnow collected was 0.86 (Table C-1). The relationship in which northern pikeminnow gain weight with length is illustrated in Figure C-3.

Table C-1. Mean total length (TL), weight (WT) and condition factor (K_{TL} and standard deviation) of each species collected from Coeur d'Alene Lake.

	MEAN TOTAL LENGTH (mm)			MEAN WEIGHT (g)			MEAN CONDITON FACTOR (K_{TL})		
SPECIES	n	TL	RANGE	n	WT	RANGE	n	K_{TL}	S.D.
NPM	290	363	97-684	284	589	5-2050	284	0.86	0.41
TCH	68	366	61-502	66	715	3-1751	66	1.35	0.48
LNS	23	421	382-473	23	848	584-1216	23	1.13	0.07
BLS	10	411	317-492	10	759	229-1078	10	1.04	0.15
LSS	698	485	228-1381	690	1218	118-2877	690	1.02	0.15
BBH	557	217	57-275	550	140	3-271	550	1.31	0.19
PIKE	26	510	293-740	26	1130	140-2750	26	0.64	0.10
WCT	118	213	59-437	114	143	2-1263	114	1.00	0.62
RBT	3	313	223-381	3	323	127-521	3	0.98	0.15
KOK	86	209	41-399	82	130	1-545	82	0.9	0.18
CHIN	129	326	41-885	129	1715	1-8491	129	1.05	0.27
MWF	8	272	191-343	8	182	58-310	8	0.83	0.05
BT	1	690	690	1	3056	3065	1	0.93	NA
COT	18	86	40-117	18	7	1-15	18	1.01	0.33
PS	116	95	34-160	115	24	1-89	115	1.96	0.64
SMB	413	144	44-407	407	63	1-822	407	1.12	0.66
LMB	252	203	32-550	238	403	1-3380	238	1.35	0.61
BC	416	139	28-281	407	66	1-344	407	1.44	0.75
YP	706	105	35-250	699	22	1-216	699	1.03	0.83

Table C-2. Mean back calculated lengths (± standard deviation) at age for northern pikeminnow.

	LENGTH AT AGE										
AGE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1											
2	83 (±14)	140 (±16)									
3	89 (±18)	150 (±31)	211 (±34)								
4	91 (±23)	147 (±35)	208 (±46)	264 (±50)							
5	86 (±25)	140 (±31)	195 (±40)	251 (±44)	303 (±46)						
6	99 (±24)	161 (±32)	226 (±41)	280 (±48)	332 (±59)	384 (±65)					
7	104 (±30)	164 (±36)	228 (±40)	292 (±45)	350 (±53)	403 (±58)	454 (±68)				
8	96 (±22)	153 (±28)	213 (±36)	274 (±39)	333 (±41)	389 (±40)	443 (±51)	488 (±56)			
9	98 (±17)	160 (±22)	224 (±30)	273 (±35)	324 (±41)	375 (±34)	426 (±29)	487 (±26)	533 (±29)		
10	96 (±16)	157 (±16)	205 (±13)	257 (±23)	306 (±14)	365 (±19)	417 (±25)	465 (±34)	499 (±39)	535 (±41)	
11	78	133	177	233	288	333	377	432	477	521	577
GRAND MEAN	**93 (±24)**	**151 (±32)**	**212 (±40)**	**270 (±46)**	**328 (±51)**	**390 (±53)**	**445 (±53)**	**484 (±50**	**514 (±36)**	**533 (±36)**	**577**
n	**0**	**14**	**31**	**38**	**33**	**21**	**31**	**26**	**5**	**4**	**1**

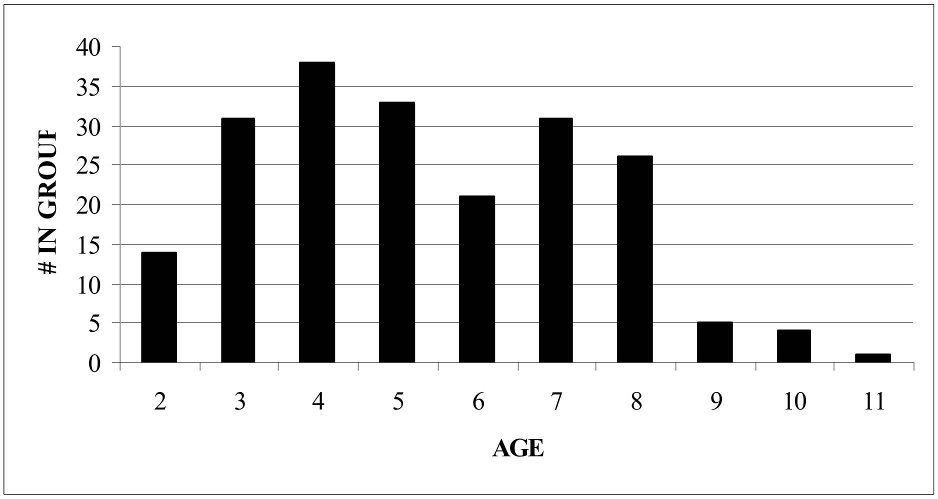

Fig. C-1. Age frequency distribution of northern pikeminnow collected for stomach analysis in Coeur d'Alene Lake (n=204).

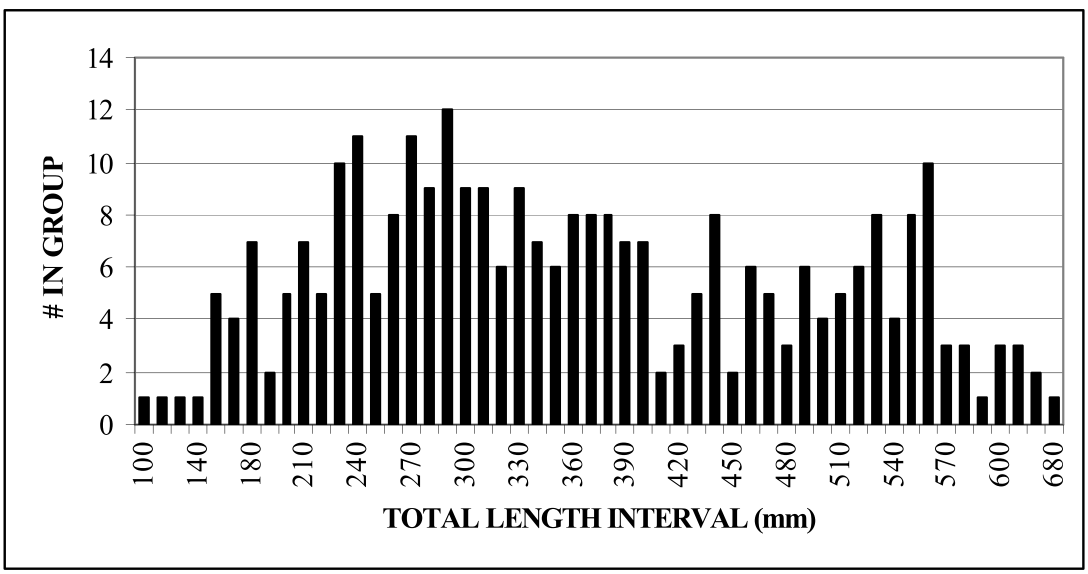

Fig.C-2. Length frequency distribution of northern pikeminnow (n=290).

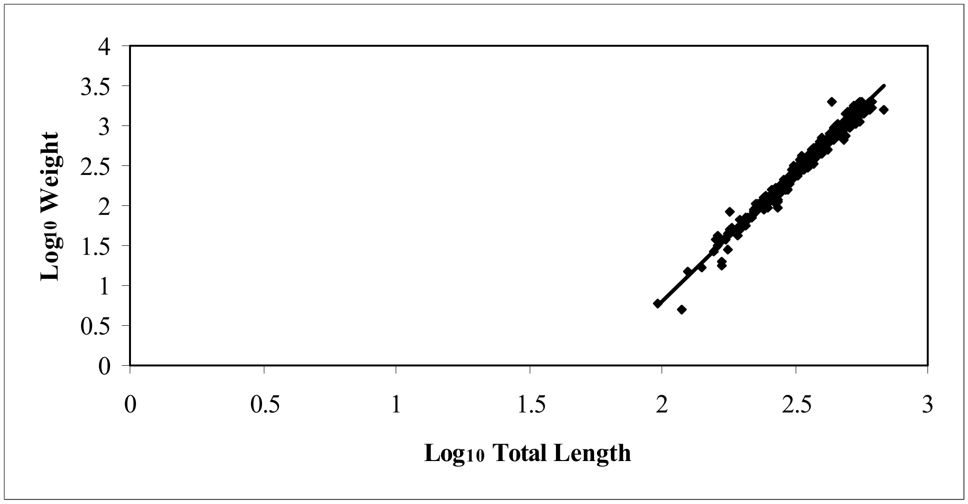

Fig. C-3. Log_{10} regression for the total length and weight of each northern pikeminnow collected (n=290, y = 3.2325x-5.6763, R^2=0.9793).

Chinook salmon

Only fifteen chinook salmon scales were readable. The rest had been regenerated and could not be aged. The intercept value for chinook was 35mm (Bruce Sanford, personal communication 2002). Ages ranged from 1 to 4 years. The mean back calculated lengths at each age are in Table C-3.

The age frequency (Figure C-4) shows how many fish were collected from each age class for stomach analysis. Larger fish were sampled disproportionately in this study. These larger, older fish are more likely to be piscivorous than smaller chinook salmon.

The length frequency distribution (Figure C-5) illustrates how the sample was structured according to length intervals. All chinook salmon sampled throughout the study are included in Figure 7, which reflects a more realistic population with smaller fish represented. The majority of large fish came from the fishing derby.

The mean condition factor for all chinook salmon collected in this study was 1.05 (Table C-1). The relationship in which chinook salmon gain weight with length is illustrated in Figure C-6.

Table C-3. Mean back calculated lengths (± standard deviation) at age for chinook salmon.

	LENGTH AT AGE			
AGE	**1**	**2**	**3**	**4**
1	151			
2	187 (± 60)	357 (± 164)		
3	214 (± 24)	406 (± 48)	632 (± 64)	
4	195 (± 39)	351 (± 57)	483 (± 59)	628 (± 50)
GRAND MEAN	**192 (± 42)**	**360 (± 92)**	**51 3(± 84)**	**628 (± 50)**
n	**1**	**4**	**2**	**8**

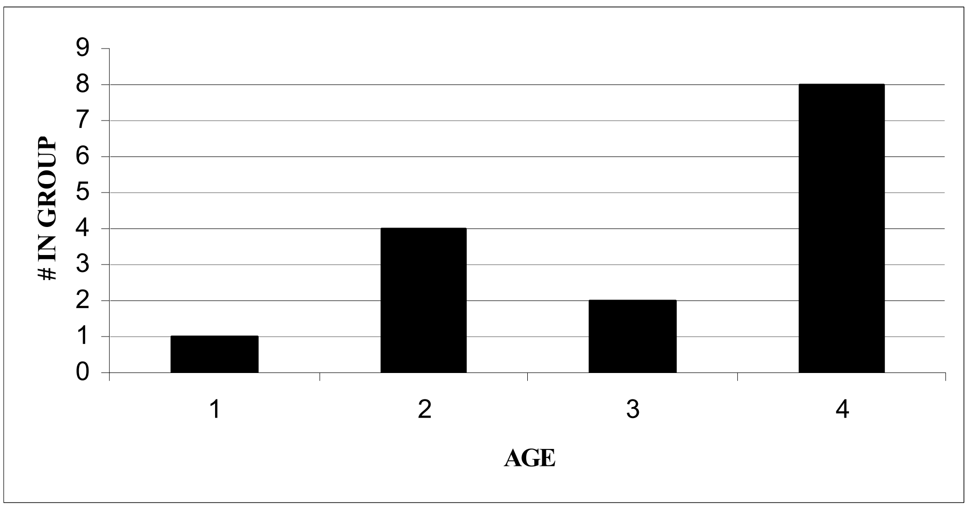

Fig. C-4 Age frequency distribution of chinook salmon collected for stomach analysis in Coeur d'Alene Lake (n=15).

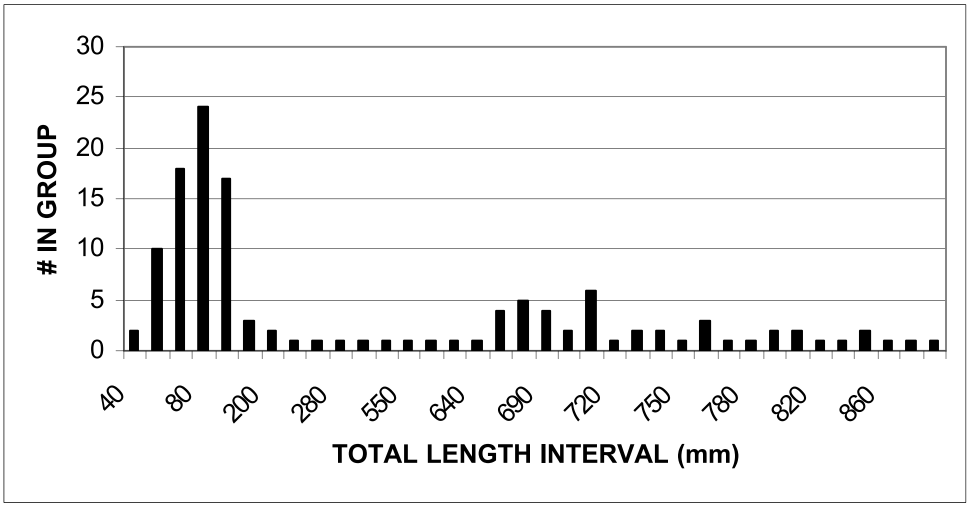

Fig. C-5 Length frequency distribution of chinook salmon (n=128).

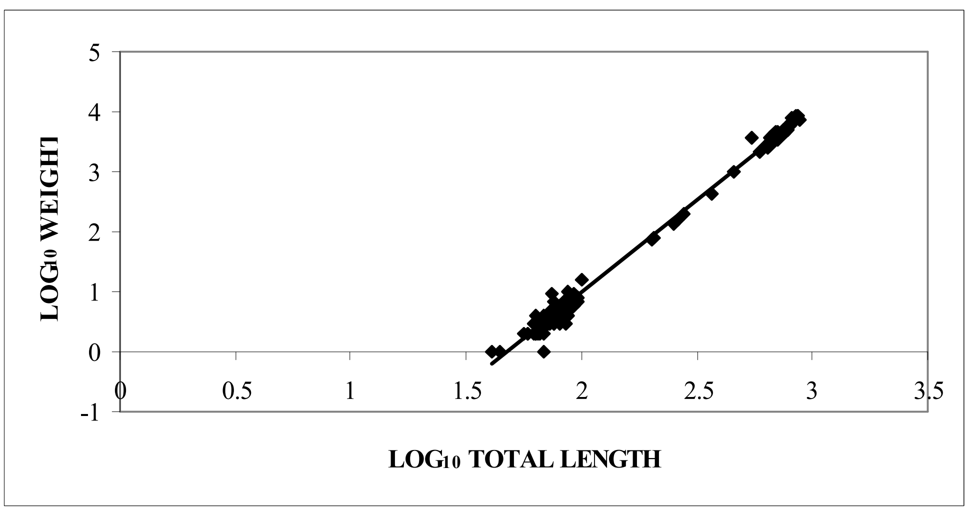

Fig. C-6 Log_{10} regression for the total length and weight of each chinook salmon collected (n=128, y = 3.0849x-5.1872, R^2=0.9947).

Largemouth bass

Scales were aged from 87 largemouth bass and aged from 2 to 10. The intercept value for largemouth bas was 20 mm (Carlander 1977). The mean back calculated lengths at each age are given in Table C-4.

The age frequency (Figure C-7) shows the number of fish collected from each age class for stomach analysis. Ages four to seven were the most abundant in our sampling.

The length frequency distribution (Figure C-8) illustrates how the sample population is structured according to length intervals. Largemouth bass are reproducing successfully in the system as indicated by the large numbers of small, young of the year fish.

The mean condition factor for all largemouth bass collected in this study was 1.35 (Table C-1). The rate at which largemouth bass gain weight with length is illustrated in Figure C-9.

Table C-4. Mean back calculated lengths (± standard deviation) at age for largemouth bass.

	LENGTH AT AGE									
AGE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1										
2	56	124								
3	91(± 33)	147(± 48)	215(± 49)							
4	79(± 20)	147(± 46)	212(± 46)	270(± 43)						
5	73(± 12)	127(± 25)	193(± 45)	268(± 45)	315(± 47)					
6	76(± 13)	141(± 39)	212(± 55)	285(± 63)	328(± 62)	364(± 58)				
7	76(± 8)	153(± 42)	236(± 55)	305(± 46)	362(± 43)	410(± 44)	446(± 42)			
8	76(± 15)	136(± 32)	199(± 48)	260(± 46)	325(± 40)	376(± 39)	416(± 34)	446(± 36)		
9	67(± 13)	121(± 22)	171(± 34)	256(± 69)	315(± 46)	367(± 39)	412(± 33)	454(± 18)	483(± 23)	
10	71(± 2)	141(± 14)	225(± 13)	325(± 8)	381(± 14)	419(± 3)	459(± 8)	493(± 6)	513(± 2)	536(± 3)
GRAND MEAN	**76(± 16)**	**141 (± 38)**	**211(± 50)**	**280(± 51)**	**335(± 51)**	**386(± 50)**	**434(± 40)**	**454(± 33)**	**493(± 24)**	**536(± 3)**
n	**0**	**1**	**4**	**19**	**14**	**15**	**18**	**10**	**4**	**2**

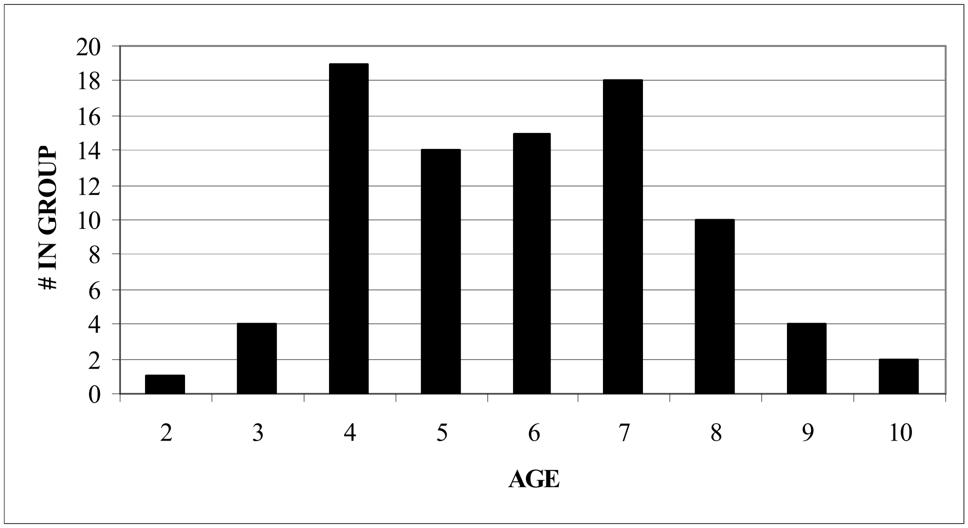

Fig. C-7 Age frequency distribution of largemouth bass collected for stomach analysis in Coeur d'Alene Lake (n=87).

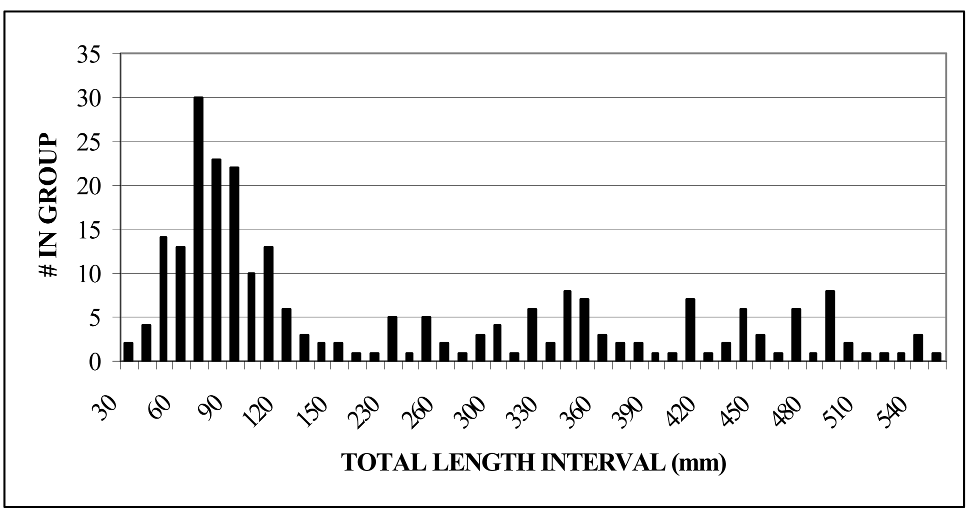

Fig. C-8 Length frequency distribution for largemouth bass n=244.

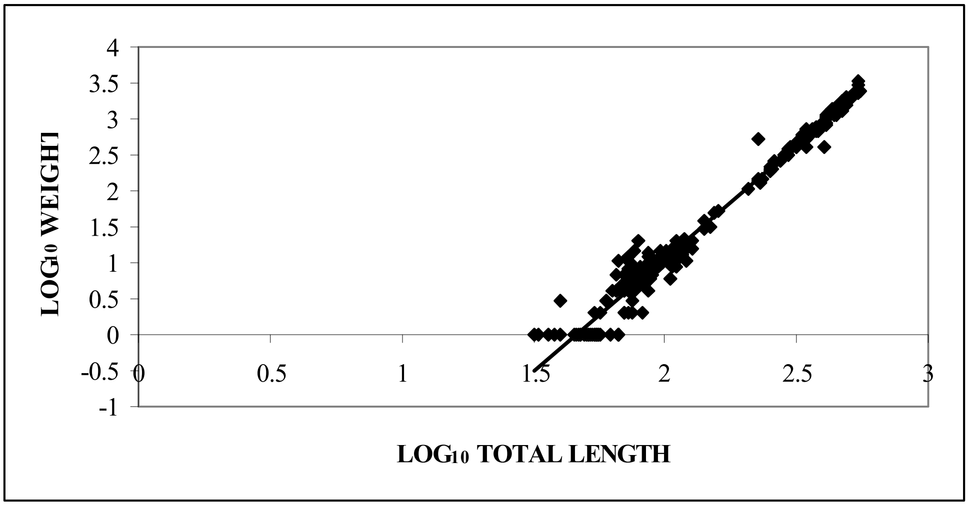

Fig. C-9 Log_{10} regression for the total length and weight of each largemouth bass collected (n=244, y = 3.1479x-5.2279, R^2=0.9764).

Smallmouth bass

Scales were aged for 109 smallmouth bass and ranged from 0 to 6 years. The intercept value for smallmouth bass is 21 mm (Carlander 1977). The mean back calculated lengths are given in Table 103. The two age zero fish (total lengths 57 mm and 70 mm) were not included in Table C-5.

The age frequency (Figure C-10) shows how many stomachs were collected from each age class. The majority of stomachs were collected from age three fish.

The length frequency distribution (Figure C-11) illustrates how the sample is structured according to length intervals. Several small fish indicate successful reproduction within the system.

The mean condition factor for all smallmouth bass collected in this study was 1.12 (Table C-1). The relationship in which smallmouth bass gain weight with length is illustrated in Figure C-12.

Table C-5. Mean back calculated lengths (± standard deviation) at ages for smallmouth bass.

	LENGTH AT AGE					
AGE	**1**	**2**	**3**	**4**	**5**	**6**
1	75 (± 6)					
2	67 (± 13)	121 (± 17)				
3	71 (± 11)	112 (± 18)	164 (± 26)			
4	69 (± 12)	112 (± 21)	160 (± 23)	216 (± 27)		
5	72 (± 18)	128 (± 41)	201 (± 64)	249 (± 77)	293 (± 58)	
6	74 (± 27)	123 (± 10)	162 (± 4)	225 (± 6)	305 (± 47)	351 (± 60)
GRAND MEAN	**70 (± 12)**	**114 (± 19)**	**164 (± 27)**	**220 (± 33)**	**299 (± 48)**	**351 (± 60)**
n	**6**	**14**	**53**	**28**	**3**	**3**

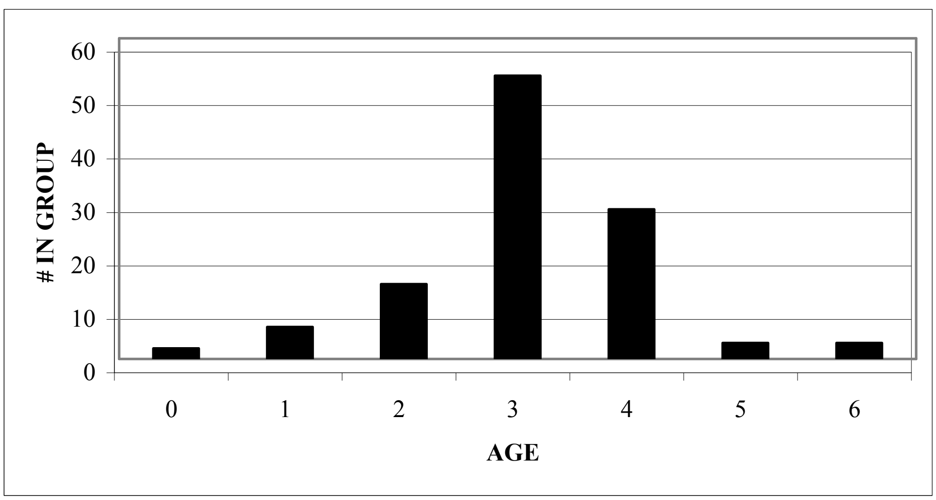

Fig. C-10 Age frequency distribution of smallmouth bass collected in Coeur d'Alene Lake (n=87).

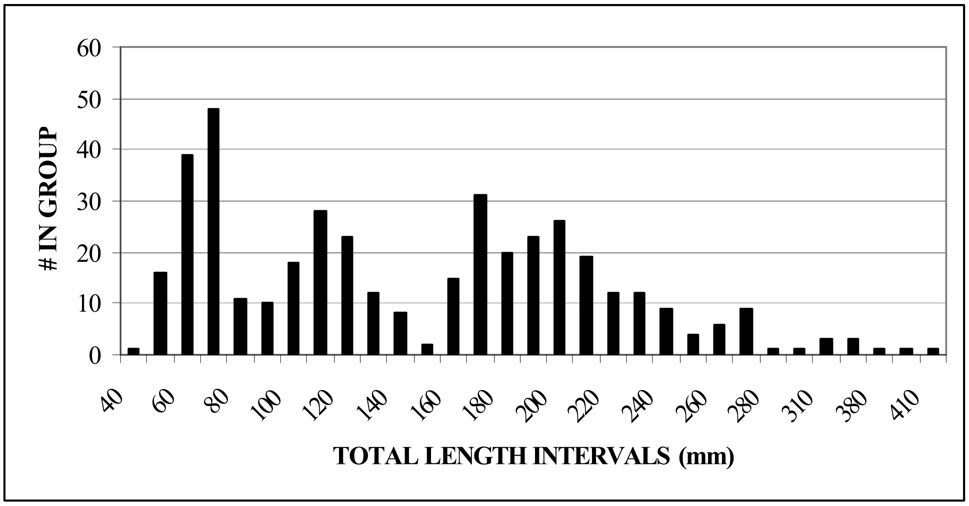

Fig. C-11 Length frequency distribution for smallmouth bass (n=413).

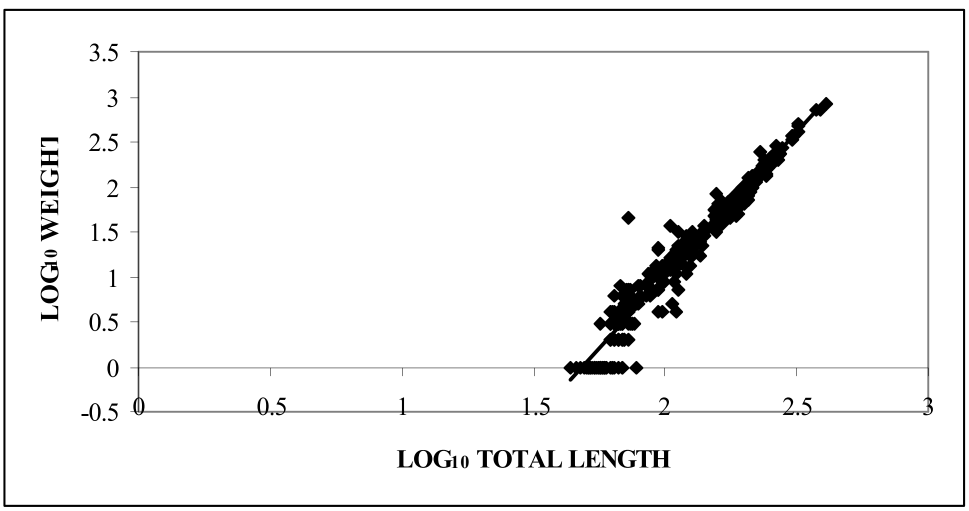

Fig. C-12 Log_{10} regression for the total length and weight of each smallmouth bass collected (n=413, y = 3.2218x-5.4497, R^2=0.9573).

Northern pike

Scales from 22 pike were readable and aged from 2 to 7 years. The scale intercept was 33.5 mm (Carlander 1969). The mean back calculated lengths are given in Table C-6.

The age frequency (Figure C-13) shows how many northern pike stomachs were collected from each age class. The sampling gear did not fully recruit northern pike in this study, those less than age three were seldomly captured.

The length frequency distribution (Figure C-14) illustrates how the population is structured according to length intervals. Because only 26 pike were collected, it is difficult to draw any conclusions about their population.

The mean condition factor for all northern pike collected in this study is 0.83. This can also be illustrated by comparing the $\log_{10}$ of the total length with the $\log_{10}$ of the weight of each fish upon capture (Figure C-15).

Table C-6. Mean back calculated lengths (± standard deviation) at age for northern pike.

	LENGTH AT AGE						
AGE	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1							
2	117 (± 31)	197 (± 31)					
3	145 (± 25)	245 (± 38)	341 (± 48)				
4	146 (± 41)	206 (± 75)	274 (± 92)	341 (± 95)			
5	135 (± 25)	213 (± 49)	308 (± 84)	438 (± 46)	558 (± 15)		
6	151 (± 42)	260 (± 75)	344 (± 96)	419 (± 109)	499 (± 128)	586 (± 91)	
7	172 (± 11)	255 (± 24)	329 (± 3)	435 (± 15)	514 (± 5)	578 (± 32)	634 (± 33)
GRAND MEAN	**145 (± 32)**	**234 (± 56)**	**322 (± 73)**	**403 (± 89)**	**520 (± 90)**	**584 (± 76)**	**634 (± 33)**
n	**0**	**2**	**6**	**4**	**3**	**5**	**2**

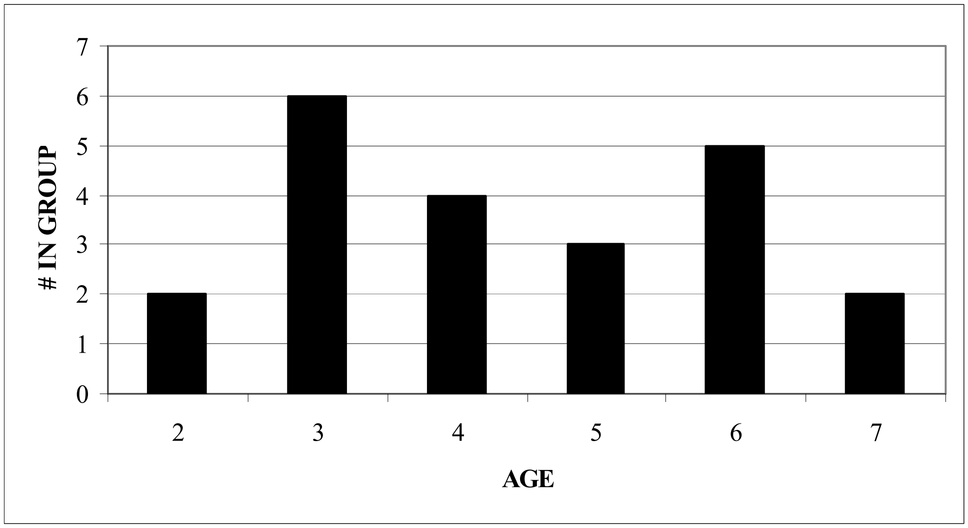

Fig. C-13 Age frequency distribution of northern pike collected in Coeur d'Alene Lake (n=22).

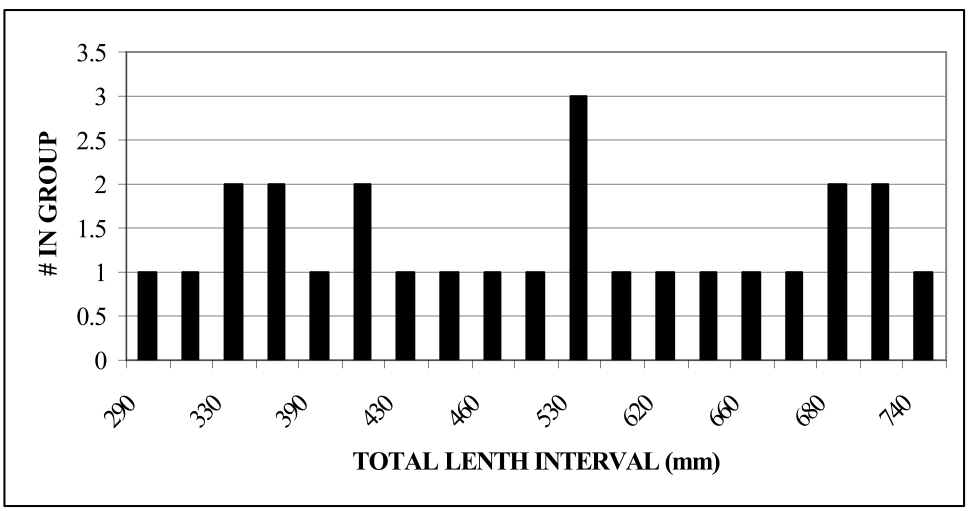

Fig. C-14. Length frequency distribution for northern pike n=26.

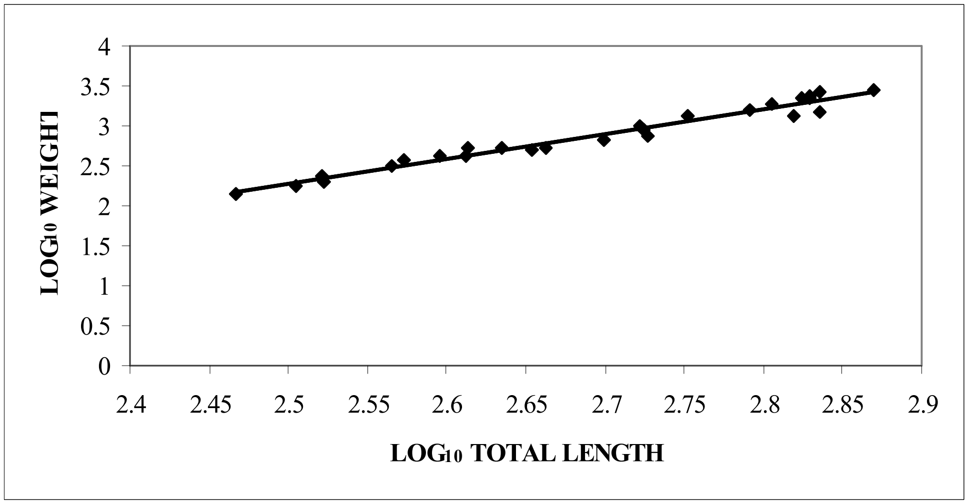

Fig. C-15 Log_{10} regression for the total length and weight of each northern pike collected (n=26, y = 3.1557x-5.6186, R^2=0.9692).

Discussion

Scales were only taken from fish whose stomachs were analyzed in an effort to try to determine which age classes of predators had the most impact on westslope cutthroat trout. For most species, 200 mm total length was considered an appropriate size to lavage and potentially find fish in the stomach contents. The average total length of adfluvial westslope cutthroat trout entering the lake system is 156 mm (Lillengreen et al. 1994). Piscivorous fishes smaller than 200 mm would not have been likely predators to cutthroat trout.

Northern Pikeminnow

The back calculated mean lengths for northern pikeminnow were slightly greater than the mean reported in Carlander (1969) for Idaho. Northern pikeminnow reached 200 mm by age 3 (Table C-2), however due to their piscivorous nature, 13 fish less than 200 were also collected for stomach contents and scales were taken. Eleven of these fish were age 2, two were age 3. No pikeminnow under 200 mm had prey fish in their stomach contents. The smallest pikeminnow with a fish in its stomach contents was 218 mm, a three year old.

Northern pikeminnow less than 200 mm were not recruited to the sampling gear (Figure C-2), so it is probable that almost every fish sampled was piscivorous. Salmonids are a favorite prey item of northern pikeminnow (Wydoski and Whitney 1979; Gray et al. 1984; Poe et al. 1986; Poe and Rieman 1988; Nigro 1989; Petersen et al. 1990a; Petersen et al. 1990b; Willis et al. 1994; Shively et al. 1996; Zimmerman 1999; Petersen 2001)

Chinook salmon

Higher numbers of age four fish represents angler selection from the fishing derby. Young chinook salmon are stocked into the system each year, so this is not representative of the population, only of the stomachs we examined.

Almost all of the chinook salmon whose stomach contents were collected from came from anglers during the fishing derby. Many of these scales were regenerated and only about half could be aged. From the fifteen scales that were readable, eight were four year old fish. This is a reflection of the anglers' efforts to catch large fish, not a reflection of the population structure of chinook salmon in Coeur d'Alene Lake. Figure C-5 includes all chinook sampled during the study and the derby fish that were weighed in. While electrofishing, many chinook under100 mm were captured. However, without sampling the pelagic zone throughout the lake, it is difficult to determine the actual population structure of chinook salmon. Natural reproduction does occur in the Coeur d'Alene and the St. Joe River systems (Fredericks et al. 2000; Fredericks et al. 2001; Fredericks et al. 2002). June 24, 2002, IDFG stocked 40,986 catchable chinook salmon (152 mm and larger) (IDFG 2002a) into Coeur d'Alene Lake. These fish were stocked after our survey was completed. The small chinook salmon that we captured via electrofishing were likely wild fish from the Coeur d'Alene River. Most were caught in grids relatively close to the mouth of the river.

The Fulton-type condition of chinook salmon was 1.05 (Table C-1), a good condition for salmonids (Carlander 1969). While their condition was good, anglers complain that the fish no longer attain the large size that they used to. The state record freshwater chinook salmon was caught from Coeur d'Alene Lake at 42 pounds (19.07 kg) (IDFG 2002b). The largest fish we collected in this study was 5.18 kg (from the derby).

Largemouth bass

The mean back calculated lengths from this study are about that same as those reported in Carlander (1977) for Idaho, Montana, and Utah. One largemouth bass stomach from a fish less than 200 mm was analyzed (age 2, Figure C-7). There were no fish in this stomach. The smallest largemouth that contained prey fish in its gut was 209 mm, a three year old. It is likely that they become piscivorous prior to 200 mm in total length, however, there are few cutthroat trout in the system that would be susceptible to smaller predators.

Largemouth bass mature from age three to five in Idaho waters (Simpson and Wallace 1982). The abundance of spawning fish throughout the system (Figure C-7) could prey on migrating cutthroat trout as largemouth bass males are very aggressive while guarding their nests (Wydoski and Whitney 1979; Simpson and Wallace 1982). They will strike at anything that comes near their nests.

Figure C-8 shows that there are many juvenile largemouth bass in the system and the population seems to be fairly stable. The mean condition factor for largemouth bass in Coeur d'Alene Lake is 1.35, slightly greater than the mean condition reported for northern populations of largemouth bass in Carlander (1977).

Smallmouth bass

Scales were collected from eleven fish smaller than 155 mm from which stomachs were not collected. The mean back calculated lengths for smallmouth bass are smaller in this study than smallmouth bass collected from other Idaho waters (Carlander 1977). The smallest fish that had prey fish in its diet was 158 mm in total length. It was a two year old. This agrees with Simpson and Wallace (1982) that smallmouth two years and older switch from invertebrate prey as the bulk of their diet to fish as the bulk of their diets.

Smallmouth bass generally mature at age three or four (Wydoski and Whitney 1979; Simpson and Wallace 1982). There are many of these fish in the system (Figure C-10) and their populations are still expanding and increasing. Smallmouth bass are quite successful in lake and river habitats (Wydoski and Whitney 1979; Simpson and Wallace 1982).

Northern pike

Mean back calculated lengths at age were much less in the present study than in Rich (1992) and Carlander (1969). This study had a smaller sample size (n=22) than most other growth studies.

The smallest pike collected in this study was 293 mm and it had a fish in its stomach contents. Pike grow quickly in their first year (Carlander 1969) and they often become piscivorous within their first year of growth.

APPENDIX D: IDENTIFICATION AND BACK CALCULATION OF ORIGINAL LENGTHS AND WEIGHTS OF PREY FISH IN COEUR D'ALENE LAKE USING A DIAGNOSTIC BONE COLLECTION.

Introduction

With the growing popularity of bioenergetics modeling, purely descriptive studies of fish diets are no longer adequate. The use of bioenergetics modeling requires specific information about the predator and the size of prey it consumes. The identity and original size of prey fish can be determined with relative certainty from diagnostic bones found in the stomachs of predators. There is a constant relationship between the fish length and the length of the bones.

Fishes known to occur in the Coeur d'Alene System were collected from lakes, rivers, and hatcheries in Eastern Washington and Northern Idaho to compile a bone collection to be used in identifying and back calculating original lengths and weights of prey fish found in the stomachs of piscivorous fishes in Coeur d'Alene Lake. Preexisting bone keys (Harrington 1955; Crossman and Casselman 1969; Eastman 1977; Newsome 1977; Scott 1977; McIntyre and Ward 1986; Hansel et al. 1988; Scharf et al. 1997; Zollweg 1998; Frost 2000) were used to identify diagnostic bones and specific keying characters.

Methods

Fish were collected from area lakes and rivers by boat and backpack electrofishing, respectively. Some species were also obtained from various local hatcheries. Total length (mm) and weight (g) was recorded for each fish. A metal tag was attached to each specimen and then was placed into a colony of dermestid beetles (*Dermestes maculatus*) to clean the bones of their flesh. Depending on the size of the specimen, it took the beetles between two and ten days to clean the skeletons. In the laboratory, the skeletons were cleaned with a mild 5% bleach solution to remove any remnant skin and prepare the bones for measurements.

Diagnostic bones, as determined by Hansel et al. (1988) and Frost (2000) were measured for each species collected. The lengths of each diagnostic bone were measured with a Mitutoyo digital caliper. For each species, the diagnostic bone lengths were plotted against the known total lengths and regression analysis was performed. A regression equation and the square of the sample correlation coefficient (R^2 value) was obtained for each. Each fish's total length was plotted against its weight in the same fashion. From these regressions, once a prey species was identified, its original total length and weight could be obtained with reasonable certainty to determine its size when consumed.

<u>Dentary</u>

The dentaries are paired V-shaped bones forming the largest part and most anterior section of the lower jaw. They form the lower portion of the mouth and contain teeth for species that typically have teeth in their lower jaws. Dentary length is measured from the mandibular symphysis to the coronoid limb of one side. In most cases dentaries can be useful in keying a species to genus, sometimes to species (Figure D-1).

Cleithra

The cleithra are paired bones that support the pectoral fins and form the frame of the body behind the branchial cavity. The anterior tips of the cleithra come together under the heart, from the anterior tips they angle back and outward, then curve upward. Three lengths were measured on each cleithrum, total length, horizontal limb, and vertical limb lengths. The cleithrum total length was measured from the anterior tip to the dorsal spine. The horizontal limb was measured from the anterior tip to the dorsoposterior lobe. The vertical limb was measured from the heel to the dorsal spine. Cleithra are also useful in identifying prey to the genus level or lower (Figure D-1).

Pharyngeal Arch

The pharyngeal arches are modified fifth gill arches that bare teeth in catostomids and cyprinids. Catostomids have fine, comb-like structures with many teeth while cyprinids exhibit larger sharp, hooked teeth or grinding plates. For cyprinids, formulas are expressed to describe the teeth on the major and minor rows. For example, the formula for northern pikeminnow (*Ptychocheilus oregonensis*) is 2,5-4,2. This means there are two teeth in each of the minor rows on both sides and there are five major teeth on the left and four on the right arch. Pharyngeal arch length was measured from the posterior tip to the anterior tip (Figure D-1).

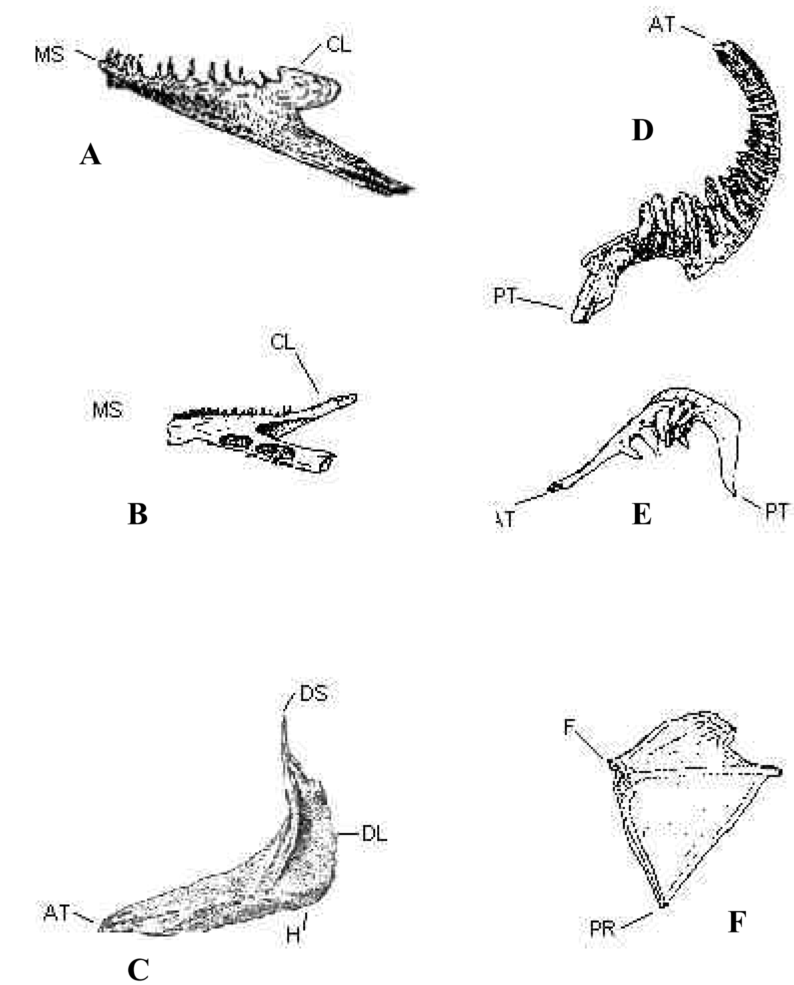

Fig. D-116 Representative diagnostic bones: (A) left dentary of rainbow trout; (B) left dentary of sculpin; (C) left cleithrum of kokanee salmon; (D) pharyngeal arch of largescale sucker; (E) pharyngeal arch of northern pikeminnow; and (F) left opercle of smallmouth bass. Abbreviations: MS = mandibular symphysis; CL = coronoid limb; AT = anterior tip; DS = dorsal spine; DL = dorsoposterior lobe; H = heel; PT = posterior tip; F= fulcrum; PR = primary ray. Figure modified from Hansel et al. (1988) and Frost (2000).

Opercle

The opercle or gill cover can be useful in identifying prey fish as well. Opercles were measured from the tip of the primary ray to the top of the fulcrum. Opercles were diagnostic to the family level, but were mostly used as secondary identification and a dentary or cleithrum as the primary identifying bone (Figure D-1).

Vertebrae

Vertebrae from each specimen were also measured. Individual vertebrae length and diameter were recorded for each specimen. Vertebrae can be used to identify salmonids from non-salmonid fishes. Salmonid vertebrae are smooth and barrel shaped with no distinct ridges. Non-salmonid fishes have distinct ridges present or are oddly shaped.

Results

Dentaries and cleithra were diagnostic to the genera level in all cases (Frost 2000). Opercles were useful only to the family level in most cases. For most specimens, the cleithra were the preferred diagnostic bones. If cleithra were not present, the dentary was the second choice for relatively easy identification. Cleithra and dentaries persisted in many stomachs analyzed and both bones have high R^2 values, indicating reliable regressions of original length, for most species evaluated.

For the following tables, n is the sample size of each bone measured. Total length can be calculated (y=) by inserting the measurement (x) of the specified bone into the given equation. Length vs. weight equation is for calculating the original weight (y=) from the back-calculated total length (x). All lengths are in millimeters and all weights are in grams.

<u>Cyprinidae</u>

Northern pikeminnows (*Ptychocheilus oregonensis*) were the only cyprinid collected for this study. Tench, *Tinca tinca*, are also present in Coeur d'Alene Lake, but no fish less than 200mm were collected. Therefore, tench were not included in the bone collection for back calculated lengths. However, tench dentaries and cleithra are included in Frost's (2000) key so they could have been identified if found in a stomach sample.

Northern pikeminnow were collected from Coeur d'Alene Lake, Long Lake and Latah Creek, Spokane, County (Table D-1).

Table D-1. Regression equations for back calculating original total lengths and weights of northern pikeminnow.

Bone	n	R^2	y=
Opercle	17	0.9803	14.341x + 4.5353
Pharyngeal arch	10	0.9856	11.746x + 16.415
Vertebrae diameter	17	0.989	67.809x + 29.678
Vertebrae length	17	0.995	75.436x + 16.67
Dentary	15	0.9889	15.78x + 16.248
Vertical cleithrum limb	16	0.9729	13.575x + 15.655
Horizontal cleithrum limb	16	0.9898	9.1626x + 27.023
Cleithrum length	16	0.989	8.301x + 14.844
Length vs. Weight	15	0.9802	$8E\text{-}07x^{3.4131}$

Catostomidae

Catostomids were easily identified to family by their cleithra, dentaries, opercles, and pharyngeal arches. None were found in the stomachs of piscivorous fish in this study, however due to their abundance in the system, they are included.

Largescale suckers (*Catostomus macrocheilus*) were collected from Coeur d'Alene Lake, Long Lake and Latah Creek, Spokane County, Washington (Table D-2).

Bridgelip suckers (*C. columbianus*) were collected from Latah Creek and the Little Spokane River, Spokane County, Washington (Table D-3).

Catostomid bones were not diagnostic to the species level, so regressions were calculated for all catostomid species combined, largescale, bridgelip, and one longnose sucker (*C. catostomus*) collected in Coeur d'Alene Lake (Table D-4).

Table D-2. Regression equations for back calculating original total lengths and weights of largescale suckers.

Bone	n	R^2	y=
Opercle	7	0.9563	13.173x + 10.555
Pharyngeal arch	4	0.9063	18.964x - 62.161
Vertebrae diameter	7	0.8292	66.783x + 36.604
Vertebrae length	7	0.6312	89.74x - 25.528
Dentary	6	0.7665	60.425x -38.816
Vertical cleithrum limb	7	0.9503	11.828x - 6.6417
Horizontal cleithrum limb	7	0.9872	14.05x - 11.473
Cleithrum length	7	0.9332	9.6828x - 11.188
Length vs. Weight	6	0.9501	$9E\text{-}06x^{3.0068}$

Table D-3. Regression equations for back calculating original total lengths and weights of bridgelip suckers.

Bone	n	R^2	y=
Opercle	11	0.9871	14.885x - 2.8083
Pharyngeal arch	6	0.976	17.146x - 11.68
Vertebrae diameter	13	0.9801	70.348x + 15.286
Vertebrae length	13	0.9216	76.594x + 13.277
Dentary	10	0.9508	64.438x - 32.116
Vertical cleithrum limb	10	0.9665	12.734x - 9.0107
Horizontal cleithrum limb	10	0.9889	14.302x - 11.38
Cleithrum length	10	0.9796	9.9854x - 10.252
Length vs. Weight	12	0.996	$2E\text{-}05x^{2.873}$

Table D-4. Regression equations for back calculating original total lengths and weights of *Catostomus* species found to occur in Coeur d'Alene Lake.

Bone	n	R^2	y=
Opercle	19	0.9852	13.085x + 14.285
Pharyngeal arch	11	0.978	15.577x + 0.1846
Vertebrae diameter	21	0.9713	71.103x + 16.918
Vertebrae length	21	0.9337	77.464x + 11.212
Dentary	17	0.9047	43.61x + 28.508
Vertical cleithrum limb	18	0.9786	11.378x + 5.943
Horizontal cleithrum limb	18	0.97	11.869x + 19.419
Cleithrum length	18	0.9809	9.13x + 2.9974
Length vs. Weight	19	0.995	$1E\text{-}05x^{2.9479}$

Ictaluridae

Brown bullhead (*Ameiurus nebulosus*) were collected from Coeur d'Alene Lake, Sprague Lake, Lincoln and Adams Counties, Washington, and Downs Lake, Spokane County, Washington (Table D-5) for use in this bone collection.

Table D-5. Regression equations for back calculating original total lengths and weights of brown bullhead.

Bone	n	R^2	y=
Spine	5	0.936	9.5779x - 6.2822
Opercle	5	0.9905	14.717x + 0.0369
Vertebrae diameter	5	0.9654	62.253x + 19.014
Vertebrae length	5	0.9921	68.083x + 11.361
Dentary	5	0.9796	9.4881x + 15.139
Vertical cleithrum limb	5	0.9959	10.27x + 7.0241
Horizontal cleithrum limb	5	0.996	6.8894x + 0.8886
Cleithrum length	5	0.997	5.8977x + 0.3618
Length vs. Weight	5	0.9977	$3E\text{-}05x^{2.842}$

Salmonidae

Salmonids are typically difficult to identify to species from diagnostic bones. Fishes in the genus *Oncorhynchus* are especially difficult to identify beyond that level. Zollweg (1998) found that cutthroat trout, *O. clarki* had a larger vertical lobe on the cleithrum and a shorter, more slender dorsal spine than rainbow trout, *O. mykiss*. Rainbow trout or steelhead (sea-run rainbow trout) have cleithrum that are undistinguishable from other Pacific salmon (Frost 2000). Since rainbow trout are seldomly encountered in Coeur d'Alene Lake, this difference allowed the identification of cutthroat trout from kokanee salmon (*O. nerka*) and chinook salmon (*O. tshawytscha*) when cleithra were present in the stomach sample. Westslope cutthroat trout (*O. clarki lewisi*) were collected from Coeur d'Alene Lake for this study (Table D-6).

Chinook salmon were not identified to species in the stomachs examined. For this reason, they are not included individually as a table. Undigested kokanee were found in the stomachs on several occasions. For this study, kokanee were collected from Coeur d'Alene Lake and Lake Roosevelt, Washington (Table D-7).

It was not possible to identify kokanee from chinook salmon if excessive digestion had occurred. If the fish was not completely digested, gill rakers could be counted to identify to the species level (Wydoski and Whitney 1979). If not, they were grouped together as salmon (Table D-8).

Mountain whitefish (*Prosopium williamsoni*) were distinguishable from the genus *Oncorhynchus* with dentaries and cleithra. Mountain whitefish were collected from

Coeur d'Alene Lake and the Little Spokane River, Spokane County, Washington (Table D-9).

Salmonids can be distinguished from other families based only on the shape of their vertebrae. Salmonid vertebrae are round with no grooves or indentations to speak of. Westslope cutthroat trout, kokanee, and chinook salmon were pooled together to form a "Salmonidae" group (Table D-10) since they were the most frequently encountered salmonids in the environments and in stomach samples.

Table D-6. Regression equations for back calculating original total lengths and weights of westslope cutthroat trout.

Bone	n	R^2	y=
Opercle	10	0.7641	13.215x + 32.548
Vertebrae diameter	13	0.7296	60.752x + 24.802
Vertebrae length	13	0.518	53.929x + 57.143
Dentary	11	0.9044	12.938x + 41.277
Vertical cleithrum limb	10	0.9709	16.611x - 0.1799
Horizontal cleithrum limb	10	0.9507	10.649x + 21.652
Cleithrum length	10	0.9831	10.012x + 2.7017
Length vs. Weight	19	0.9776	$0.0003x^{2.3357}$

Table D-7. Regression equations for back calculating the original total lengths and weights of kokanee salmon.

Bone	n	R^2	y=
Opercle	7	0.9625	12.963x + 18.752
Vertebrae diameter	8	0.9739	80.645x + 19.125
Vertebrae length	8	0.9768	110.84x - 34.303
Dentary	8	0.9624	9.2413x + 53.572
Vertical cleithrum limb	7	0.967	11.589x + 23.55
Horizontal cleithrum limb	7	0.9922	9.3368x + 24.289
Cleithrum length	7	0.9841	8.1507x + 24.829
Length vs. Weight	10	0.9987	$9E-05x^{3.4388}$

Table D-8. Regression equations for back calculating original total lengths and weights of salmon (kokanee and chinook salmon combined).

Bone	n	R^2	y=
Opercle	20	0.982	12.594x + 27.294
Vertebrae diameter	25	0.956	82.398x + 4.6783
Vertebrae length	25	0.9677	100.21x + 1.3594
Dentary	25	0.9764	9.9671x + 30.377
Vertical cleithrum limb	19	0.9893	11.785x + 18.47
Horizontal cleithrum limb	19	0.9966	9.5332x + 17.941
Cleithrum length	19	0.9935	8.4753x + 12.357
Length vs. Weight	26	0.9926	$2E\text{-}06x^{3.3313}$

Table D-9. Regression equations for back calculating original total lengths and weights of mountain whitefish.

Bone	n	R^2	y=
Opercle	14	0.9781	15.8x - 1.8883
Vertebrae diameter	14	0.9259	66.633x + 27.387
Vertebrae length	14	0.8925	72.417x + 11.375
Dentary	13	0.9599	23.991x - 46.531
Vertical cleithrum limb	12	0.994	16.821x + 7.9525
Horizontal cleithrum limb	12	0.9922	12.886x + 3.4076
Cleithrum length	12	0.9935	12.288x - 18.418
Length vs. Weight	14	0.9967	$4E\text{-}06x^{3.153}$

Table D-10. Regression equations for back calculating original total lengths and weights of *Oncorhynchus* species ("Salmonidae") found to frequently occur in Coeur d'Alene Lake.

Bone	n	R^2	y=
Opercle	30	0.9482	12.595x + 31.209
Vertebrae diameter	38	0.8946	76.222x + 6.8761
Vertebrae length	38	0.8412	86.437x + 12.296
Dentary	36	0.9211	9.8657x + 43.691
Vertical cleithrum limb	29	0.9542	11.574x + 32.066
Horizontal cleithrum limb	29	0.9818	9.467x + 25.762
Cleithrum length	29	0.9834	8.4713x + 18.135
Length vs. Weight	45	0.9456	$4E\text{-}05x^{2.7002}$

Cottidae

Sculpins (*Cottus spp*.) were grouped together by genus, not species and were all collected from Coeur d'Alene Lake (Table D-11). Cleithra and dentaries were diagnostic to the family level on all occasions. The length vs. weight regression was calculated using the measurements of fish collected throughout the entire study, not only bone key fish were used for this regression, hence the larger sample size.

Table D-11. Regression equations for back calculating original total lengths and weights of *Cottus* species.

Bone	n	R^2	y=
Vertebrae diameter	4	0.7576	50x + 23
Vertebrae length	4	0.8148	55x + 7.75
Dentary	4	0.8859	6.661x + 21.465
Vertical cleithrum limb	4	0.7953	7.1143x + 13.087
Horizontal cleithrum limb	4	0.9482	7.7794x - 2.0444
Cleithrum length	4	0.9384	5.2488x + 3.2741
Length vs. Weight	18	0.7592	$6E\text{-}05x^{2.5685}$

Centrarchids

Largemouth bass (*Micropterus salmoides*) were collected from Coeur d'Alene Lake for this bone collection.

Smallmouth bass (*M. dolomieui*) were collected from Coeur d'Alene Lake for this bone collection (Table D-13).

In most cases, the bass prey fish were too far digested to identify to the species level so regressions were calculated for both *Micropterus* species combined (Table D-14). Cleithra and dentaries were diagnostic to the genus level.

Black crappie (*Pomoxis nigromaculatus*) were collected from Coeur d'Alene Lake, and Newman and Downs Lakes, Spokane County, Washington (Table D-15).

Pumpkinseed sunfish (*Lepomis gibbosus*) were collected in Coeur d'Alene Lake (Table D-16). The length vs. weight regression was calculated using the measurements of fish collected throughout the entire study, not only bone key fish were used for this regression, hence the larger sample size.

Table D-12. Regression equations for back calculating original total lengths and weights of largemouth bass.

Bone	n	R^2	y=
Opercle	13	0.9884	10.059x + 2.114
Vertebrae diameter	13	0.9627	53.589x + 19.045
Vertebrae length	13	0.9782	56.933x + 7.3571
Dentary	11	0.9565	8.9653x + 14.827
Vertical cleithrum limb	10	0.9898	11.938x + 9.9104
Horizontal cleithrum limb	10	0.9781	6.4156x + 19.032
Cleithrum length	10	0.9851	5.9369x + 13.138
Length vs. Weight	13	0.9275	$1E\text{-}04x^{2.618}$

Table D-13. Regression equations for back calculating original total lengths and weights of smallmouth bass.

Bone	n	R^2	y=
Opercle	9	0.942	11.23x + 0.7589
Vertebrae diameter	9	0.9341	54.873x + 17.949
Vertebrae length	9	0.9541	60.359x - 6.3138
Dentary	9	0.9607	11.061x - 9.6817
Vertical cleithrum limb	9	0.9387	14.383x - 1.2253
Horizontal cleithrum limb	9	0.951	6.8573x + 3.733
Cleithrum length	9	0.9456	6.4771x + 0.5584
Length vs. Weight	8	0.9556	$5E\text{-}05x^{2.7452}$

Table D-14. Regression equations for back calculating original total lengths and weights of *Micropterus* species ("bass") found to occur in Coeur d'Alene Lake.

Bone	n	R^2	y=
Opercle	22	0.964	10.589x + 1.7299
Vertebrae diameter	22	0.955	54.183x + 18.686
Vertebrae length	22	0.9689	57.361x + 4.3189
Dentary	20	0.9504	9.6319x + 8.5613
Vertical cleithrum limb	19	0.9568	12.789x + 8.1916
Horizontal cleithrum limb	19	0.9651	6.5004x + 14.491
Cleithrum length	19	0.9685	6.1108x + 9.3781
Length vs. Weight	21	0.9401	$9E\text{-}05x^{2.6366}$

Table D-15. Regression equations for back calculating original total lengths and weights of black crappie.

Bone	n	R^2	y=
Opercle	11	0.9746	8.6811x + 4.74
Vertebrae diameter	12	0.9676	52.523x + 16.68
Vertebrae length	12	0.9793	60.028x - 1.1442
Dentary	12	0.8675	12.388x + 15.342
Vertical cleithrum limb	11	0.9768	10.201x + 3.4449
Horizontal cleithrum limb	11	0.9769	5.8703x + 10.301
Cleithrum length	11	0.987	5.0677x + 5.5193
Length vs. Weight	13	0.9699	$6E\text{-}05x^{2.7254}$

Table D-16. Regression equations for back calculating original total lengths and weights of pumpkinseed sunfish.

Bone	n	R^2	y=
Opercle	8	0.9578	9.0047x + 0.419
Vertebrae diameter	8	0.9688	48.318x + 26.193
Vertebrae length	8	0.9426	40.563x + 24.985
Dentary	7	0.9524	13.698x + 12.587
Vertical cleithrum limb	8	0.9875	7.6854x + 18.358
Horizontal cleithrum limb	8	0.9701	6.083x + 2.1165
Cleithrum length	8	0.9937	4.2316x + 11.967
Length vs. Weight	116	0.8322	$5E\text{-}05x^{2.795}$

Percidae

Yellow perch (*Perca flavescens*) are the only species in this family known to occur in Coeur d'Alene Lake. Cleithra, dentaries, and opercles are all diagnostic to the family level, so they were easily identifiable as yellow perch (Table D-17).

Table D-17. Regression equations for back calculating original total lengths and weights of yellow perch.

Bone	n	R^2	y=
Opercle	24	0.9451	11.815x + 14.639
Vertebrae diameter	24	0.9148	55.023x + 35.106
Vertebrae length	24	0.9264	48.83x + 29.795
Dentary	24	0.9625	13.8x + 13.516
Vertical cleithrum limb	22	0.9854	12.841x + 16.769
Horizontal cleithrum limb	22	0.9932	7.6428x + 9.3999
Cleithrum length	22	0.9881	6.7533x + 10.199
Length vs. Weight	19	0.9628	$9E\text{-}06x^{3.018}$

The raw data used to calculate the regressions for all species are included in Table D-18. Original total lengths and weights of the fish from the bone collection are recorded. For each fish, the measurements from each bone were also recorded. Total lengths were plotted against bone length to form the previously described regressions.

Table D-18. Original total length and weight of fish used in regression analysis to back-calculate original total lengths and weights from the specified bones. (Spine length is pectoral spine, only for Ictaluridae).

Species	TL (mm)	WT (g)	Cleithra Length (mm)	Cleithra Horizontal Limb (mm)	Cleithra Vertical Limb (mm)	Dentary Length (mm)	Vertebrae Length (mm)	Vertebrae Diameter (mm)	Pharyngeal Arch Length (mm)	Opercle Length (mm)	Spine Length (mm)
NPM	82		9	7	5.8	4.3	0.9	0.8		5.3	
NPM	118	5	12.4	10.2	8.1	6.2	1.3	1.3	8.5	7.2	
NPM	125	13	14.1	11.2	9.3	7.3	1.4	1.6	9.3	8.4	
NPM	145	21					1.7	1.6		9.6	
NPM	151		17.6	14	10.8	9.2	1.8	1.8	12.6	11	
NPM	155	25	17.7	15	10.5	9	1.7	1.8	12.2	10.7	
NPM	160	27	17.3	14.3	11	8.7	1.9	2.1	11.4	10.5	
NPM	168	32	18.4	15.2	11.4	9.3	2	1.9	12.8	10.6	
NPM	178	51	22.1	18.4	12.7	10.9	2.3	2.3	15.6	14.5	
NPM	193	51	21.6	18	13.3	10.8	2.5	2.3		13	
NPM	214	69	24	20.7	14.3	13.2	2.6	2.7	16.5	14.3	
NPM	243	108	26.1	22.3	17.1	14.1	3	3		19	
NPM	245	127	25.9	22.4	15.9	14.3	3.2	3.1		15.7	
NPM	249	119	27.2	23.9	15.8	13.5	2.9	3.5		16.3	
NPM	326	313	35.6	30.3	20.9	19.6	3.9	4.6		23.3	
NPM	373	505	40.6	35.8	22.8	23	4.8	4.6	27.1	23.7	
NPM	553	1418	67.4	59.7	42.1		7.1	7.8	46.9	38	
BLS	65	3	7.5	5.3	6	1.4	0.7	0.8	4.8	4.4	
BLS	69	4					0.8	0.8			
BLS	74	4				1.8	0.9	0.8			
BLS	95	8	10.8	6.9	8.6	1.9	1	1.1		6.7	
BLS	96	9	10.8	7.7	8.7		1.1	1.1	6.2	6.7	
BLS	112	14									

Table D-18 (continued).

Species	TL (mm)	WT (g)	Cleithra Length (mm)	Cleithra Horizontal Limb (mm)	Cleithra Vertical Limb (mm)	Dentary Length (mm)	Vertebrae Length (mm)	Vertebrae Diameter (mm)	Pharyngeal Arch Length (mm)	Opercle Length (mm)	Spine Length (mm)
BLS	116		13.3	9.3	9.7	2.4	1.4	1.5		8.4	
BLS	129	22				2.4	1.6	1.6		8.9	
BLS	152	30	16.1	11.8	12.6	3.3	1.8	1.9	9.7	10.2	
BLS	209		22.5	15.9	17.8	3.9	2.8	2.8		14.7	
BLS	212	96	21	15.1	16.5		2.7	2.9		14.8	
BLS	213	88	21.9	16.2	16.5	3.5	2.6	3	12.7	14.4	
BLS	213	102	21	15.5	16	3.6	2.7	2.8	12.2	13.3	
BLS	230	101	25.7	16.2	20.4	4	2.1	2.7	15	15.8	
LSS	174	48	18	13.5	14	4	3	2		11	
LSS	175		20.4	13.4	16	3.5	2.1	1.9	12.6	13.2	
LSS	193	78	22	14	18		2.5	3		15	
LSS	246	162	25.8	18.4	21.4	4.5	2.9	3.4		18.4	
LSS	268	141	31	20.5	24.4	5.7	3.1	3.2	18.7	19.5	
LSS	298	271	29.9	21.4	24.5	5.1	3.6	3.7	18.2	21.2	
LSS	298	285	31.6	22.1	25.3	5.2	3.2	3.7	18.4	21.5	
BBH	57	3	9.9	8.2	5.1	4.6	0.7	0.6		4.1	6.8
BBH	183	73	31.1	25.8	16.9	17.2	2.5	2.8		12.1	19.1
BBH	185	79	30.2	26.8	17.2	17.5	2.6	2.6		12	23
BBH	205	113	34.9	30.6	18.8	21.7	2.7	3.2		14.5	21.1
BBH	237	187	40.6	33.8	23	22.4	3.4	3.2		16.2	23.8
WCT	39	1				2	0.5	1		2	
WCT	119	15	11	9	7	7	1	1.5			
WCT	140	28	15	13	9	9	2.5	2.5		9	
WCT	142	30					2	2			
WCT	148	26	15	13	9	8	1.5	2		7	

Table D-18 (continued).

Species	TL (mm)	WT (g)	Cleithra Length (mm)	Cleithra Horizontal Limb (mm)	Cleithra Vertical Limb (mm)	Dentary Length (mm)	Vertebrae Length (mm)	Vertebrae Diameter (mm)	Pharyngeal Arch Length (mm)	Opercle Length (mm)	Spine Length (mm)
WCT	160	40	15	13	9	8	1.5	1.5		9	
WCT	162	41	15.5	13	10	9	2	2		10	
WCT	171	54	17	13.5	10		3	3			
WCT	173	43	17	14	11	10	2	2.5		14	
WCT	183	66	18	14	11.5	10	3	3		15	
WCT	193	64	19	15	11	10	2	2		10	
WCT	230	115				12.5	2	3		13	
WCT	285	228	28	25	17	21	3	4		16	
KOK	54	1				3	1	0.5			
KOK	89	4	8	7	6	3	1	1		6	
KOK	343	475	38.5	32.5	27.4	29.8	3.4	3.8		22.7	
KOK	308	350	37.3	31.7	27.4	28.8	3.2	3.7		23.9	
KOK	333	410	37.9	32.9	24.7	28.3	3.1	3.9		23.2	
KOK	360	560	42	36.6	29.4	36.6	3.5	4.6		28	
KOK	360	540	39	35.9	28.2	34	3.8	4.2		26.1	
KOK	306	280	33.5	30	23.8	23.1	2.9	3.1		21.9	
CHIN	75					6	1	1			
CHIN	75					6				4	
CHIN	81		9	7.5	6	6.5	1	1		5	
CHIN	87	5	10	8	6	6	1	1		6	
CHIN	87	5					1	1			
CHIN	89	6	9	7.5	6.5	7	1	1			
CHIN	97	8			7.5		1	1			
CHIN	102		11	9.5	7.5	8	1	1.5			
CHIN	107	14	12	9.5	7.5	8	1	1		7	

Table D-18 (continued).

Species	TL (mm)	WT (g)	Cleithra Length (mm)	Cleithra Horizontal Limb (mm)	Cleithra Vertical Limb (mm)	Dentary Length (mm)	Vertebrae Length (mm)	Vertebrae Diameter (mm)	Pharyngeal Arch Length (mm)	Opercle Length (mm)	Spine Length (mm)
CHIN	107	12	10	9	7.5	8	1	1		6	
CHIN	108	12				8	1	1.5		7	
CHIN	109	11				7	1	1		5.5	
CHIN	111	14	12	10	8	8	1	1.5		6.5	
CHIN	117	16	13	10	8.5	8.5	1	1.5		6	
CHIN	119	16	12	10	9	8	1	1.5		9	
CHIN	125	22	13	11	8.5	9	1	1		6	
CHIN	128	22	13.5	11.5	9	9.5	1	2		7	
CHIN	130	21	13	11	8	9.5	1	2		8	
MWF	84	5	8	6.5	5	5	1	1		5	
MWF	95	6					1	1		7	
MWF	113	11				7	2	1.5		8	
MWF	125	13	12	9.5	7	7.5	1.5	1.5		7.5	
MWF	132	17	12	9	7	7.5	1.5	2		8	
MWF	138	19	13	11	7.5	9	2	1.5		9	
MWF	139	19	13	11	8	7	1.5	1.5		9	
MWF	160	30	15	12	9	9	2	2		11	
MWF	166	37	15	12.5	9.5	8.5	3	2		10	
MWF	265	161	23	21	15	13.5	3	3.5		18	
MWF	270	186	22.5	21	15	13	3.5	4		16	
MWF	273	161	23	20	15.5	12	3.5	4		17	
MWF	286	197	25	22	17	14	3.5	3		19	
MWF	303	249	27	23	18	14.5	4	4		18.5	
COT	68	3	12.3	8.9	7.9	6.9	1.1	0.9			
COT	80	5	15.2	10.8	10.1	9.3	1.4	1.2			

Table D-18 (continued).

Species	TL (mm)	WT (g)	Cleithra Length (mm)	Cleithra Horizontal Limb (mm)	Cleithra Vertical Limb (mm)	Dentary Length (mm)	Vertebrae Length (mm)	Vertebrae Diameter (mm)	Pharyngeal Arch Length (mm)	Opercle Length (mm)	Spine Length (mm)
COT	80	7	14.4	10.7	9	8.9	1.3	1.2			
COT	89	4	16	11.4	10.2	9.6	1.4	1.2			
PS	70	3	13.6	10.5	6.8	4.4	1.1	0.9		8.1	
PS	82		16.8	13.9	8.1	5.4	1.5	1.2		9.7	
PS	84	12	17.1	13.9	8.7		1.4	1.2		8.6	
PS	103	24	21.4	16.6	10.6	6	2.1	1.7		11.2	
PS	112	31	24.3	18.9	12.5	7.2	2	1.7		12.7	
PS	125	46	25.6	18.7	14.6	8.8	2.5	1.9		14.2	
PS	135	61	29.2	22	14.8	8.4	2.9	2.4		13.8	
PS	146	67	31.9	23.6	16.3	9.8	2.7	2.4		16.5	
SMB	57	3	9.1	8	3.7	6	1	0.8		5.5	
SMB	70	5	8.4	7.2	4.7	6.9	1.1	1		6.3	
SMB	105	36	22.5	20.5	10.5	13.7	2.5	2.4		12.8	
SMB	113	19	16.7	15.5	7.4	11	1.9	1.5		8.6	
SMB	120	27	18.9	17.3	8.7	11.1	2.1	1.8		10.7	
SMB	128	30	18.5	17.3	8.2	11.6	2.1	1.8		10.7	
SMB	167	51	25.6	23.7	11.7	15.3	2.9	2.5		13.8	
SMB	215		30.9	29.4	13.9	19.6	3.5	3.3		17.4	
SMB	284	272	43	39.8	19.5	26.5	4.7	4.9		25.7	
LMB	36	1	3.1	2.5	1.7		0.7	0.5		2.7	
LMB	40	1				4.6	0.6	0.4		3.9	
LMB	40	3	4.7	3.9	2.9	4.1	0.8	0.5		4.2	
LMB	57	2					0.9	0.8		5.3	
LMB	65	7	10.8	9.3	5.2	5.9	1	1		6.2	
LMB	72	12	8.8	6.5	4.3	6.1	1.2	1		6.9	

Table D-18 (continued).

Species	TL (mm)	WT (g)	Cleithra Length (mm)	Cleithra Horizontal Limb (mm)	Cleithra Vertical Limb (mm)	Dentary Length (mm)	Vertebrae Length (mm)	Vertebrae Diameter (mm)	Pharyngeal Arch Length (mm)	Opercle Length (mm)	Spine Length (mm)
LMB	73	12	11.3	9.9	5.1	7.4	1.3	1		7.7	
LMB	76	15	12.7	11.2	6.1	8.5	1.2	1		7.5	
LMB	89	11	10	7	7.5	6.5	1	1.5		8.5	
LMB	90					7.4	1.4	1.2		9.3	
LMB	171	46	27	24	13	13	2.5	2		17	
LMB	230	131	34.2	31.5	17.4	24.5	4	4.2		20.4	
LMB	275	244	45.1	40.2	22.9	30	4.8	4.8		28.3	
BC	28	1	4.7	3.6	3	3.5					
BC	30	1	5.2	3.7	2.9	2.1	0.6	0.4		3.5	
BC	30	1	4.5	3.3	2.5		0.5	0.4		3.6	
BC	41	1	7.5	5.9	3.5	3.1	0.6	0.5			
BC	42	1				2.9	0.8	0.6		5.3	
BC	48	1				2.5	1	0.5		3.5	
BC	163	55	29.6	24.6	14.7	12.5	2.5	2.6		18.3	
BC	180	122	38	32.5	20	8	3	3		20	
BC	181	89	34.5	26.5	17.5	14.6	3	2.8		21.5	
BC	200	107	41	35.5	20	13	3.5	4		24	
BC	200	107	36	32	19	11.5	3	3		19.5	
BC	205	150	38.5	32.5	19.1	16.9	3.8	3.9		24.3	
BC	209	166	38	30.5	17.9	17.8	3.4	3.6		21.9	
YP	58	4				3.5	1	0.5		4	
YP	64	3	8.5	7.5	4	4	1	1		4.5	
YP	64		8	8	4	4.5	1	1		5.5	
YP	74	3	10	8.5	5	4.5	1	0.5		5	
YP	86		10.5	9	5	5	1	1		6	

Table D-18 (continued).

Species	TL (mm)	WT (g)	Cleithra Length (mm)	Cleithra Horizontal Limb (mm)	Cleithra Vertical Limb (mm)	Dentary Length (mm)	Vertebrae Length (mm)	Vertebrae Diameter (mm)	Pharyngeal Arch Length (mm)	Opercle Length (mm)	Spine Length (mm)
YP	87		9	9	6	6	1.5	1		6	
YP	90		13	11.5	6.5	6.5	1.5	1		7.5	
YP	93	6	11	10	5.5	5	1	1		6.5	
YP	96		14	12	6.5	6.5	1.5	1.5		8	
YP	96	7				6	1	1		7	
YP	97	7	13	11.5	6	6	1.5	1		6.5	
YP	111	16	15	13.5	7	7	2	2		9	
YP	120	12	17	15	7	8	1.5	1		9	
YP	121	15	17	15	7.5	8	1.5	1.5		9	
YP	137	28	19.5	16.5	9.5	9.5	2	1.5		10	
YP	145	32	21	18	11	7	2	2		10	
YP	161	30	23	20	11.5	9	2.5	2		12	
YP	165	41	22	19.5	10.5	10.5	2.5	2		13	
YP	196	76	26	24.5	13.5	13	4	3		14	
YP	201	83	28	24.5	14.5	14	4	3.5		16.5	
YP	203	91	28	26	14	15	3.5	3		11.5	
YP	215	121	30	26	16	15	3.5	3		18	
YP	247	171	34.5	31.5	18	17	4.5	4		21	
YP	254	206	37	32	18.5	16.5	4	3.5		20	

Discussion

Cleithra and dentaries were found to be the best diagnostic bones to use in identifying prey fish from the stomachs of piscivores. They were persistent in most stomachs, and allow the investigator to identify the prey fish to at least the family level, in most cases to the genus. Pharyngeal arches are also useful in identifying catostomids and cyprinids; however none were found in the stomach samples examined in this study.

The linear relationships of diagnostic bone length to total length are consistent with Mann and Beaumont (1980), McIntyre and Ward (1986) and Hansel et al. (1988). For most species, it is recommended that the total cleithrum length be used when possible to back calculate original lengths. They persist in many stomachs and are very diagnostic. Total cleithra length also tends to consistently have high R^2 values, indicating a functional regression.

Admittedly, there are limitations to the confidence of back calculating original lengths and weights such as this study. The bones used to form the regressions were not preserved in formalin and the stomach samples were. This could have affected the lengths of bones found in the diets of piscivorous fishes and skew the regressions used in back calculating original lengths. Sample sizes should also be increased for a more complete study, increasing confidence in the regressions. However, due to the high R^2 values, and minimal bone shrinkage caused by formalin, these regressions were considered accurate for back calculating original lengths of prey fish found in the stomachs of piscivorous fishes in Coeur d'Alene Lake.

The use of such regressions in back calculating original lengths of prey fish may enable further investigations into the feeding habits of piscivores. Such knowledge will aid in bioenergetics studies, a current trend in diet analysis. For the current study, knowledge of the size of fish being selected by the predators could assist hatchery managers (for the proposed westslope cutthroat trout hatchery) in determining the size of fish to be stocked as to result in the lowest frequency of predation.

APPENDIX E: ZOOPLANKTON DENSITIES

Zooplankton samples were collected with a Wisconsin net, 11 cm radius and 80 µ mesh, towed vertically from the bottom to the surface (Rabeni 1996). Samples were collected in duplicate at three gillnet sites and/or electrofishing sites each day fish sampling occurred. Collections were preserved in 5% formalin.

In the laboratory, each sample was filtered through a 100 micron mesh filter and placed on a plankton wheel. All organisms were enumerated and keyed to genus using Brooks (1957) and Pennak (1989).

Zooplankton densities were calculated for each tow and averaged to estimate seasonal and annual densities. In order to find densities, the volume of water sampled was calculated according to the following formula:

$$V = \pi r^2 h$$

where:

p = 3.14
r = radius of Wisconsin net opening (m), and
h = depth of water column sampled (m).

Densities were calculated according to this formula:

$$D = \frac{N_i}{V}$$

where:

D = density (number of organisms/m^3),
N_i = total number of zooplankton genera i,
V = volume of water sampled with Wisconsin net.

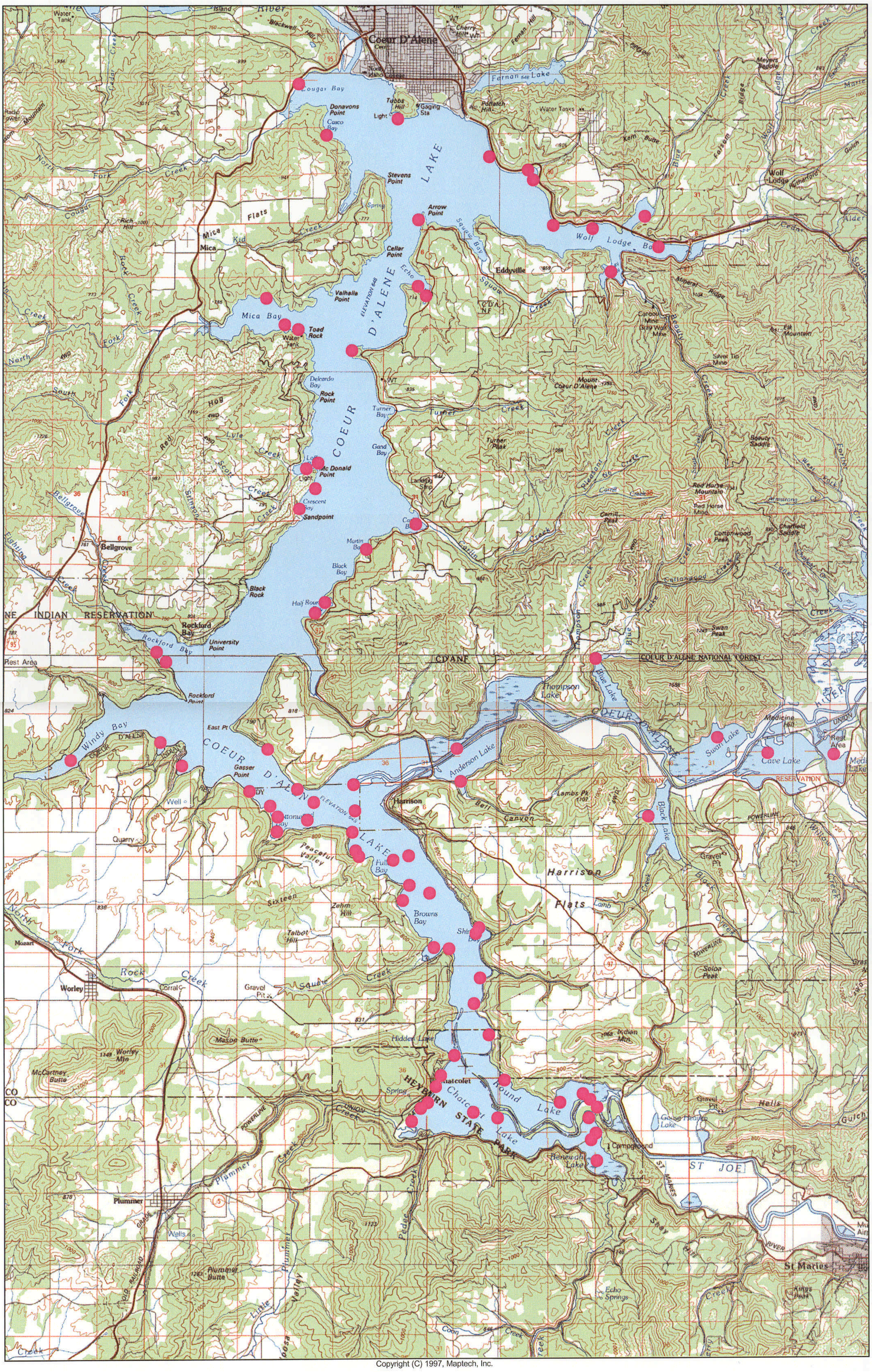

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Fig. E-117 Sites of zooplankton tows in Coeur d'Alene Lake, July 2001 to June 2002.

Densities were calculated annually and seasonally for the entire sample area (Table E-1). Densities were also calculated from the pelagic zones (Table E-2), the shoreline zones (Table E-3), and tributary zones (Table E-4) on a seasonal basis.

Table E-1. Mean seasonal and annual zooplankton density (#/m^3) (± standard deviation) for the entire sample area, July 1, 2001 to June 30, 2002.

ORGANISM	SUMMER	FALL	WINTER	SPRING	ANNUAL
Daphina	2160.7 (1778.1)	1174.4 (1051.1)	20.0 (32.3)	182.4 (528.1)	849.3 (1284.7)
Bosmina	0.4 (2.4)	3.4 (8.5)	1.2 (1.6)	34.2 (125.7)	14.4 (79.3)
Leptodora	31.7 (43.8)	4.7 (7.6)	0.1 (0.3)	0.8 (2.0)	7.8 (22.8)
Polyphemus	0.2 (0.7)	6.4 (23.2)		0.7 (3.6)	2.3 (13.3)
Calanoida	156.9 (104.0)	132.0 (39.2)	4.2 (3.7)	37.2 (89.4)	85.6 (170.4)
Cyclopoida	7.6 (13.3)	21.8 (61.6)	7.3 (6.5)	114.7 (206.3)	53.1 (140.7)
Diaphanosoma	0.2 (0.8)	9.8 (22.9)	0.2 (0.8)		3.1 (13.4)
Hydrarachna	0.5 (1.6)	0.1 (0.4)		0.2 (1.7)	0.2 (1.3)
Alona	383.9 (1461.7)	8.8 (55.3)			76.5 (650.6)
Hydra	4.4 (17.0)			2.0 (9.6)	1.6 (9.6)
Chaoborus	0.1 (0.4)	0.4 (1.8)	0.5 (2.1)	0.2 (1.1)	0.3 (1.4)
GRAND MEANS	**249.7 (311.3)**	**123.8 (115.6)**	**3.0 (4.3)**	**33.8 (88.0)**	**99.5 (217.0)**

Table E-2. Mean seasonal and annual zooplankton density (#/m^3) (± standard deviation) for the pelagic zones, July 1, 2001 to June 30, 2002.

ORGANISM	SUMMER	WINTER	SPRING	ANNUAL
Daphina	1377.2 (180.0)	2.0 (1.4)	50.5 (14.9)	867.5 (716.6)
Bosmina		1.2 (0.3)	14.2 (0.7)	2.1 (5.0)
Leptodora	32.8 (41.5)	0.4 (0.5)	1.1	20.7 (35.5)
Polyphemus	0.3 (0.7)			0.2 (0.5)
Calanoida	126.0 (41.2)	6.1 (1.4)	1.6 (0.7)	80.5 (70.2)
Cyclopoida	8.8 (18.0)	12.2 (10.0)	19	10.9 (14.6)
Diaphanosoma	0.3 (0.7)	1.1 (1.6)		0.5 (0.9)
Hydrarachna				
Alona				
Hydra				
Chaoborus				
GRAND MEANS	**140.5 (25.6)**	**2.1 (1.4)**	**7.8 (1.5)**	**89.3 (76.7)**

Table E-3. Mean seasonal and annual zooplankton density (#/m^3) (± standard deviation) for the shoreline zones, July 1, 2001 to June 30, 2002.

ORGANISM	SUMMER	FALL	WINTER	SPRING	ANNUAL
Daphina	2390.3 (1448.9)	1377.0 (910.1)	53.7 (11.5)	61.1 (108.7)	750.7 (1043.4)
Bosmina		0.1 (0.3)	0.1 (0.3)	12.3 (12.7)	5.6 (10.4)
Leptodora	51.1 (72.6)	3.5 (2.9)		0.8 (1.5)	6.3 (23.3)
Polyphemus		7.1 (22.7)		0.5 (1.1)	2.8 (12.7)
Calanoida	217.4 (118.7)	64.2 (52.5)	4.4 (1.9)	13.0 (14.8)	49.4 (73.9)
Cyclopoida	9.9 (17.1)	32.6 (75.5)	3.3 (2.9)	52.0 (78.6)	36.7 (70.3)
Diaphanosoma		13.7 (23.7)			5.0 (15.4)
Hydrarachna	0.5 (0.9)	0.2 (0.4)			0.1 (0.4)
Alona	2.6 (4.5)				0.2 (1.3)
Hydra	21.9 (38.0)			0.3 (1.1)	2.1 (11.5)
Chaoborus				0.3 (1.1)	0.1 (0.8)
GRAND MEANS	**244.9 (154.6)**	**136.2 (98.9)**	**5.6 (1.5)**	**12.8 (20.0)**	**78.1 (115.0)**

Table E-4. Mean seasonal and annual zooplankton density (#/m^3) (± standard deviation) for the tributary zones, July 1, 2001 to June 30, 2002.

ORGANISM	SUMMER	FALL	WINTER	SPRING	ANNUAL
Daphnia	2621.9 (2359.8)	971.7 (989.1)	3.7 (3.2)	321.7 (750.3)	933.3 (1492.2)
Bosmina	0.9 (2.5)	6.6 (8.5)	1.9 (0.5)	59.0 (182.9)	24.8 (113.3)
Leptodora	22.6 (28.6)	5.9 (7.1)		0.7 (2.2)	6.4 (14.9)
Polyphemus	0.2 (0.5)	5.7 (7.6)		1.0 (3.5)	2.3 (5.3)
Calanoida	153.0 (105.7)	199.8 (280.7)	3.0 (2.7)	65.6 (121.6)	118.9 (190.5)
Cyclopoida	5.8 (9.3)	10.9 (19.8)	7.8 (2.4)	188.8 (275.9)	76.9 (188.3)
Diaphanosoma	0.2 (0.7)	6.0 (15.7)			2.0 (9.1)
Hydrarachna	0.8 (1.4)			0.5 (1.8)	0.4 (1.3)
Alona	821.6 (2173.6)	17.5 (60.8)			161.1 (945.1)
Hydra				3.9 (14.0)	1.5 (8.7)
Chaoborus	0.2 (0.4)	0.8 (1.7)	1.1 (2.2)		0.4 (1.2)
GRAND MEANS	**329.7 (425.7)**	**111.4 (126.5)**	**1.6 (1.0)**	**58.2 (122.9)**	**120.7 (270.0)**

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