

This report was funded by the Bonneville Power Administration (BPA), U.S. Department of Energy, as part of BPA's program to protect, mitigate, and enhance fish and wildlife affected by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The views in this report are the author's and do not necessarily represent the views of BPA.

For additional copies of this report, write to

Bonneville Power Administration
Public Information Center - CKPS-1
P.O. Box 3621
Portland, OR 97208

Please include title, author, and DOE/BP number from the back cover in the request

Resident Fish Planning: Dworshak Reservoir, Lake Roosevelt, and Lake Pend Oreille

Prepared by

Duane H. Fickeisen¹
David R. Geist

Pacific Northwest Laboratory
Richland, Washington
Operated for the U.S. Department of Energy by
Battelle Memorial Institute
under Contract **DE-AC06-76RLO** 1930

Prepared for the U.S. Department of Energy
Bonneville Power Administration
Division of Fish and Wildlife
P.O. Box 3621
Portland, Oregon 97208-362 1

Project No. 93-026
Task Order No. **DE-AT79-92BP6** 1203
to Master Agreement **DE-AI79-86BP62611**

December 1993

¹ Mr. Fickeisen performed this work under a contract between the Pacific Northwest Laboratory and ASCI (ASCI sub-contract 132127-A-BI)

EXECUTIVE SUMMARY

Research projects are presently being conducted to reduce the amount of uncertainty in how reservoir operations within the Columbia River federal power system affect resident fish. Many of these research projects are being conducted to better **define** operation strategies being proposed under the Columbia River System Operation Review (SOR). This project provides a basis for understanding the potential effects of different operating strategies being considered under the SOR on reservoir fisheries at Lake Roosevelt, Dworshak Reservoir, and Lake Pend Oreille. The methodological framework used here was adapted from the Regional Assessment of Supplementation Project (RASP) a project framework used for evaluating supplementation strategies for anadromous fish. RASP attempts to diagnose the factors that limit production of fishes and outlines a process that can be followed to systematically reduce uncertainty while achieving the objective.

All three reservoirs are managed to support an active sport fishery. Kokanee provide an important part of these fisheries in each of the reservoirs, but kokanee populations are apparently limited by reservoir operations. Kokanee production at Dworshak Reservoir and Lake Roosevelt is limited by dam operations that entrain juvenile kokanee during periods of increased flow. The primary strategy to improve production of kokanee at Dworshak Reservoir is to operate the selector gates on Dworshak Dam to draw water from depths where kokanee densities are lowest. A **multi-**year study at Dworshak is presently underway that is attempting to describe a model of kokanee behavior in areas of the reservoir where they are most at risk of entrainment, and relate entrainment losses of kokanee to project operations.

The primary strategy to increase production of kokanee at Lake Roosevelt relies on supplementation. **Operational** strategies to reduce kokanee entrainment are mainly directed at determining the best period to release kokanee from the hatchery. Studies are being done at Lake Roosevelt to evaluate the relative return rate back to the hatchery based on each release strategy. Indirect estimates of entrainment are also be conducted; however, additional research in this area is warranted. Because operational constraints at Grand Coulee Dam create less than optimal conditions for kokanee in Lake Roosevelt, and because of the large amount of uncertainty relative to establishing a successful kokanee fishery under present operations, we recommend additional resident species, such as walleye and rainbow trout, continue to be included in any enhancement efforts at Lake Roosevelt.

A lack of suitable spawning habitat because of lake level manipulations caused from operations at Albeni Falls Dam, rather than entrainment, apparently is the limiting factor for kokanee at Lake Pend Oreille. Annual operations create unsuitable spawning habitat and/or dewater shoreline areas where fish have already spawned. The primary strategy identified at Lake

Pend Oreille is to alter the operation of **Albeni** Falls to maintain the lake level at full pool during the winter.

In **all** three reservoirs concerns exist about protecting sensitive species, particularly bull trout and cutthroat trout. Both species are threatened by changes in other **salmonid** populations that provide food for bull trout or prey on cutthroat trout. The genetic makeup of cutthroat trout is further threatened by intergression (hybridization) with rainbow trout.

In all three reservoirs a need exists for additional baseline information to provide an adequate understanding of the populations of interest. This is especially true of the **physical-chemical** environment under various operating conditions. This need is particularly acute in Lake Roosevelt.

ACKNOWLEDGMENTS

We thank Charlie Craig, contract representative from the Bonneville Power Administration (BPA), Phil Thor, BPA, project manager in the Columbia River System Operation Review, which funded for this project, and Tom Vogel, BPA, project manager for the Regional Assessment of Supplementation Project (RASP). We especially thank Dr. Lars **Mobrand, Mobrand** Biometrics, who assisted in one day of the workshop. We also thank each of the workshop participants, especially Dr. **Melo** Maiolie, Idaho Department of Fish and Game, who provided useful comments on earlier versions of this document.

CONTENTS

Executive Summary	iii
Acknowledgments	v
1. Introduction	1
2. Dworshak Reservoir	5
2.1. Description of Reservoir	5
2.2. Resident Fish Species of Interest	5
2.2.1. Kokanee	5
2.2.1.1. Background	7
2.2.1.2. Management Objective	9
2.2.1.3. Strategies	10
2.2.1.4. Assumptions and Uncertainties	10
2.2.2. Smallmouth Bass	11
2.2.2.1. Background	12
2.2.2.2. Management Objective	13
2.2.2.3. Strategies	14
2.2.2.4. Assumptions and Uncertainties	15
2.2.3. Westslope Cutthroat Trout	15
2.2.3.1. Background	16
2.2.3.2. Management Objective	16
2.2.3.3. Strategies	16
2.2.3.4. Assumptions and Uncertainties	16
2.2.4. Bull Trout	17
2.2.4.1. Background	17
2.2.4.2. Management Objective	18
2.2.4.3. Strategies	18
2.2.4.4. Assumptions and Uncertainties	19
2.3. Summary	20
3. Lake Pend Oreille	21
3.1. Description of the Lake	21
3.2. Species of Interest	21
3.2.1. Kokanee	21
3.2.1.1. Background	22
3.2.1.2. Management Objective	24
3.2.1.3. Strategies	24

3.2.1.4.	Assumptions and Uncertainties	24
3.2.2.	Bull Trout	25
3.2.2.1.	Background	25
3.2.2.2.	Management Objective	25
3.2.2.3.	Strategies.....	26
3.2.2.4.	Assumptions and Uncertainties	26
3.2.3.	Westslope Cutthroat Trout	26
3.2.3.1.	Background	26
3.2.3.2.	Management Objective	27
3.2.3.3.	Strategies	27
3.2.3.4.	Assumptions and Uncertainties	27
3.2.4.	Largemouth Bass	28
3.2.4.1.	Background	28
3.2.4.2.	Management Objective	28
3.2.4.3.	Strategies	28
3.2.4.4.	Assumptions and Uncertainties	29
3.2.5.	Rainbow Trout	29
3.2.5.1.	Background	29
3.2.5.2.	Management Objective	30
3.2.5.3.	Strategies	30
3.2.5.4.	Assumptions and Uncertainties	30
3.3.	Summary	31
4.	Lake Roosevelt.....	33
4.1.	Description of Reservoir.....	33
4.2.	Species of Interest.....	33
4.2.1.	Kokanee	33
4.2.1.1.	Background	33
4.2.1.2.	Management Objective	34
4.2.1.3.	Strategies	34
4.2.1.4.	Assumptions and Uncertainties	36
4.2.2.	Rainbow Trout	36
4.2.2.1.	Background	36
4.2.2.2.	Management Objective	37
4.2.2.3.	Strategies	37
4.2.2.4.	Assumptions and Uncertainties	38
4.2.3.	Walleye	39

4.2.3.1.	Background.....	39
4.2.3.2.	Management Objective.....	40
4.2.3.3.	Strategies..	41
4.2.3.4.	Assumptions and Uncertainties	41
4.2.4.	Sensitive Species	41
4.2.4.1.	Background..	41
4.2.4.2.	Management Objective..	41
4.2.4.3.	Strategies..	42
4.2.4.4.	Assumptions and Uncertainties	42
4.2.5.	White Sturgeon..	42
4.2.5.1.	Background..	42
4.2.5.2.	Management Objective	42
4.2.5.3.	Strategies..	42
4.2.5.4.	Assumptions and Uncertainties	42
4.3.	Summary..	45
5.	References	45
Appendix I.	A.1

FIGURES

Figure 1. Nine-Step Planning Process	2
Figure 2. Major Dams in the Columbia River Basin	6
Figure 3. Habitat Use by Life History Stage for Dworshak Kokanee	7
Figure 4. Carrying Capacity for Spawning and Incubation and for Age 0+ to Age II+ Kokanee in Dworshak Reservoir.....	8
Figure 5. Kokanee Population Density in Dworshak Reservoir	9
Figure 6. Habitat Use by Life History Stage for Dworshak Reservoir Smallmouth Bass	12
Figure 7. Current and Potential Habitat Use by Dworshak Reservoir Smallmouth Bass by Life History Stage	13
Figure 8. Typical Reservoir Levels for Past Operation of Dworshak Reservoir.....	14
Figure 9. Habitat Use by Life History Stage for Dworshak Reservoir Westslope Cutthroat Trout and Rainbow Trout	17
Figure 10. Habitat Use by Life History Stage for Dworshak Reservoir Bull Trout.....	18
Figure 11. Current and Potential Habitat Use by Dworshak Reservoir Bull Trout by Life History Stage.....	19
Figure 12. Habitat Use by Life History Stage for Lake Pend Oreille Kokanee	23
Figure 13. Historic, Potential, and Current Habitat Use by Kokanee in Lake Pend Oreille	23
Figure 14. Habitat Use by Life History Stage for Lake Pend Oreille Bull Trout	25
Figure 15. Habitat Use by Life History Stage for Lake Pend Oreille Cutthroat Trout	27
Figure 16. Habitat Use by Life History Stage for Lake Pend Oreille Largemouth Bass.....	28
Figure 17. Habitat Use by Life History Stage for Lake Pend Oreille Rainbow Trout.....	30
Figure 18. Habitat Use by Life History Stage for Lake Roosevelt Kokanee.....	34
Figure 19. Historic, Potential, and Current Habitat Use by Kokanee in Lake Roosevelt.....	35
Figure 20. Habitat Use by Life History Stage for Rainbow Trout in Lake Roosevelt	37
Figure 21. Habitat Use by Life History Stage for Walleye in Lake Roosevelt.....	40
Figure 22. Habitat Use by Life History Stage for Yellow Perch, Sculpins, and Cyprinids	40

1. INTRODUCTION

The objective of this project is to summarize and communicate information that will assist researchers and funding agencies implement research projects. Specifically, the project targets those research projects designed to reduce the uncertainties associated with proposed strategies-to meet management objectives for resident fish species of interest in large upstream storage reservoirs in the Columbia River Basin. The need for this project stems primarily from planning efforts currently part of the Columbia River System Operation Review (SOR). The SOR is a multi-year project to evaluate alternatives for operation of the complex federal system of dams, reservoirs, hydroelectric facilities, navigation, irrigation, and recreation facilities in the Columbia River Basin.

The SOR seeks to balance demands on the system to meet competing, and often conflicting, economic, recreational, and environmental objectives within the context of a complex and interdependent system of facilities subject to large natural variations in the primary input to the system--water. Early in the SOR planning process it became obvious that the management and protection objectives for resident fish in the Columbia River system were largely known only to specific management entities. Essentially, no adequate framework existed within which to develop strategies and priorities to resolve basic uncertainties in how new operating strategies would affect resident fish.

This project provides a basis for understanding the potential effects of alternatives considered under the SOR on reservoir fisheries. Further, it provides the rationale for systematically evaluating research needs to ensure that the limited resources available to support biological research produce effective results by establishing defensible priorities for research. The project also was designed to identify information gaps --"critical uncertainties" --that, unless resolved, result in risks of failure of proposed mitigation and enhancement strategies because of the lack of knowledge.

The scope of the project was limited to three large upstream storage reservoirs: Dworshak Reservoir, Lake Pend Oreille, and Lake Roosevelt. The scope was further limited to fish species of particular significance, because they are important in the fishery, are sensitive species identified by resource managers as likely needing protection, or because they are representative of an important cluster of species. Specific management objectives have been published or could be articulated for most species of interest in each reservoir.

The methodological framework employed was developed and used by the Regional Assessment of Supplementation Project (RASP), a Bonneville Power Administration (BPA)-funded project to provide a framework for evaluating strategies to supplement anadromous fish populations (BPA 1993). The RASP developed a nine-step planning process (Figure 1) that

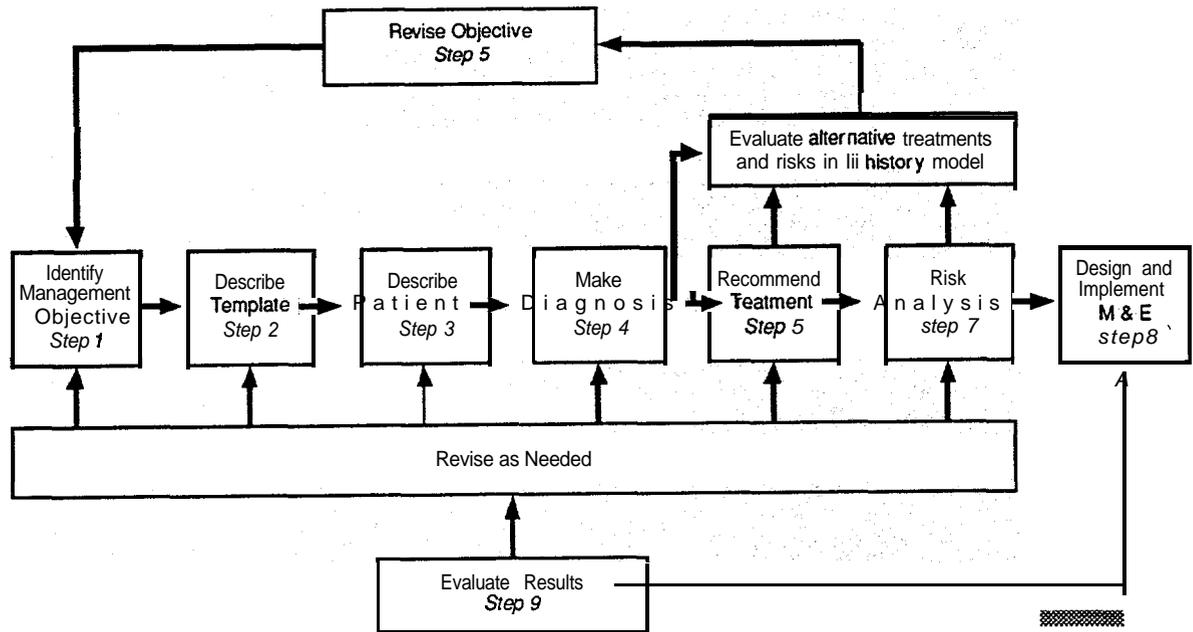


Figure 1. Nine-Step Planning Process. RASP (1993) developed this nine-step, iterative process for use in planning research on supplementation projects. The approach was adapted for use in the current study.

begins with a specific management objective, diagnoses the factors that limit accomplishment of the objective, and identifies potential strategies to achieve the objective. The planning process then examines the assumptions that underlie the strategies and identifies the degree of uncertainty about the assumptions as well as the risk to the success of a proposed strategy that results from the uncertainties. An evaluation of the uncertainties leads to their classification and to a list of critical uncertainties--those for which a substantial lack of information exists and those deemed likely to pose a significant risk to the success of the strategy. The diagnosis portion of the planning process seeks to identify limiting factors (i.e., "bottleneck") to meeting management objectives. It depends on an analysis of existing 1) biological and ecological information related to habitat requirements at each stage in the life history of the species, and 2) physical and ecological information about the habitat that describes the suitable habitat historically available, potentially available, actually available, and currently used. This analysis is referred to by RASP as a "patient-template analysis" (PTA).

The entire process is iterative; that is, analysts are encouraged to evaluate the objectives and to modify them as more information and a deeper understanding of the system is developed either through analysis or the collection of new data. This iterative nature of the process is intended to ensure that the objectives are reasonable and achievable and is intended to be undertaken in the spirit of adaptive management.

To accomplish project objectives, we **first** conducted a 2-day workshop to present the RASP methodology and explore its application to the SOR process. We followed the workshop with three 1 -day planning sessions specific to each individual reservoir. Workshop and planning session attendees were members of the SOR Resident Fish Work Group as well as others with expertise in resident fish in the three reservoirs of interest (see Appendix I for a listing of attendees and workshop and planning session locations). The 2-day workshop was designed to introduce participants to the RASP methodology and its potential application to accomplishing the goals of this project. The 1-day planning sessions were designed to summarize available information on resident fish species of particular interest in Dworshak Reservoir (an impoundment of the North Fork Clearwater River, Idaho), Lake Pend Oreille (a natural lake regulated by Albeni Falls Dam near Sandpoint, Idaho), and Lake Roosevelt (the reservoir impounded by Grand Coulee Dam on the Columbia River, Washington, and British Columbia, Canada), respectively. Following the 2-day workshop, participants decided that an adaptation of the RASP methodology would be useful in accomplishing project goals. A summary of the workshop was prepared and distributed to workshop participants (see letter report from D. Geist to C. Craig, July 16, 1993).

This report summarizes the information gathered during the three 1 -day planning sessions. For purposes of preparing the report, we used only information provided by experts knowledgeable in the study reservoirs and their respective fisheries issues. Thus, the available information varies in quantity and quality among the reservoirs and among the species considered. No attempt was made to conduct an independent analysis of the literature or gather new information on any of the projects.

This report is organized by reservoir and, within each reservoir, by species. It identifies life history and habitat use; factors limiting recruitment of fish to the populations of interest (i.e., bottlenecks); opportunities and strategies for enhancement, their underlying assumptions, and critical uncertainties associated with the assumptions, to the extent this information is available. The analysis should be revisited and revised appropriately as additional information is developed, and management objectives are refined. This report should be viewed as a "snapshot" in time of a work in progress subject to revision.

2. DWORSHAK RESERVOIR

We provide a brief description of the reservoir and our analysis of each of the species of interest in the sections below. Additional information on the reservoir and its fish populations can be found in Maiolie et al. (1992).

2.1. Description of Reservoir

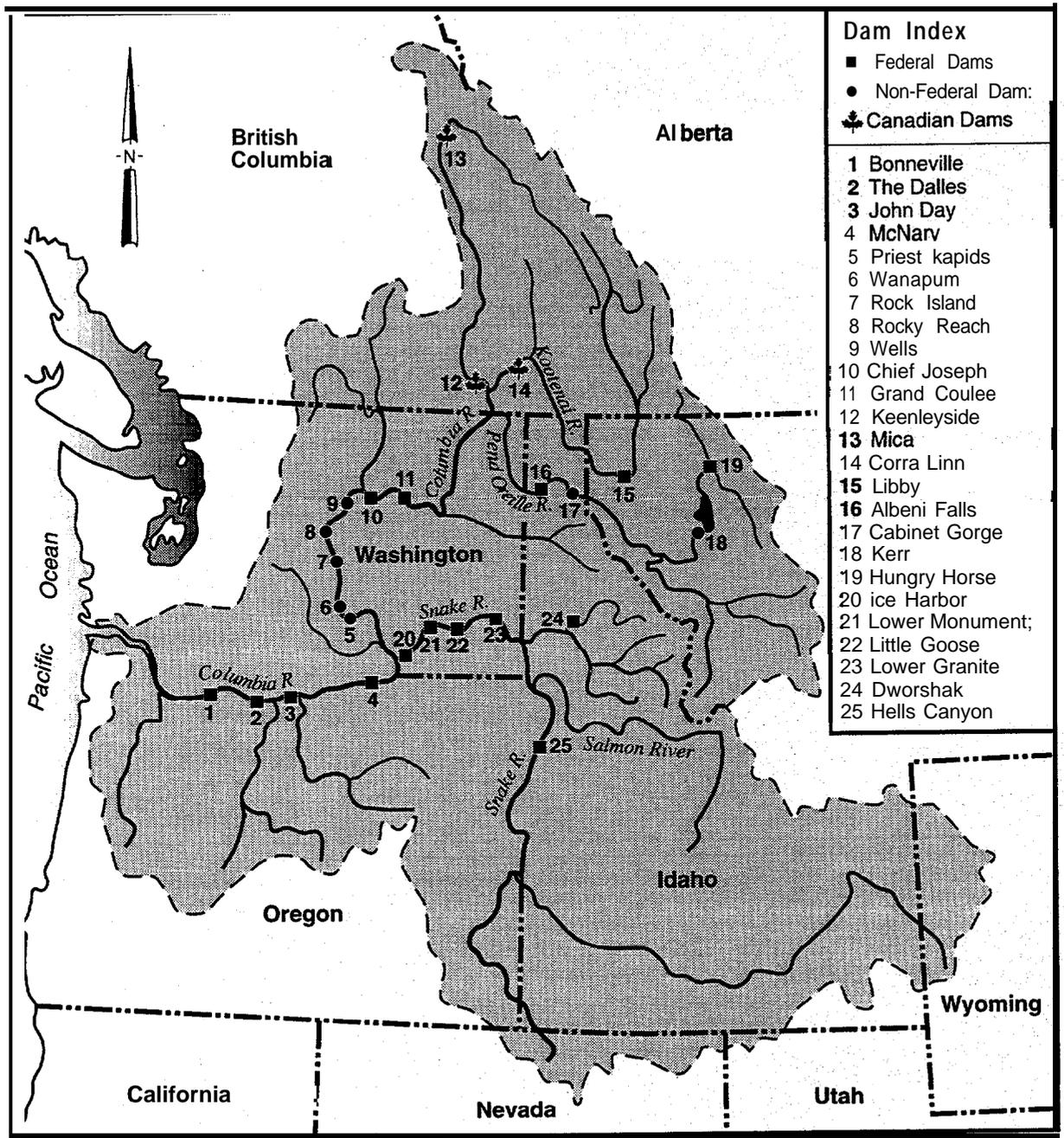
Dworshak Reservoir is located on the North Fork Clearwater River, Idaho (Figure 2). The river is impounded 3.2 km upstream from its confluence with the Clearwater River by Dworshak Dam, which was completed in 1973. The reservoir is 86 km long, up to 194 m deep, and has a total volume of 3.5 million acre feet (MAF), usable volume of 2.1 MAF, surface area of 6,644 hectares, and a mean depth of 56 m. The storage project provides power production, recreation, navigation, and flood control. Operations for flood control and power production result in winter drawdown of as much as 47 m from the full pool elevation of 488 m above mean sea level (msl). Deep drawdowns potentially can reduce the volume of the reservoir by as much as 60%. Typically, the reservoir is drawn down in the fall and remains low through the winter. It usually refills during the spring freshet to reach full pool between mid-June and late July. The average annual discharge from Dworshak Dam is 4.1 MAF, and the mean water retention time is highly dependent on precipitation, ranging from 6 to 22 months depending on the water year.

2.2. Resident Fish Species of Interest

The resident fish species of interest in Dworshak Reservoir include kokanee (*Oncorhynchus nerka*) and smallmouth bass (*Micropterus dolomieu*), which are both managed to provide a recreational fishery, and westslope cutthroat trout (*O. clarki*) and bull trout (*Salvelinus confluentus*), which are managed as sensitive species with a goal of protection. Rainbow trout (*O. mykiss*) are stocked by the Department of the Interior as mitigation for the construction of Dworshak Dam. The Idaho Department of Fish and Game has published statewide and water-body-specific fishery management objectives.

2.2.1. Kokanee

In this section we describe the status of kokanee in Dworshak Reservoir, management objectives, strategies to accomplish these objectives, and assumptions and uncertainties regarding the strategies.



S9310020.1

Figure 2. Major dams in the Columbia River Basin. Dworshak Reservoir is the impoundment formed by Dworshak Dam (#24). Lake Roosevelt is the impoundment formed by Grand Coulee Dam (#11). Lake Pend Oreille is a natural lake partially impounded by Albeni Falls Dam (#16).

2.2.1.1. Background

Kokanee are a resident (non-anadromous) form of sockeye salmon. Kokanee were introduced to Dworshak Reservoir by stocking as a mitigation measure after the reservoir was impounded.

Up to 3 million kokanee per year were stocked between 1972 and 1979. Dworshak Reservoir historically produced both early and late spawning stocks of kokanee. The early spawning kokanee are a self-sustaining population that spawn in tributaries to Dworshak Reservoir. However, late spawning kokanee were primarily shore spawners and have been extirpated from Dworshak Reservoir because of water-level fluctuations during the spawning and incubation period.

Figure 3 shows habitat use by life history stage for Dworshak kokanee. Spawning takes place in tributary streams in late September. After juveniles emerge from the redds in late spring, they move into the reservoir. Once the young fish reach the reservoir, they tend to move gradually toward the **forebay**. Depending on flow, and other factors not entirely understood, once in the **forebay** area they are subject to entrainment through the dam and consequent loss from the reservoir. Spawning habitat does not appear to be fully seeded even in years when the population density is within the target management range (Maiolie et. al. 1992). Counts of spawners in three tributaries appear to be correlated with estimates of population density in the reservoir. Figure 4 shows estimated available and actual habitat use.

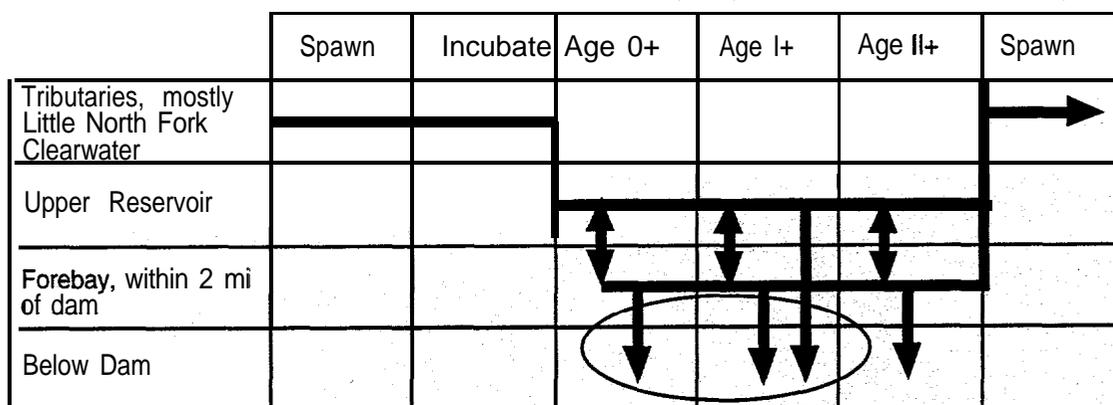


Figure 3. Habitat Use by Life History Stage for Dworshak Kokanee. Spawning takes place in late September and fish emerge from the redds between April and June of the following spring. Spawning habitat is not limiting for the target population density. Entrainment losses through the dam appear to be the primary factor influencing year-to-year population density. The oval indicates the principle bottlenecks to production. See text.

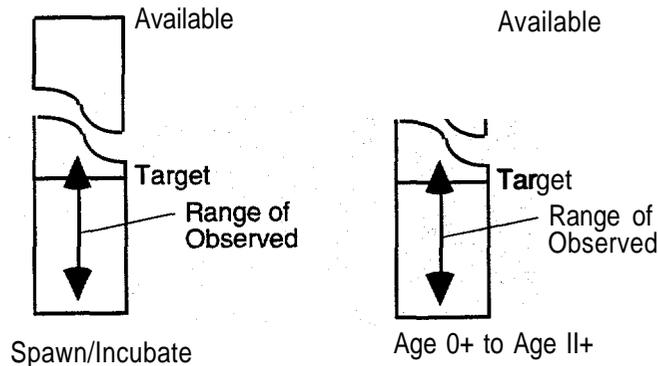


Figure 4. Carrying Capacity for Spawning and Incubation and for Age 0+ to Age II+ Kokanee in Dworshak Reservoir. Note that the target population is within the carrying capacity for both spawning and incubation and for subsequent pelagic stages.

In the past, kokanee year-class strength in the reservoir has been variable as a function of stream discharge (as measured at Dworshak Dam; Figure 5). In drought years recruitment has been good, and the resulting population has been at the target density. However, in higher flow years, recruitment has been relatively poor. For example, in 1991, a high flow year, the estimated density of recruited kokanee dropped from a high of 32.4 fish per hectare (ha) in 1989 to only 4.6 fish per ha despite a normal abundance of age-0 fish in this cohort and lower than normal fishing pressure and estimated catch rates. Survival from age-0 to age-1, and particularly from age-1 to age-2, is reduced in high-flow years. The working hypothesis is that the higher mortality in high flow years is due to increased entrainment of age-0 and age-1 fish through the dam. Four hypotheses have been put forward to explain the increased entrainment:

- Faster velocity through the reservoir in high flow years moves age-0 fish into the **forebay** earlier than under lower velocity.
- With higher discharge through the dam, kokanee are entrained more efficiently.
- Higher discharge through the dam provides cues to age-0 and age-1 fish to migrate downstream.

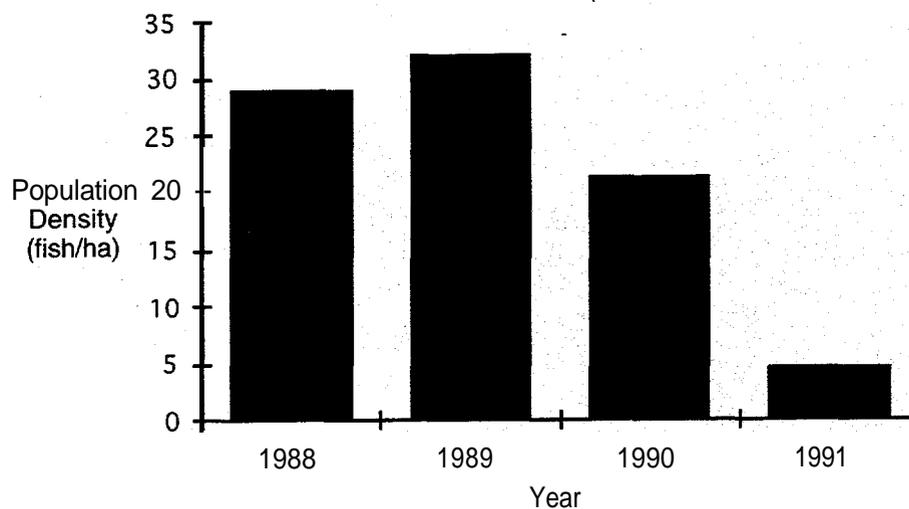


Figure 5. Kokanee Population Density in Dworshak Reservoir. Age II+ population data from trawl survey data. The state target population density is 30 to 50 fish per hectare. See text.

- Higher velocity through the reservoir, combined with physiological changes, increases the urge to smoltify, a natural occurrence in juvenile salmon as they begin downstream migrations.

A hydroacoustic study funded by BPA was initiated in 1993 to test the hypothesis that entrainment is the cause of the increased mortality. The investigators hope to define seasonal and diurnal variations in entrainment with a goal of providing information upon which a reservoir operation management strategy may be designed to reduce entrainment losses.

2.2.1.2. Management Objective

The state of Idaho's objective for kokanee in Dworshak Reservoir is to establish a stable population with a density of 30 to 50 catchable kokanee (age-2) per ha. Research on kokanee populations, growth rates, and catch rates indicates that kokanee growth is food-limited in Dworshak Reservoir (see Maiolie et al. 1992, Figure 34). Higher densities (>50 fish/ha) result in the same catch rate as the target density, but growth is slower, and the harvested fish tend to be smaller at the higher densities. Reduction of year-to-year variability in recruitment is the primary objective, with a goal of increasing the survival rate from age-0 to age-1 to 35% and the survival rate from age-1 to age-2 to 45%.

2.2.1.3. Strategies

In this section we describe proposed strategies to reduce entrainment of kokanee as well as alternative strategies that have been considered.

2.2.1.3.1. Primary Strategies

The proposed strategy is to reduce entrainment by operating the dam's selector gates to draw water from depths where kokanee densities are low. Under present operation, selector gates at the turbine intakes are operated from April to September for thermal control to provide water at 11.1 °C for the U.S. Fish and Wildlife Service salmon hatchery below the dam. The forebay is essentially isothermal from October to March; consequently, selector gates are not used for thermal control then and could potentially be used to reduce entrainment.

Efforts to reduce entrainment of kokanee may decrease entrainment of zooplankton, depending on zooplankton distribution during these periods. Decreasing entrainment of zooplankton is expected to result in increased density of zooplankton, which are the primary food resource for kokanee. The increased availability of food would likely increase the growth rate of kokanee, improving the quality of the fishery.

2.2.1.3.2. Alternative Strategies

Alternatives to the proposed strategy include maintaining a higher reservoir elevation in the winter which would potentially reduce entrainment by reducing the velocity of water in the reservoir and increasing the residence time for water. Thus, kokanee would be less likely to be flushed from the reservoir.

Should the kokanee populations increase to densities greater than the target number, a predator of kokanee could be stocked into the reservoir to crop the excess kokanee population. Chinook salmon are currently stocked for this purpose in Lake Coeur d'Alene. However, it is important for managers to have adequate population control of the predators on kokanee so reservoir ecology does not shift dramatically from stable conditions.

2.2.1.4. Assumptions and Uncertainties

The proposed strategy assumes that entrainment is a limiting factor in kokanee density and the primary source of year-to-year variability in population density. Although there appears to be a correlation between discharge and juvenile kokanee entrainment, a high degree of uncertainty exists in this correlation because of the difficulty in accurately quantifying entrainment as a function of dam operations. The hydroacoustic study presently underway is investigating the feasibility of deploying fixed acoustic equipment on the project to more accurately quantify entrainment as a

function of discharge (i.e., flow). The acoustic study will also use mobile surveys in the vicinity of the **forebay** in an effort to describe kokanee behavior under various dam operating conditions.

The use of selector gates further assumes that the depth of withdrawal of water is a critical factor in entrainment rates, and that significant entrainment takes place between October and March. Again, the ongoing hydroacoustic study is designed to investigate entrainment in order to develop working hypotheses about the operation of selector gates to minimize entrainment losses. The study is expected to detail **seasonality** of entrainment losses, as well as information about the diurnal distribution of kokanee with depth in the dam **forebay**. Results of the hydroacoustic study will be examined to estimate the efficacy and risks associated with the proposed strategy and to develop additional strategies not already considered here (e.g., diversion nets, sound, etc.).

Part of the monitoring and evaluation of any strategy will most likely incorporate kokanee spawner surveys. An assumption has been made that the spawner surveys are correlated to adult populations in the reservoir. Verification of this assumption would include putting tighter confidence intervals around the mid-water trawl estimates and continuing to statistically relate spawner counts to mid-water trawl counts.

Alternative strategies that involve improving habitat are assumed to be ineffective because spawning habitat is assumed to be not limiting under existing operating conditions. However, complete data set currently does not exist that accurately describes the distribution and availability of kokanee habitat under various operating conditions. Basic habitat availability information for all life stages could easily be collected and input to the Geographic Information System (GIS) database currently being developed for Dworshak Reservoir. This would provide long-term baseline information that could be used to ensure a change in operating conditions did not result in specific habitat types becoming limiting, thus altering this assumption.

It is also assumed that higher kokanee densities in Dworshak Reservoir may deplete the food source, resulting in reduced growth. Although research has been conducted on the relationship between food availability and kokanee densities, considerable uncertainty still exists as to the exact nature of this relationship. Defining an optimal adult kokanee density under present operating conditions (and hence food availability) may be altered under new operating conditions being proposed under the SOR. This should be considered in long-term planning.

2.2.2. Smallmouth Bass

In this section we describe the status of smallmouth bass in Dworshak Reservoir, management objectives, strategies to accomplish these objectives&d assumptions and uncertainties regarding these strategies.

2.2.2.1. Background

Fishing pressure on smallmouth bass in Dworshak Reservoir is low. Growth is relatively slow because of the cool temperature of the reservoir and limited food supply. The observed mortality rate is moderate, and losses because of entrainment through the dam are judged to be insignificant.

Habitat requirements by life stage are shown in Figure 6. Smallmouth bass spawn in shallow (0 to 1.5 m), warm water when shoreline water temperatures reach 15°C, which is about June 1 in Dworshak Reservoir (Maiolie et al. 1992). Spawning takes place over a period of about 1 month, and if a first spawning fails to hatch, smallmouth bass will frequently spawn a second time. Incubation requires about 1 month, and fry emerge between July 1 and August 1. The weight (quality) of young-of-the-year entering their first winter is important to subsequent growth. The relatively low condition factor for these fish appears more important to subsequent recruitment than is the absolute population, which does not appear to be limiting. Figure 7 shows current and potential habitat use by life history stage. Current production is probably at the carrying capacity for most stages of the life history.

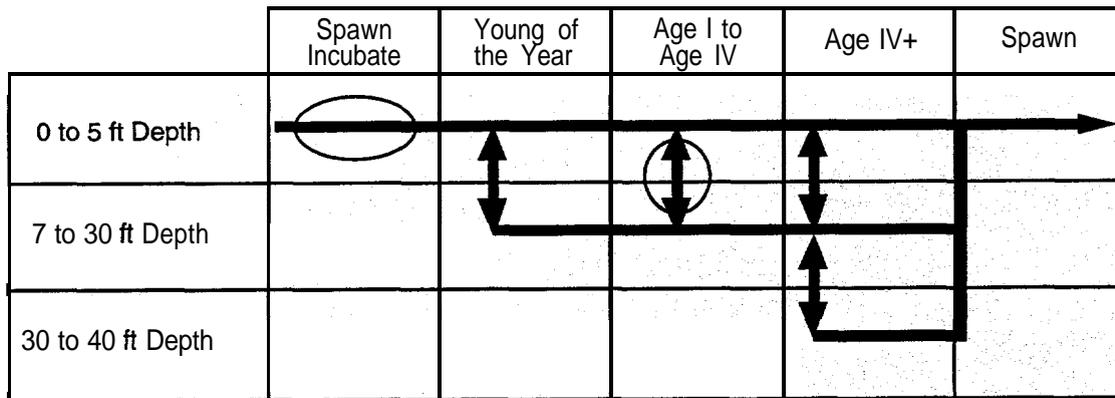


Figure 6. Habitat Use by Life History Stage for Dworshak Reservoir Smallmouth Bass. Spawning takes place in the spring in shallow water when temperatures reach 15°C (60°F). Fry emerge after about one month of incubation. Limiting factors are fluctuating water levels during incubation that result in desiccation of nests and limited beds of aquatic weeds that provide habitat for production of food needed by age I to age IV fish. The ovals highlight bottlenecks to production. See text.

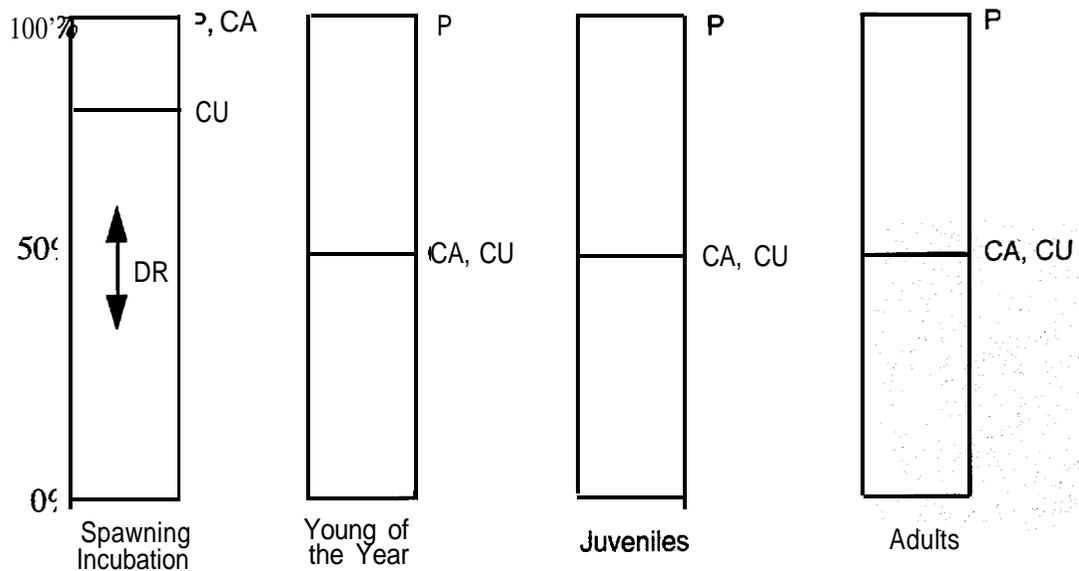


Figure 7. Current and Potential Habitat Use by Dworshak Reservoir Smallmouth Bass by Life History Stage. P = potential (the amount of production that could be made available), CA = currently available (the amount of production that can be supported by habitat that is currently available), CU = current use (the amount of production that is supported by current habitat use, and DR = range of available habitat if the reservoir is drawn down in the critical period.

Management of the water level within the reservoir appears to affect all life stages of smallmouth bass (Figure 8). Reservoir water level is critical during the incubation period. A reduction in water level results in mortality to incubating eggs if they are dewatered before hatching. An increase in water level can flood shorezone areas with cold water, causing development to be arrested and potentially killing the incubating larvae.

Fluctuating reservoir levels also limit **weedbed** development in the reservoir, which provide important habitat for production of forage fish that smallmouth bass use as food as well as for cover for smallmouth bass young-of-the-year. **Redside** shiners (*Richardsonius balteatus*) were an abundant source of food for juvenile smallmouth bass until the shiner population crashed; possibly as shoreline vegetation was lost.

2.2.2.2. Management Objective

The goal for smallmouth bass is to improve the quality of fishing by improving recruitment and increasing the proportion of larger smallmouth bass in the population. Specific management objectives include:

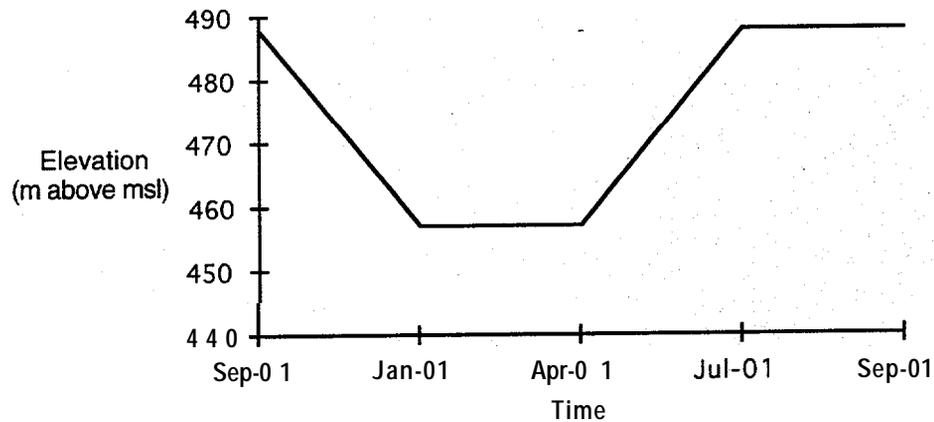


Figure 8. Typical Reservoir Levels for Past Operation of Dworshak Reservoir.

- increasing the proportion of larger fish in the population as indexed by the proportional stock density (PSD), which is the ratio of the population of fish over 280 mm length to the population of fish over 180 mm length. The target PSD is 30. Currently, the PSD is 24 to 25.
- increasing the mean relative weight (a measure of growth relative to standards for the species) to 100. The current values range from 88 to 95. Values lower than 100 indicate that food is limiting growth.
- maintaining spawning conditions so that reproduction is not limiting. Historically reproduction has not been limiting, but changes in reservoir operation could threaten spawning and incubation.

2.2.2.3. Strategies

In this section we describe proposed strategies to improve the quality of the smallmouth bass fishery.

2.2.2.3.1. Primary Strategies

The primary strategies for smallmouth bass focus on improving the availability of food stocks and providing protected rearing habitat for young-of-the-year. This would include reestablishing **weedbeds** through revegetation with flood-tolerant terrestrial plants or **drought-tolerant semi-aquatic plants** and establishing “catch ponds” by impounding small embayments to retain water after the reservoir is drawn down.

Higher reservoir levels during summer would permit insect drop from riparian vegetation to be used as a food source. The proposed catch ponds have the potential for capturing such insect drop and making it available to the fish.

2.2.2.3.2. Alternative Strategies

Alternatives to improve food availability include maintaining a full summer reservoir to increase the area of shallow **weedbeds** and to capture terrestrial insect drop from riparian vegetation.

It is also important not to draw down the reservoir from June through August. Draw downs during that time dewater smallmouth bass nests resulting in loss of the incubating larvae. Further, avoid rising pool levels and associated temperature depressions in the spring when smallmouth bass are spawning.

2.2.2.4. Assumptions and Uncertainties

The proposed strategies assume that food is limiting smallmouth bass growth. This hypothesis is supported by available information on the condition of smallmouth bass in the reservoir. However, as with kokanee, this assumption is based on current operating conditions that may be much different in the future.

Plans to expand **weedbeds** assume that suitable plant species can be found that will tolerate seasonal dewatering and flooding and that they will provide suitable habitat for production of food organisms. The causes for the observed crash in **redside** shiners are unknown, and consequently, it is not known whether the area of **weedbed** habitat limits food production or if other conditions are also limiting smallmouth bass population.

Plans to provide catch ponds assume that such ponds would result in production of suitable food organisms and that they would be available to smallmouth bass after the catch ponds were flooded again by the seasonal refilling of the reservoir. Before habitat alterations are attempted, baseline surveys of specific physical, chemical, and biological variables important in determining smallmouth bass production should be done. This could then be followed with small-scale demonstration projects designed to show how habitat alterations may alter shiner and smallmouth bass production.

2.2.3. Westslope Cutthroat Trout

In this section we describe the status of westslope cutthroat trout in Dworshak Reservoir, management objectives, strategies to accomplish these objectives, and assumptions and uncertainties regarding the strategies.

2.2.3.1. Background

Native westslope cutthroat trout are an unequivocally important and valued species in the North Fork Clearwater River. Their importance is likely to increase over time as other stocks of westslope cutthroat trout are lost or hybridized through intergression.

Impoundment reduced the historically available cutthroat trout spawning area, and only remnant spawning remains in the impounded area. Current reservoir operations are likely to extirpate remaining spawning within the reservoir. However, spawning habitat in tributaries to the reservoir is available and does not appear to be limited.

Westslope cutthroat are highly vulnerable to fishing pressure and to genetic hybridization through intergression, particularly with rainbow trout. Both smallmouth bass and bull trout are predators on cutthroat.

Dworshak Dam prevents upstream migration of non-native **salmonid** species that could potentially hybridize with cutthroat, and thus, can be made to work for the benefit of the species. Management is particularly important then to prevent introduction of species **that** would threaten the genetic integrity of the stock.

Figure 9 shows habitat use for cutthroat and rainbow trout. Stocking of rainbow trout into Dworshak Reservoir is the primary threat to cutthroat trout genetic integrity. The Department of Interior stocks 100,000 pounds of rainbow trout in the reservoir per year under a mitigation requirement.

2.2.3.2. Management Objective

The management objective is to protect westslope cutthroat stocks, with a focus on Kelly Creek, a tributary to Dworshak Reservoir.

2.2.3.3. Strategies

No specific strategies have been developed to protect westslope cutthroat trout genetic integrity. The problem of potential conflicts between stocking rainbow trout and the management objective for westslope cutthroat trout has not been addressed; however, a genetic inventory of cutthroat in the North Fork Clear-water drainage is needed and recommended (Maiolie et al. 1992). If rainbow trout are found to contribute to genetic deterioration, off-site plantings of rainbow trout have been recommended to reduce genetic dilution in the cutthroat population.

2.2.3.4. Assumptions and Uncertainties

Development of a strategy depends on an understanding of details of the life history and habitat use by stocks of cutthroat trout in the North Fork Clearwater River; however, little specific

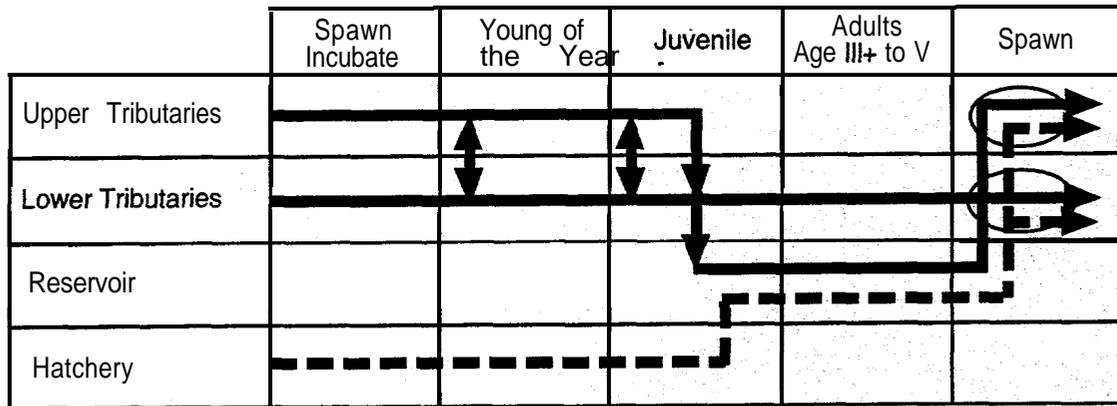


Figure 9. Habitat Use by Life History Stage for Dworshak Reservoir Westslope Cutthroat Trout and Rainbow Trout. The genetic integrity of native cutthroat (solid lines) is threatened by intergression with stocked rainbow trout (dashed lines). Ovals indicate principal bottlenecks to production. See text.

information is available. The descriptions above are adapted from information about other stocks of cutthroat and the impacts of stocking rainbow trout. A detailed management program would be a first step toward reducing the uncertainty of how rainbow trout/cutthroat trout populations are interrelated.

2.2.4. Bull Trout

In this section we describe the status of bull trout in Dworshak Reservoir, management objectives, strategies to accomplish these objectives, and assumptions and uncertainties regarding these strategies.

2.2.4.1. Background

Bull trout are aggressive predators on other salmonids as well as younger bull trout. Although only limited information is available on bull trout habitat use and limiting factors, Dworshak Dam appears to have little impact except in terms of the loss of the eggs and fry of other anadromous species that were a significant source of food prior to construction of the dam. However, this loss may be offset by the subsequent presence of kokanee.

Figure 10 shows habitat use by life history stage of bull trout. Bull trout migrate to high elevation tributaries during the spring freshet and over-summer in the tributaries. They spawn in the fall and migrate back downstream during winter storm events. They likely do not spawn again

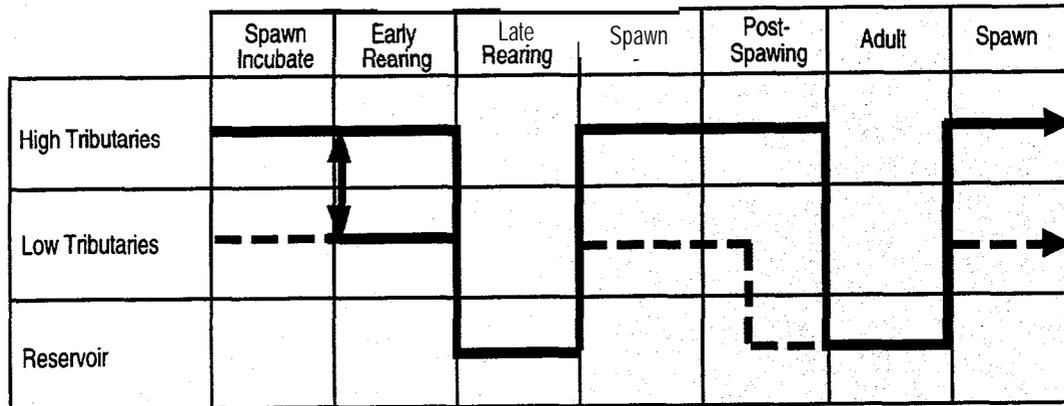


Figure 10. Habitat Use by Life History Stage for Dworshak Reservoir Bull Trout. Solid lines indicate primary use. Dashed lines indicate minor use. Bull trout migrate to high tributaries in the spring (when high flows make passage possible) in order to spawn. Spawning takes place in the fall after the adults spend the summer in the high reaches of the tributaries. The adult spawners then return to lower tributaries or to the reservoir with the increased flow during winter storm events. Most likely they do not return the following year, but remain in the lower areas for over a year before spawning again. See text.

until two years later after an extended period of recovery. There is some speculation that they are attracted to the reservoir and may be “pulled” out of lower tributaries that were their historic habitat.

Figure 11 shows the historical, potential, and current use of habitat by life history stage. The primary problems are loss of quality upper tributary spawning habitat from logging and road construction and loss of the anadromous species on which bull trout formerly fed.

2.2.4.2. Management Objective

Bull trout are managed for protection and for a recreational fishery in Dworshak Reservoir.

2.2.4.3. Strategies

In this section we describe proposed strategies to protect bull trout.

2.2.4.3.1. Primary Strategies

Strategies that enhance production of kokanee and zooplankton in the reservoir likely benefit bull trout by increasing food availability. However, the primary problem appears to be loss of upper tributary habitat and specific strategies to address this problem have not been developed.

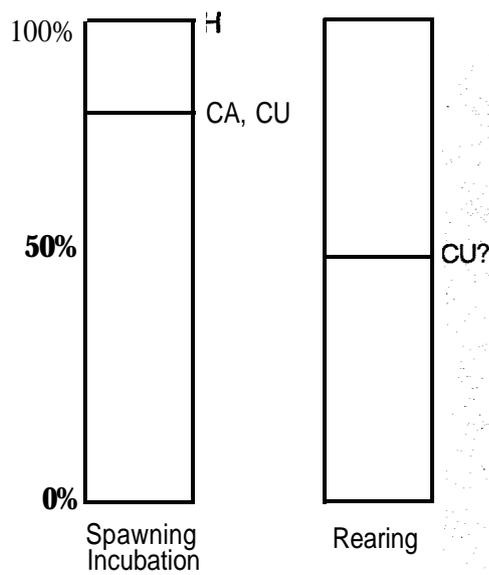


Figure 11. Current and Potential Habitat Use by Dworshak Reservoir Bull Trout by Life History Stage. H = historic (the amount of habitat available prior to dam construction), CA = currently available (the amount of production that can be supported by habitat that is currently available), and CU = current use (the amount of production that is supported by current habitat use. Loss of spawning habitat is due primarily to logging and road construction in high upper tributary basins. Current use of rearing habitat is reduced by lack of full seeding and loss of salmon eggs and fry as food. Of the remaining current use of habitat for rearing, about two-thirds is estimated to be in the river with the remaining one-third in the reservoir. See text.

2.2.4.3.2. Alternative Strategies

Consideration has been given to stocking a lake form of bull trout, but additional information on habitat use and limiting factors is needed before more detailed strategies can be developed.

2.2.4.4. Assumptions and Uncertainties

The principal assumptions underlying the proposed strategies are that bull trout populations are threatened by loss of food availability and habitat degradation. However, considerable uncertainty exists in these assumptions because of a lack of adequate information on the basic life history of bull trout in the Dworshak system. Bull trout populations in western United States and Canada are severely depressed. Many stocks are currently being considered for petition or listing under the Endangered Species Act (ESA). Strict management plans are being implemented in several states that reduce the harvest of this sensitive species. Management objectives and strategies of this species will move to the federal level if the species is listed under the ESA. By developing an adequate data base on the life history, habitat use, and effects of reservoir operation on this species may provide needed long-term information that currently does not exist.

2.3. Summary

The primary focus for mitigation strategies in Dworshak Reservoir is on reducing entrainment losses through seasonal operation of the selector gates at the dam to withdraw water from depths in the forebay that minimize entrainment losses. This strategy is designed primarily for the benefit of kokanee, but would benefit other species as well, mostly by increasing food availability. Considerable uncertainty exists as to the feasibility of developing alternative operational strategies to reduce this entrainment, but present and future research is being conducted to address these questions. Definitive research and management plans for other sensitive and recreational species does not exist, however. As sensitive stocks of native salmonids become further depressed, attention will need to shift to providing more rigid protection measures to ensure they don't become extinct.

3. LAKE PEND OREILLE

We provide a brief description of the reservoir and our analysis of each of the species of interest in the sections that follow based on information provided in the 1-day planning session. Additional information about the reservoir can be found in Paragamian et al. (1993, 1991), Hoelscher et al. (1990), and Bowles et al. (1989, 1988, 1987, 1986).

3.1. Description of the Lake

Lake Pend Oreille is the largest natural lake in Idaho and is located near Sandpoint (Figure 2). It has a surface area of 38,300 ha, a maximum depth of 351 m, and a mean depth of 164 m. The lake is impounded and regulated by Albeni Falls Dam, which was constructed in 1952 approximately 24 km downstream from the lake on the Pend Oreille River near the Idaho-Washington border. The Pend Oreille River flows northwest through Washington and into Canada to its confluence with the Columbia River in British Columbia. The average annual outflow of the Pend Oreille River at Albeni Falls Dam is approximately 18.6 MAF. The Clark Fork River is the largest tributary to the lake.

The south end of Lake Pend Oreille is very deep with steep sides while the north end is relatively shallow. The reservoir is maintained at a high-pool elevation during summer for recreation and drawn down about 3.3 m in winter for flood control. The project provides a usable storage volume of 1.04 MAF; however, the unused volume of the lake is over 51 MAF. Summer recreation on the lake is particularly important to the economy of the communities near the lake.

The river between the lake and the dam is warm (24 to 27°C) and is isothermal in summer. During the winter **drawdown** the river reverts to its original channel and nearly freezes. The combination of warm summer temperatures and lack of protection for overwintering results in the river reach being nearly devoid of fish life.

3.2. Species of Interest

The lake supports an active fishery for kokanee and a trophy fishery for Gerrard strain rainbow trout. In addition cutthroat trout, bull trout, largemouth bass (*Micropterus salmoides*), smallmouth bass, and crappie (*Pomoxis nigromaculatus*) provide recreational fisheries. Brown trout (*Salmo trutta*) and lake trout (*Salvelinus namaycush*) **are** also present.

3.2.1. Kokanee

In this section we describe the status of kokanee in Lake Pend Oreille, management objectives, strategies to accomplish these objectives, and assumptions and uncertainties regarding the strategies.

3.2.1.1. Background

Kokanee were present in Lake Pend Oreille prior to construction of Albeni Falls and Cabinet Gorge dams in 1952. The annual harvest from Lake Pend Oreille was approximately 1 million fish before the dams were built. Between 1964 and 1976, catches declined to about 200,000 fish per year, which is approximately the current level of harvest. Commercial fishing for kokanee ended in the 1970s. The causes of the declines are not entirely known, although strong evidence points toward reduced recruitment as a result of impacts of Cabinet Gorge Dam, over-fishing from the commercial fishery, and reservoir level fluctuations caused from Albeni Falls Dam, which impacts kokanee spawning success. In addition, opossum shrimp (*Mysis relicta*) have been postulated to have contributed to the decline in the kokanee population.

Naturally spawning populations have continued to decline, but have been supplemented with hatchery fish produced by the Cabinet Gorge kokanee hatchery, which began operation in 1985. The hatchery has a capacity to produce 15 million 5-cm fish but is limited by egg availability to about 5 to 6 million fish per year.

Figure 12 shows habitat utilization by life history stage for kokanee. Most spawning takes place along the south shore of the lake in November and December. Access to suitable spawning habitat is limited because of drawdown, particularly along north and east shore areas.

Habitat use is shown in Figure 13. The greatest potential for enhancement is to improve access to suitable spawning substrate along the north shore, as described below. Because Cabinet Gorge Dam eliminated access to a significant portion of available tributary spawning areas, the population depends on lakeshore spawning. Summer storm events during full pool clean and deposit bars of spawning gravel at depths of 1 to 2.5 m. From 1952 until 1968, the lake elevation dropped after late-fall (November to December) spawning, resulting in desiccation of redds. By agreement in 1968, the lake elevation is now drawn down before spawning. However, this results in the suitable gravel habitat being above the lake level leaving mostly unsuitable silt and sand substrate for spawning.

Additional drawdowns have been made for power production since 1968 to near the natural winter lake (pre-dam) elevation of 614 m msl. Year-class strength is strongly correlated with pool elevation during the spawning period. In years with higher lake levels that provide access to spawning gravel, the subsequent recruitment has been strong while it has been weak in years when the lake was drawn down to lower levels.-

Spawner-recruitment curves indicate a very small surplus of production, so that recovery of the population may be slow even with improved access to spawning areas. The low surplus production also indicates a threat of over harvest from fishing. In addition, it is possible that

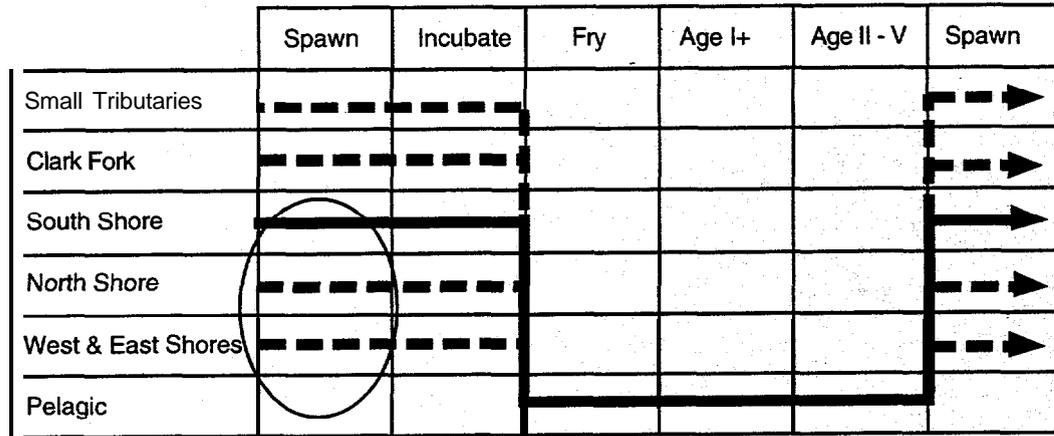


Figure 12. Habitat Use by Life History Stage for Lake Pend Oreille Kokanee. Solid lines indicate primary use; dashed lines indicate relatively minor use. Spawning takes place in November and December and fish emerge from the redds between April and June of the following spring. The oval indicates principal bottlenecks to production. See text.

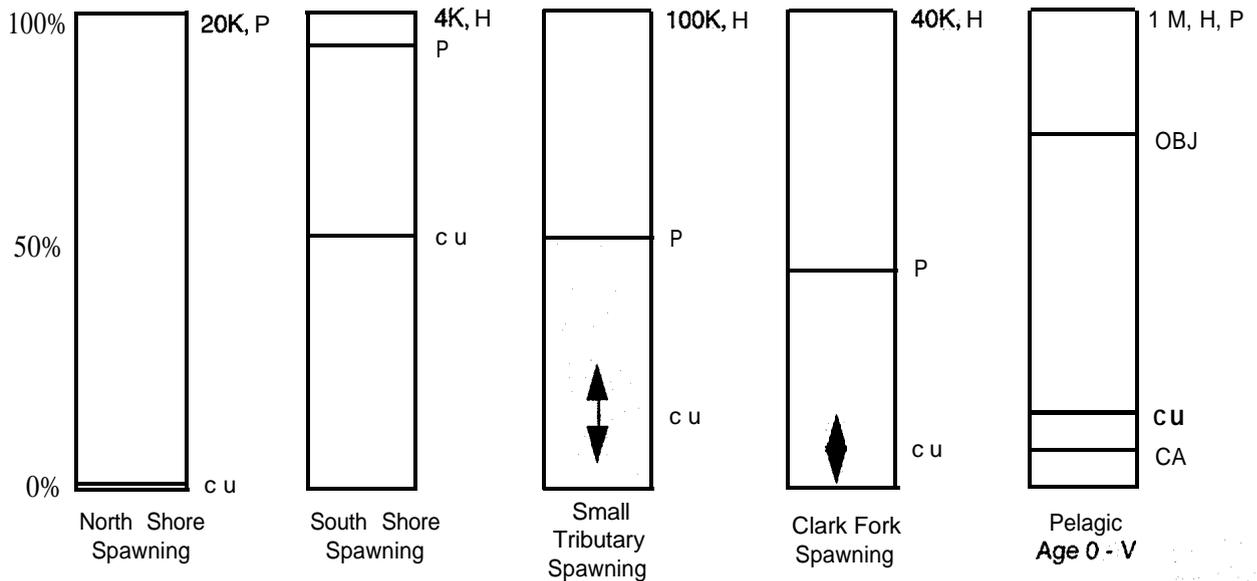


Figure 13. Historic, Potential, and Current Habitat Use by Kokanee in Lake Pend Oreille. H = historic (the amount of habitat available before dam construction), P = potential (the amount of production that could be achieved with habitat restoration), CA = currently available (the amount of production that can be supported by habitat that is currently available), CU = current use (the amount of production that is supported by current habitat use, and OBJ = management objective. Current use exceeds current available because of hatchery stocking which supplements natural production capacity. See text.

competition from mysid shrimp for zooplankters has reduced the food availability needed to support the target population; however, mysids typically stay in the hypolimnion when summer surface temperatures exceed 14°C, and therefore, are unlikely to directly compete with kokanee for zooplankters.

3.2.1.2. Management Objective

The management objective is to provide a population sufficient to support a sustained catch of 750,000 kokanee per year (up from the present catch of 227,000).

3.2.1.3. Strategies

In this section we describe proposed strategies to increase the kokanee population.

3.2.1.3.1. Primary Strategies

The proposed strategy is to increase spawning habitat to increase the carrying capacity. The primary means to accomplish this is to maintain a higher pool elevation during the spawning season. A lake elevation of 616.8 m is the flood control rule curve and would leave about half of the gravel habitat available. Current operations result in additional drawdowns to as low as 614.4 m during the spawning season, essentially eliminating all good spawning substrate.

3.2.1.3.2. Alternative Strategies

A secondary strategy is to increase the age at maturity to age-4 fish. These older fish are typically 7.5 cm longer than age-3 fish. The larger, older fish would be more attractive to the fishery and would crop some of the mysid population.

3.2.1.4. Assumptions and Uncertainties

The primary strategy assumes that spawning is limiting the population and that a sufficient food supply is available to support the target population level. Interactions with other species (predator-prey and/or competition for limited resources), within species interactions (natural and hatchery), and complex habitat use strategies by kokanee life stages introduce considerable uncertainty to this assumption. Small-scale experiments designed to reduce the uncertainty associated with this assumption might include operating the reservoir differently for a period of time and then observing changes in the kokanee population and/or habitat quality. The primary strategy also assumes that the proposed changes in reservoir operation would, over the long term, result in increased access to suitable spawning habitat during the spawning period.

It appears that the key to the alternative strategy of increasing the age at maturity is to have a large population of fry so that growth is slow before age-2. **This** assumes that slower growth leads to delayed maturity. Under the proposed scenario, subsequent cropping by predators would

reduce the age-2 to age-5 population resulting in normal growth rates for the older fish. The uncertainty in this strategy is whether or not slower growth equates to a longer life span. Presently a graduate student project is investigating this uncertainty.

3.2.2. Bull Trout

In this section we describe the status of bull trout in Lake Pend Oreille, management objectives, strategies for accomplishing these objectives, and assumptions and uncertainties regarding these strategies.

3.2.2.1. Background

Bull trout are a species of particular interest because of declining populations throughout their range. Background information on bull trout is provided in section 2.2.4.1.

Figure 14 shows habitat use by life-history stage for bull trout. Before Cabinet Gorge Dam was constructed, bull trout had access to tributaries that extended into Montana, but they apparently did not fully use this extensive habitat. Currently only an estimated 10% of the historically available habitat is still accessible.

3.2.2.2. Management Objective

The management objective for bull trout in Lake Pend Oreille is to protect the species, restore their population to higher abundance, and provide a limited consumptive (quality) fishery.

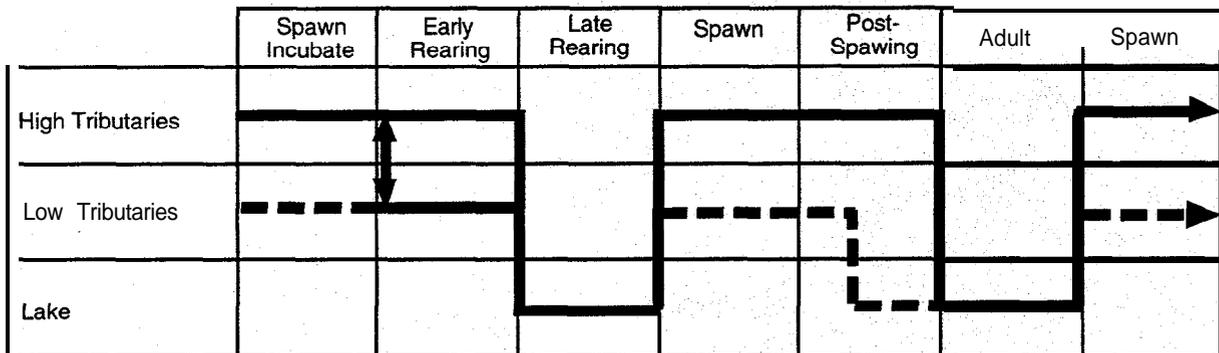


Figure 14. Habitat Use by Life History Stage for Lake Pend Oreille Bull Trout. Habitat use is similar to that for Dworshak Reservoir bull trout (See Figure 10 and text).

3.2.2.3. Strategies

In this section we describe proposed strategies to protect bull trout.

3.2.2.3.1. Primary Strategies

Potential strategies for bull trout include closing fishing in tributaries and maintaining habitat quality by controlling U.S. Forest Service timber sales and shoreline construction permits.

3.2.2.3.2. Alternative Strategies

No additional alternative strategies have been proposed.

3.2.2.4. Assumptions and Uncertainties

The proposed strategies assume that closing fishing and improving habitat quality would lead to recovery of the population, neither of which has been demonstrated. As in Dworshak Reservoir, a long-term management plan has not been developed for bull trout. This, once again, limits the ability of local managers to develop management strategies that will result in realized benefits to the bull trout population. Eventually, management of this and other sensitive species could end up at the federal level where less attention will be directed toward long-term monitoring.

3.2.3. Westslope Cutthroat Trout

In this section we describe the status of westslope cutthroat trout in Lake Pend Oreille, management objectives, strategies for accomplishing the objectives, and assumptions and uncertainties regarding the strategies.

3.2.3.1. Background

Cutthroat trout, along with bull trout, provided the major historic fishery in Lake Pend Oreille. The historic harvest was over 5000 fish per year. Originally, the Pend Oreille cutthroat were an adfluvial stock, but the native stocks have been supplemented for over 40 years with hatchery fish.

Figure 15 shows habitat use by life history stage for cutthroat trout in Lake Pend Oreille. Note the extensive use of tributary habitat. Access to over 90% of the historically available tributary habitat is blocked and remaining habitat has been degraded by logging and road construction. Predation by brook trout (*S. fontinalis*) in tributaries and by lake trout in the lake and competition with kokanee for zooplankters are also factors that contribute to the decline in cutthroat populations.

	Spawn incubate	Early Rearing	Adult	Spawn
Tributaries				
Lake				

Figure 15. Habitat Use by Life History Stage for Lake Pend Oreille Cutthroat Trout. Cutthroat trout depend heavily on tributaries for spawning, incubation, and early rearing. They are threatened by intergression with rainbow trout and predation by other salmonids.

3.2.3.2. Management Objective

The management objective is to restore and enhance quality fishery for cutthroat from the present remnant harvest level of 700 fish per year.

3.2.3.3. Strategies

In this section we describe proposed strategies to enhance the westslope cutthroat trout fishery.

3.2.3.3.1. Primary Strategies

The principal strategy under consideration for cutthroat trout is net pen rearing to supplement natural production and increase the number of harvestable fish.

3.2.3.3.2. Alternative' Strategies

Alternative strategies include enhancing natural production through restoration of tributary habitat, reducing predation, and reducing competition from other species in the lake.

3.2.3.3.4. Assumptions and Uncertainties

The proposed strategy assumes that the carrying capacity for adult cutthroat trout is not limiting, and that supplementation of the naturally produced populations with pen-reared fish would enhance the fishery without adverse impacts on the naturally producing population. Considerable uncertainty exists associated with these assumptions. To our knowledge, no studies on the effect of cutthroat trout introductions on other species have been conducted.

The alternative strategies assume that spawning is limiting or that the population suffers from predation and competition by other fish species.

3.2.4. Largemouth Bass

In this section we describe the status of largemouth bass in Lake Pend Oreille, management objectives, strategies for accomplishing these objectives, and assumptions and uncertainties regarding these strategies.

3.2.4.1. Background

Largemouth bass are present in limited numbers in Lake Pend Oreille. Figure 16 shows habitat requirements by life history stage for largemouth bass. The Pend Oreille River between the lake and dam provides good largemouth habitat in spring, summer, and fall, but there is little suitable winter habitat. Largemouth bass prefer over-winter habitat that provides at least 1.5 m of water depth and water velocities less than 0.06 m per second. The current **drawdown** returns the river to its original channel during winter resulting in cold, shallow, fast-flowing water, which is poor habitat for largemouth bass.

3.2.4.2. Management Objective

The statewide management objective for warm water fish is to “Maintain existing warm-water fisheries where they will not interfere with salmonid management programs” (IDFG 1991).

3.2.4.3. Strategies

No specific strategy was identified for enhancing largemouth bass populations in Lake Pend Oreille or the Pend Oreille River.

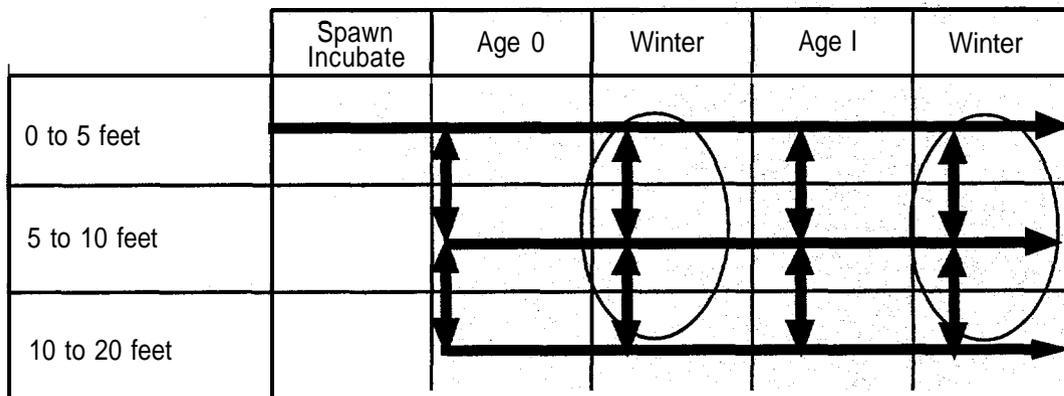


Figure 16. Habitat Use by Life History Stage for Lake Pend Oreille Largemouth Bass. Ovals indicate principal bottlenecks to production. Overwintering habitat is restricted because of draw down, which returns the Pend Oreille River to its narrow, shallow channel, resulting in cold, fast-flowing water that is unsuitable for largemouth bass.

Strategies that might be successful would likely focus on providing suitable overwintering habitat, and most likely would require maintaining a full pool through the winter.

3.2.4.4. Assumptions and Uncertainties

It is assumed that overwintering habitat limits largemouth bass populations. A graduate student is currently conducting a study on largemouth bass in Lake Pend Oreille and the Pend Oreille River that may lead to a refined management objective or to specific strategies to improve the fishery. Accurate assessments of largemouth bass habitat during different seasons and operating conditions is needed to reduce this uncertainty.

3.2.5. Rainbow Trout

In this section we describe the status of rainbow trout in Lake Pend Oreille, management objectives, strategies for accomplishing these objectives, and assumptions and uncertainties regarding the strategies.

3.2.5.1. Background

Gerrard strain rainbow trout were introduced from Kootenay Lake to Lake Pend Oreille and provide a trophy fishery. The Gerrard strain matures at age-5 and thus grows particularly large. Current concerns about over-stocking with predator species have resulted in reduction of stocking rates to a relatively few (10,000 trout) per year. Pure Gerrard strain from Kootenay Lake are used in an attempt to improve the genetics of the naturally producing rainbow, which have suffered some intergression with other strains of rainbow trout and with cutthroat trout.

Figure 17 shows habitat requirements by life history stage. Rainbow trout in the system are not currently **limited** by habitat; however, the Forest Service is conducting some stream structure improvement work. Risks to the kokanee population are of concern as kokanee provide an important food resource for both rainbow trout and bull trout. The current catch **limit** for rainbow trout is one fish over 61 cm in length. In addition to the consumptive fishery, there is a catch and release fishery of about 14,800 fish per year. Incidental harvest of small rainbow trout during the kokanee fishery presents a management challenge.

	Spawn Incubate	Age 0 to II	Age II+	Spawn
Tributaries	—————			—————→
Lake			—————	

Figure 17. Habitat Use by Life History Stage for Lake Pend Oreille Rainbow Trout. Habitat is apparently not limiting to current populations of rainbow trout (See text).

3.2.5.2. Management Objective

The management objective is to maintain the trophy fishery.

3.2.5.3. Strategies

In this section we describe proposed strategies to maintain the rainbow trout fishery.

3.2.5.3.1. Primary Strategy

The primary management strategy is to improve the abundance of kokanee and utilize restrictive management regulations to increase their abundance to match the prey base.

3.2.5.3.2. Alternative Strategies

Alternative strategies would include stocking pure Gerrard strain at low numbers while regulating against overharvest and maintaining the quality of tributary spawning habitat.

3.2.5.4. Assumptions and Uncertainties

The strategy assumes that stocking with pure Gerrard strain will be an effective tool to improve the genetics of the stocks present in the lake, and that the present stocking rate is low enough to protect against adverse impacts of predation by rainbow trout on kokanee, and that intergression with westslope cutthroat trout will be at an acceptable level.

Fishery harvest restrictions are assumed to be an effective method of managing the fishery to protect against overharvest and to maintain a quality fishery on trophy-sized rainbow trout. Habitat enhancement, although not limiting, is assumed to increase production. This is not defined sufficiently to substantiate this assumption.

3.3. Summary

The primary fishery management problem in Lake Pend Oreille is to provide adequate spawning habitat for kokanee to increase recruitment to a level that supports the management objective for the sport fishery. Additional efforts seek to protect the rainbow trout fishery, and-to preserve westslope cutthroat trout and bull trout. Some potential exists to provide a largemouth bass fishery. Maintaining a healthy kokanee population would likely benefit other species (especially rainbow trout) as well.

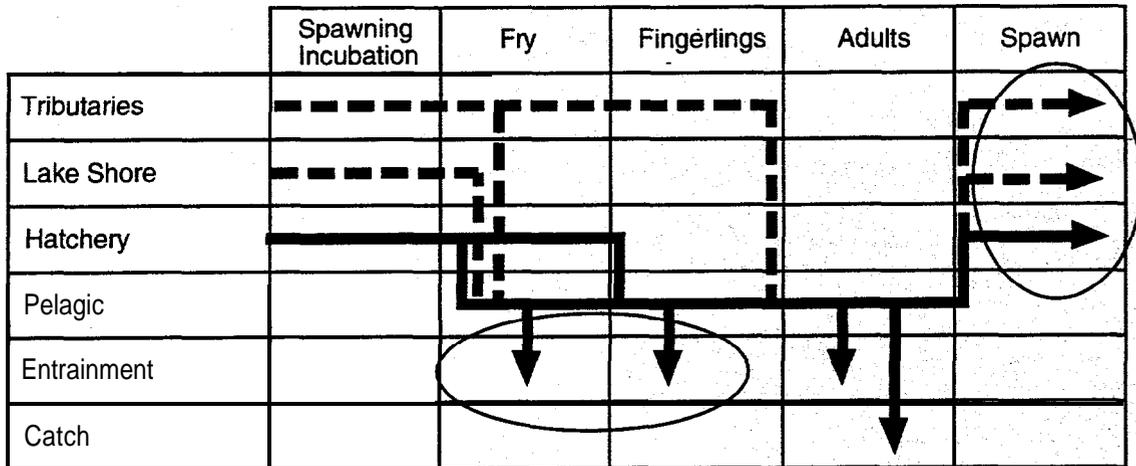


Figure 18. Habitat Use by Life History Stage for Lake Roosevelt Kokanee. Fish emerge from redds in March to April and begin to migrate as fry to the lake in June. They reach fingerling size in September. Hatchery fish are released as fry in June or as fingerlings in June of their second year. Hatchery fish mature at age III. Naturally produced fish mature at age III or IV. Ovals indicate principal bottlenecks to production.

A U.S. Fish and Wildlife Service study of tributary spawning habitat indicated potential natural production of 180,000 kokanee, but the lake zooplankton density is assumed to be sufficient to support a much larger population of 16 million kokanee. Figure 19 shows historical, potential, and current habitat use. Historically, several thousand kokanee spawned in Big Sheep Creek and in the Sanpoil River. Hawk Creek also supported natural production, but spawning is limited to a few fish each year now. The Colville Tribe has a spawning survey underway and have experimented with outplanting to encourage natural production in under-used tributaries.

4.2.1.2. Management Objective

The management goal for kokanee in Lake Roosevelt is to provide a sustained harvest of 300,000 adults over 300 mm long per year.

4.2.1.3. Strategies

In this section we describe proposed strategies to improve the kokanee fishery.

4.2.1.3.1. Primary Strategy

The primary management strategy for kokanee relies on hatchery supplementation. Based on estimated survival and entrainment, a hatchery was constructed with a capacity of 8 million fry which was targeted at producing 3 million adults. However the escapement of 20,000 to 25,000

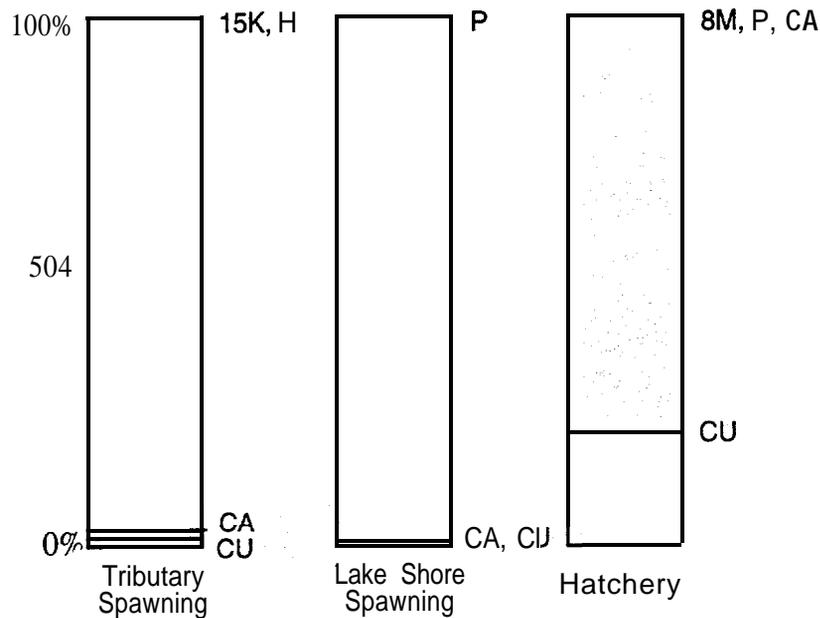


Figure 19. Historic, Potential, and Current Habitat Use by Kokanee in Lake Roosevelt. H = historic (the amount of habitat available prior to dam construction), P = potential (the amount of production that could be achieved with habitat restoration), CA = currently available (the amount of production that can be supported by habitat that is currently available), and CU = current use (the amount of production that is supported by current habitat use. See text.

fish required for full seeding of the hatchery has not been realized and currently the hatchery provides only about 1.7 million fish for stocking into Lake Roosevelt and 200,000 for Banks Lake. The objective for the hatchery is to increase egg availability to reach hatchery capacity.

4.2.1.3.2. **Alternative Strategies**

Other potential strategies are being considered to reduce entrainment losses. These include delaying release from the hatchery until August of the second year to reduce entrainment losses of age-2 fish and releasing fish in locations and at times that protect them from entrainment.

Stabilizing summer reservoir levels is a strategy to improve fishing that is poor when the reservoir is subject to frequent fluctuations in water level. However, this strategy is focused more on improving the catchability of kokanee rather than on increasing the population of fish available.

An untested strategy would be to rear kokanee in net pens as is currently-done for rainbow trout (see below).

4.2.1.4. Assumptions and Uncertainties

Hatchery supplementation assumes that the carrying capacity of the reservoir for sub adults and adults greatly exceeds the potential production from natural spawning. This hypothesis is supported by recent studies of available food; however, earlier studies have not always yielded this same conclusion. A continued monitoring program of the food production at increased densities of all species is needed.

Strategies to reduce entrainment assume that losses as a result of entrainment are significant and that they can be effectively reduced in order to improve survival of hatchery releases. Reduction of entrainment would permit more efficient operation by reducing the hatchery output required to meet target harvest levels. However, the causes and effects of entrainment are not well understood in Lake Roosevelt. Several experiments are underway to provide additional information about entrainment of kokanee and to test potential methods of reducing entrainment losses. These include an experimental release of 9 1,000 age-2 fish, which was conducted in 1992 to test the hypothesis that age-2 fish would be less susceptible to entrainment than smaller fish. Experiments are also being undertaken to determine whether time and location of release effect entrainment losses. However, the present measurement capabilities are limited in their sensitivity to detect statistical differences between control and treatment groups.

Hydroacoustic studies near the dam are being considered in conjunction with acoustic surveys presently underway for Dworshak Reservoir. Acoustic studies may have useful applications at Grand Coulee Dam in reducing the uncertainties regarding kokanee behavior under different operating strategies, which present measurement techniques are not able to accomplish. However, acoustic surveys will be expensive and will require specific study objectives be defined before allocating considerable resources to this effort. Trawl sampling capability and pit-tagging equipment were listed by the investigators as additional critical equipment needs to accomplish research objectives and further define the impacts of entrainment.

4.2.2. Rainbow Trout

In this section we describe the status of rainbow trout in Lake Roosevelt, management objectives, strategies to accomplish these objectives, and assumptions and uncertainties regarding the uncertainties.

4.2.2.1. Background

The rainbow trout fishery in Lake Roosevelt depends on both natural and net-pen reared fish, with net-pen fish dominant in the catch. The current total harvest is about 25,000 to 30,000 fish per year. The catch comprises 33 to 75% net-pen fish.

Figure 20 shows habitat use by life history stage for rainbow trout. The Colville Tribe has conducted habitat surveys, but overall only limited data are available on natural production of rainbow trout in tributary streams. Net pens are operated by volunteers using fish reared at the Spokane Tribal Hatchery taken as eggs from Washington Department of Wildlife (WDW) broodstock at the WDW Spokane Hatchery.

4.2.2.2. Management Objective

The management objective is to increase the annual catch from the present level of under 30,000 fish to a combined catch of naturally produced and net-pen fish of 125,000 to 150,000 fish of 0.5 to 0.75 kg size.

4.2.2.3. Strategies

In this section we describe proposed strategies to improve the rainbow trout fishery in Lake Roosevelt.

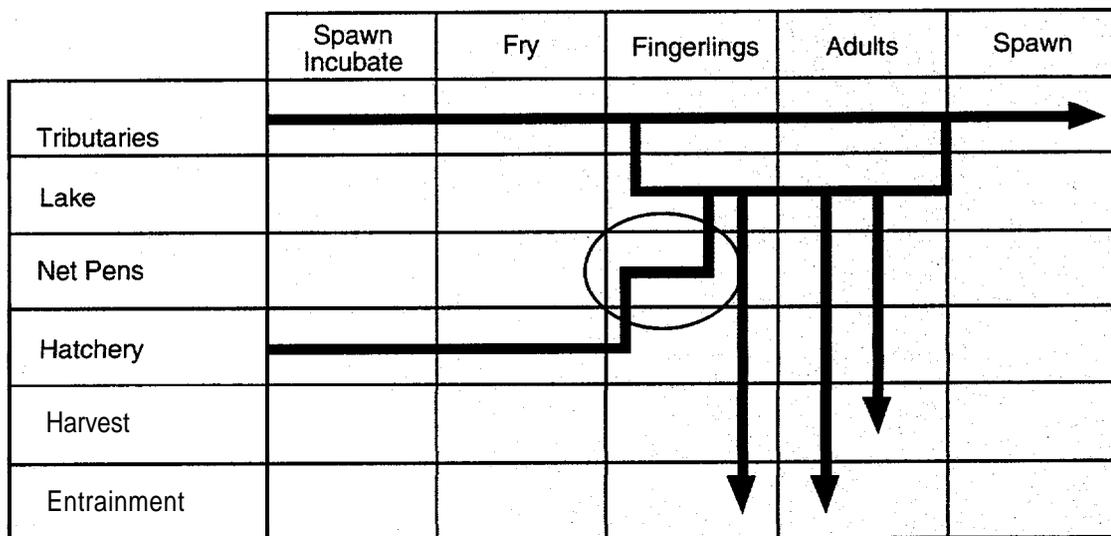


Figure 20. Habitat Use by Life History Stage for Rainbow Trout in Lake Roosevelt. Rainbow trout spawn in the wild in February and emerge in May. They reach fingerling size, and some of them move to the lake between April and June. They mature at age III+. Hatchery rainbow trout are spawned in November and are transferred to net pens in October of the following year. They are released from the net pens by May. Rainbow trout enter the fishery at age I+ and II+. The oval indicates the principal bottleneck to production.

4.2.2.3.1. Primary Strategy

The primary strategy for improving the rainbow trout fishery is to increase net pen production to 500,000 fingerlings, which are expected to contribute 100,000 adult fish to the harvest. The net-pen program is a voluntary program that makes use of space at commercial marinas during the off season. The Lake Roosevelt Forum, a consortium of state and federal governments with tribal governments, has proposed hiring a net pen coordinator to provide better program management.

4.2.2.3.2. Alternative Strategies

Habitat improvements are being undertaken by the Colville Tribe on three or four tributaries to improve natural production.

Changes in the operation of the net pens might improve the survival rate for released fish. These strategies involve extending the pen rearing time to release fish at a larger size when they are expected to be less susceptible to entrainment. Two alternatives have been considered: 1) releasing fish in June rather than May, and 2) holding fish over winter for release in late winter or early spring. However, as currently operated, the program is limited to release by May when the boating season begins, and the space used by the net pens. at marinas is needed for boats.

4.2.2.4. Assumptions and Uncertainties

Increases in the release of net pen reared rainbow trout assume that the carrying capacity of the reservoir is sufficient to support the additional population density. This strategy also assumes that additional space can be found for net pens.

Extended rearing schemes assume that a later release would result in reduced entrainment losses and increased production. This is supported by early results from tag recoveries from experimental releases comparing fish reared until March with those held until June; however, as previously mentioned, measurement sensitivity may limit interpretation of these results. It also assumes that net pen production can be extended into the operating season for the marinas, and that suitable locations can be found for late spring and summer pen rearing that have adequate summer water quality (i.e., reduced temperatures, high dissolved oxygen, etc.).

A limited tag-recovery program is being undertaken to investigate possible alternative rearing and release strategies. An advantage of the program is that it is low cost; however, the numbers of tag returns are relatively low, limiting the statistical power of the tests.

Fishery managers are concerned that conditions for natural production of rainbow trout in Lake Roosevelt will continue to decline as Grand Coulee Dam is operated with less flexibility to absorb changes in operations at other dams such as Dworshak and Brownlee. This leads to the

need for ongoing data collection including tagging and entrainment studies, creel census, and food production studies and interaction studies between hatchery' and naturally produced fish.

4.2.3. Walleye

In this section we describe the status of walleye in Lake Roosevelt, management objectives, strategies for accomplishing the objectives, and assumptions and uncertainties regarding the strategies.

4.2.3.1. Background

Although a non-native fish species, walleye provide an active sport fishery in Lake Roosevelt, which has increased from 80,000 angler trips in 1990 to 160,000 trips in 1991. The harvest in the early 1980s was about 120,000 fish per year. A tagging study in the early 1980s indicated an estimated population of 370,000 fish. This was at the end of a decade of intensive harvest and the carrying capacity may be somewhat higher. Recent harvest rates have ranged from 80,000 and 82,000 in 1989 and 1990, respectively, to 168,000 in 1991.

Figure 2 1 shows habitat use by life history stage for walleye. Spawning areas include an area just below Little Falls Dam, which shuts off flow at night after the spring freshet, potentially dewatering the areas of the tributary used by walleye fry after mid-July. Any additional drawdowns of Lake Roosevelt from June' through August would make the dewatering problem more severe.

The peak flow of the spring freshet corresponds with walleye spawning. During that time, the pool is typically filling. Subsequent drawdowns may increase entrainment of walleye and the zooplankton food base on which they depend. These variations in the environment make it desirable to find ways to extend the period of walleye spawning to reduce current strong year-class fluctuations.

A significant factor in walleye production is the production of forage fish, particularly yellow perch (*Perca flavescens*) on which walleye depend. Other cyprinids, catostomids, and sculpins are also part of the walleye food base. The diet of walleye in Lake Roosevelt is only 50 to 60% fish (the rest is primarily benthic organisms), compared with over 90% fish in other locations. This indicates that their preferred diet of forage fish is limited. Yellow perch, sucker (*Catostomus sp.*), and cyprinid habitat needs are shown in Figure 22. Because these species spawn in shallow vegetation, their reproduction is impacted by reservoir drawdowns during the late winter to summer spawning periods if shorezone vegetation is dewatered.

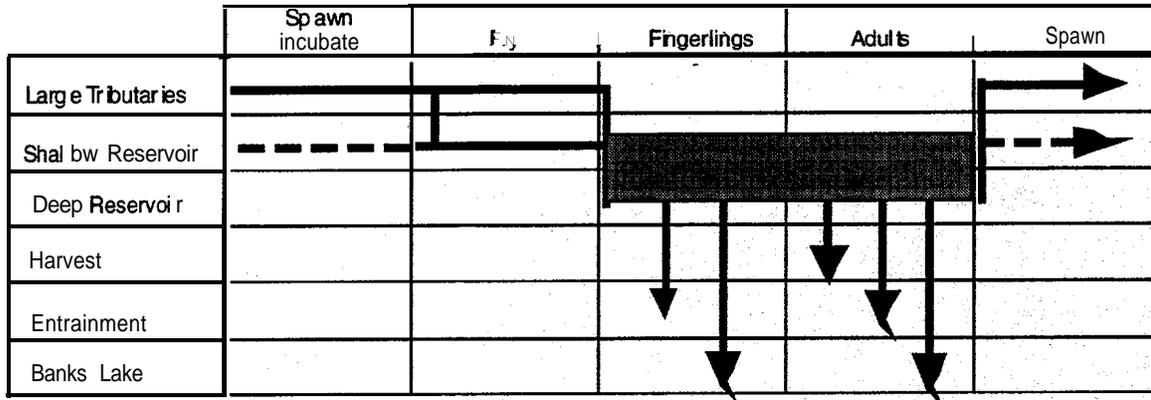


Figure 21. Habitat Use by Life History Stage for Walleye in Lake Roosevelt. Walleye spawn in late April to late May and are broadcast spawners. Incubation is complete within about one month. Walleye fingerlings and adults move between shallow and deep areas of the reservoir, spending nights in deeper water and moving to shallow water to feed during the day. Walleye appear to be limited by low abundance of forage fish rather than habitat availability.

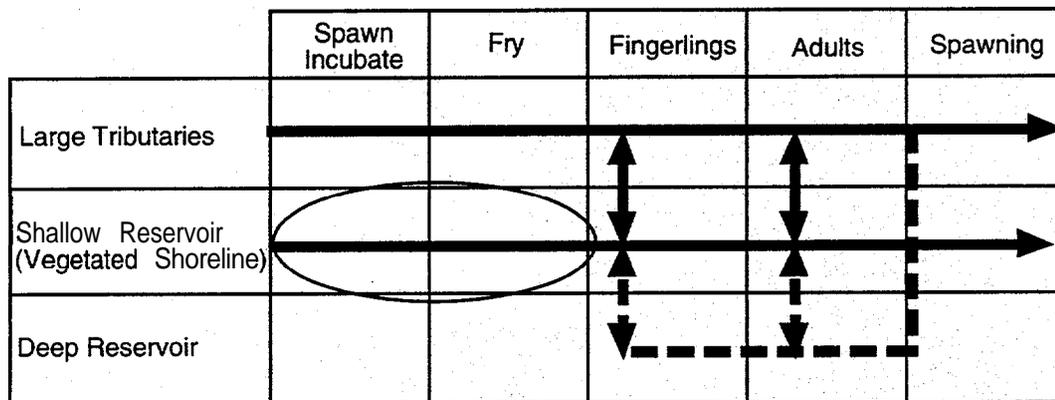


Figure 22. Habitat Use by Life History Stage for Yellow Perch, Sculpins, and Cyprinids. Solid lines pertain to all three groups. Dashed lines pertain to yellow perch only. Yellow perch spawn between February and early April. Suckers and cyprinids spawn later, in May through July or August. All spawn in vegetation or debris in water less than 10 feet deep. These forage fish are important components of the food base for walleye production. The oval indicates the principle bottleneck to production.

4.2.3.2. Management Objective

The management objective for walleye is to maintain a population of 500,000 walleye with an annual harvest of 125,000 fish.

4.2.3.3. Strategies

In this section we describe proposed strategies to enhance walleye populations and fishery.

4.2.3.3.1. Primary Strategies

Strategies to improve walleye production focus on providing a suitable base of forage fish. Potential habitat changes include the possibility of damming embayments to retain warm water in vegetated areas after the reservoir is drawn down and providing more log debris and other structures at lower elevations as spawning habitat for the forage fish.

4.2.3.3.2. Alternative Strategies

Alternative strategies for walleye were not identified.

4.2.3.4. Assumptions and Uncertainties

Strategies that focus on forage species assume that food is limiting walleye production and that through habitat improvement or other manipulations the populations of forage fish can be increased sufficiently to support a much higher population of walleye. Obviously; before a strategy such as habitat improvement is initiated, a better description of the baseline conditions in the reservoir is needed. Manipulating habitat for the purposes of increasing forage fish production is largely untested. Basic information on habitat availability, habitat use, identification of bottlenecks, and measurable strategies are all needed.

4.2.4. Sensitive Species

In this section we describe the status of three sensitive species: cutthroat trout, bull trout, and Paiute sculpins in Lake Roosevelt; management objectives; strategies for the accomplishment of the objectives; and assumptions and uncertainties regarding the strategies.

4.2.4.1. Background

Cutthroat trout, bull trout, and Paiute sculpins are species of special concern. Some question exists as to whether bull trout are still present in the reservoir. Cutthroat trout are thought to be present in remnant numbers in some tributaries but have not been confirmed to be present since 1989.

4.2.4.2. Management Objective

The management objective for the species of concern is protection of existing stocks if they are present.

4.2.4.3. Strategies

No effective strategies have been identified to protect the sensitive species at this time.

4.2.4.4. Assumptions and Uncertainties

Assumptions and uncertainties cannot be identified until strategies are proposed.

4.2.5. White Sturgeon

In this section we describe the status of white sturgeon in Lake Roosevelt, management objectives, strategies for accomplishing the objectives, and assumptions and uncertainties regarding the strategies.

4.2.5.1. Background

White sturgeon are present in Lake Roosevelt and support a limited fishery with an annual catch of 25 to 40 fish. However, very little information is available on white sturgeon populations in the lake.

4.2.5.2. Management Objective

No specific management objective was identified for white sturgeon.

4.2.5.3. Strategies

In this section we describe proposed strategies to protect white sturgeon.

4.2.5.3.1. Primary Strategies

Canada has closed sturgeon fishery in the reservoir and the Washington Department of Fisheries has restricted harvests.

4.2.5.3.2. Alternative Strategies

No specific alternative strategies were identified.

4.2.5.4. Assumptions and Uncertainties

Fishing regulation assumes that the restricted harvest will protect white sturgeon from overfishing. At this time, the limited information on white sturgeon in Lake Roosevelt precludes evaluating the current strategy or status of the stocks.

4.3. Summary

Management of Lake Roosevelt fisheries depends on supplementation with hatchery kokanee and pen-reared rainbow trout. Relatively little information is available about other species of interest, and consequently, detailed strategies were not developed for them.

Under the current operation strategies for Grand Coulee Dam, it is uncertain if kokanee supplementation will be successful. The uncertainty could be a function of kokanee behavior (i.e.,

5. REFERENCES

- Bonneville Power Administration (BPA). 1993. Supplementation in the Columbia Basin. Final Report. Bonneville Power Administration, Portland, Oregon.
- Bowles, E.C, V. Ellis, and B. Hoelscher. 1989. Kokanee Stock Status and Contribution of Cabinet Gorge Hatchery, Lake Pend Oreille, Idaho. Annual Progress Report to the Bonneville Power Administration, Portland, Oregon.
- Bowles, E.C, V. Ellis, and D. Hatch. 1988. Kokanee Stock Status and Contribution of Cabinet Gorge Hatchery, Lake Pend Oreille, Idaho. Annual Progress Report to the Bonneville Power Administration, Portland, Oregon.
- Bowles, E.C, V. Ellis, D. Hatch, and D. Irving. 1987. Kokanee Stock Status and Contribution of Cabinet Gorge Hatchery, Lake Pend Oreille, Idaho. Annual Progress Report to the Bonneville Power Administration, Portland, Oregon.
- Bowles, E.C, V. Ellis, and D. Washick. 1986. Kokanee Stock Status and Contribution of Cabinet Gorge Hatchery, Lake Pend Oreille, Idaho. Annual Progress Report to the Bonneville Power Administration, Portland, Oregon.
- Hoelscher, B., Bowles, E., and V. Ellis. 1990. Kokanee Stock Status and Contribution of Cabinet Gorge Hatchery, Lake Pend Oreille, Idaho. Annual Progress Report to the Bonneville Power Administration, Portland, Oregon.
- Idaho Department of Fish and Game (IDFG). 1991. Fisheries Management Plan: 1991-1995. Idaho Department of Fish and Game, Boise, Idaho.
- Maiolie, M. A., D. P. Statler, and S. Elam. 1992. Dworshak Dam Impact Assessment and Fishery Investigation and Trout, Bass, and Forage Species. Final Report, Bonneville Power Administration, Portland; Oregon.
- Paragamian, V., V. Ellis, and S. Andersen. 1993. Kokanee Stock Status and Contribution of Cabinet Gorge Hatchery, Lake Pend Oreille, Idaho. Annual Progress Report to the Bonneville Power Administration, Portland, Oregon.
- Paragamian, V., V. Ellis, and R. Gariss. 1991. Kokanee Stock Status and Contribution of Cabinet Gorge Hatchery, Lake Pend Oreille, Idaho. Annual Progress Report to the Bonneville Power Administration, Portland, Oregon.
- RASP (Regional Assessment of Supplementation Project). 1993. Report for the Regional Assessment of Supplementation Project, Bonneville Power Administration, Portland, Oregon.

APPENDIX I.

Participants in Workshop and Planning Meetings

2-Day Kickoff Workshop

Spokane, Washington

July 7-8, 1993

David Bennett

Charlie Craig

Cathy Gee

David Geist (Thursday only)

Janelle Griffith

Jeff Laufle

Melo Maiolie

Amy McDowell

David Statler

curt Vail

Lars Moberg (Presenter, Wednesday only)

Duane Fickeisen (Facilitator)

Dworshak Reservoir Planning Meeting

Couer d' Alene, Idaho

July 15, 1993

Melo Maiolie

Dave Statler

Charlie Craig

Duane Fickeisen

Lake Pend Oreille Planning Meeting

Couer d' Alene, Idaho

July 16, 1993

Melo Maiolie

Charlie Craig

Duane Fickeisen

Lake Roosevelt Planning Meeting

Spokane, Washington

July 20, 1993

Janelle **Griffith**

John Hisata

Amy McDowell

Al Schulz

curt Vail

Charlie Craig

Duane Fickeisen