PART I - ADMINISTRATIVE

Section 1. General administrative information

Title of project **Lake Pend Oreille Fishery Recovery Project**	
BPA project number	**9404700**
Contract renewal date (mm/yyyy)	**10/1999**
Multiple actions? (indicate Yes or No)	**No**
Business name of agency, institution or organization requesting funding **Idaho Department of Fish and Game**	
Business acronym (if appropriate)	**IDFG**
Proposal contact person or principal investigator:	
Name **Mailing address** **City, ST Zip** **Phone** **Fax** **Email address**	**Melo A. Maiolie, Ph.D.** **PO Box 806** **Bayview, ID 83803** **(208) 683-3054** **(208) 683-3054** **mmaiolie@micron.net**
NPPC Program Measure Number(s) which this project addresses **10.6E, 10.6E.1, 5.4D.7**	
FWS/NMFS Biological Opinion Number(s) which this project addresses **N.A.**	
Other planning document references **1998 Lake Pend Oreille Key Watershed Bull Trout Problem Assessment. Prepared for Lake Pend Oreille Water Advisory Group, State of Idaho, by Panhandle Bull Trout Advisory Team, 92 pp. (supports this project as helping bull trout recovery)**	
Short description **Enhances resident fish populations by changing the winter draw down of Lake Pend Oreille and the Pend Oreille River and researches other possible mechanisms for fish declines including predation and competition.**	
Target species **Kokanee, Kamloops rainbow trout, Lake trout, Bull trout, Largemouth bass, Black crappie.**	

Section 2. Sorting and evaluation

Subbasin
Pend Oreille subbasin

Evaluation Process Sort

CBFWA caucus		CBFWA eval. process		ISRP project type	
X one or more caucus		If your project fits either of these processes, X one or both		X one or more categories	
	Anadromous fish	X	Multi-year (milestone-based evaluation)		Watershed councils/model watersheds
X	Resident Fish		Watershed project eval.		Information dissemination
	Wildlife				Operation & maintenance
					New construction
				X	Research & monitoring
					Implementation & mgmt
					Wildlife habitat acquisitions

Section 3. Relationships to other Bonneville projects

Umbrella / sub-proposal relationships. List umbrella project first.

Project #	Project title/description

Other dependent or critically-related projects

Project #	Project title/description	Nature of relationship
	none	

Section 4. Objectives, tasks and schedules

Past accomplishments

Year	Accomplishment	Met biological objectives?
1997	First year of project. US Army Corps successfully changed winter lake level.	No. Higher lake level added nearly 2 million square feet of spawning gravel to shoreline areas of the lake, but it was too early to have improved

		kokanee density.
1997	Three University projects were started.	No, too early.
1997	Kokanee population was successfully measured by hydroacoustics, trawling and spawner counts.	No, the lake had the heaviest flooding in the last 40 years and dissolved gasses reached 120-130%. All age classes of kokanee declined. Spawning population declined to record low levels.
1997	Kokanee spawning activity was mapped on 100 miles of shoreline. Kokanee were documented to have moved into new shoreline areas for spawning.	No, kokanee population remained low.
1997	Depths of kokanee spawning were measured. Kokanee were found to have moved on to newly available gravel at shallower depths.	No. The bulk of the kokanee population spawn at a 4 foot depth on the newly created clean gravel. This was a good indication that spawning was improving.
1997	Shrimp population was successfully measured by random sampling in three sections of lake.	No. Shrimp population declined slightly, so we can conclude it did not affect outcome of lake level testing.
1998	Kokanee population successfully measured by trawling and hydroacoustics. Fry abundance very low.	No. Record low numbers of eggs were laid in 1997 which produced low numbers of fry in 1998. Flooding and high dissolved gas confounded the results of the lake level experiment.
1998	Graduate student study successfully shows that newly emerged kokanee do not starve because of competition with Mysis shrimp.	No. Studies indicate that competition with shrimp did not reduce kokanee abundance nor is it preventing kokanee recovery.
1998	Extensive sampling of shoreline spawning gravel shows very little siltation due to changing lake levels during first two years.	Yes. The sub-objective of having no net change in the amount of shoreline spawning gravel was met.

Objectives and tasks

Obj 1,2,3	Objective	Task a,b,c	Task
1.	Recover kokanee abundance so that a harvest of 750,000 fish can be maintained on an annual basis. This would require an adult kokanee population of 3.7 million fish.	a.	U.S. Army Corps of Engineers raises the lake level 4 feet during the winter of 1996-97, 1997-98, and 1998-99.
	Sub-objective: determine if adult kokanee population reaches 3.7 million and determine if egg to fry	b.	Conduct mid-water trawling in the lake to determine population estimates, biomass, age, and size of kokanee.

Obj 1,2,3	Objective	Task a,b,c	Task
	survival exceeds 3.6%.		Estimate number of eggs being laid.
	Sub-objective: verify the accuracy of trawling and determine its net-efficiencies.	c.	Conduct mobile hydroacoustic surveys to estimate age classes of kokanee and determine location of fry.
	Sub-objective: determine trend of lake levels to kokanee population and its statistical significance.	d.	Compare kokanee population to past data and relate to changes in lake level using multiple regression analysis.
	Sub-objective: use spawning kokanee abundance as a surrogate index of adults, look for a doubling of spawning fish.	e.	Conduct spawner counts of kokanee along shoreline and relate to past data.
	Sub-objective: determine if egg to fry survival exceeds 3.6%.	f.	Calculate survival rates of kokanee and determine if lake level changes cause changes in survival.
	Sub-objective: determine if kokanee pioneer new areas to reduce intra-specific competition of fry and determine if kokanee use the cleaner newly created gravel to improve survival.	g.	Map location and depth of kokanee spawning along 100+ miles of shoreline.
	Sub-objective: try in-situ experiments to estimate improvement in egg to fry survival.	h.	Place kokanee eggs in Vibert type boxes and bury in the shoreline substrates of different qualities to determine changes in incubation with changed lake levels.
	Sub-objective: determine changes in wild fry survival without masking the effect by stocking hatchery fish.	I.	Cold-brand the otoliths of all hatchery produced fry that are stocked into the lake so that they can be separated from wild fry.
	Sub-objective: provide a diagrammatic over-view of the relationships within the lake, as per Power Planning Council's request.	J.	Build a systems model (not a computer model) of the lake as well as a sensitivity analysis of the state variables and feedback loops to show determinants of recruitment and survivorship.
2.	Have no net change in the amount of shoreline spawning gravel due to erosion or siltation during this experiment (maintain 1.7 million sq. feet).	a.	Monitor the quality of shoreline gravel by scuba diving and analyzing the silt, sand, gravel, and cobble content.
3.	Increase the warm water fish population in the Pend Oreille River seven fold.	a.	Change the winter elevation of the river 4 feet. (This task is being done by the U.S. Army Corps.)

Obj 1,2,3	Objective	Task a,b,c	Task
		b.	Monitor warm water fish populations in the Pend Oreille River by gillnetting, seining, and electrofishing and compare to data collected in 1991 and 1992.
		c.	Determine year class strength and over winter mortality of fish produced with changed river levels.
4.	Determine whether other factors could be limiting the kokanee population by either competition or predation.	a.	Build a year-round energy budget model for the lake including zooplankton, shrimp, kokanee, and predators.
		b.	Monitor zooplankton weekly during spring and fall and monthly the remainder of the year.
		c.	Sample shrimp annually to determine density and abundance.
		d.	Estimate predator abundance using mark and recapture methodology.
		e.	Electro-fish shorelines to define impact of near shore predators.
		f.	Calculate consumption of predators using bioenergetics and incorporate into energy model.
		g.	Survival of wild fry will be correlated to hatchery stocking to determine potential impact of hatchery fish.
5.	Keep Eurasian milfoil from becoming a significant problem in Lake Pend Oreille	a.	Conduct a literature review of the life history of milfoil.
		b.	Map areas of the lake that are milfoil habitat.
		c.	Search for milfoil along 100+ miles of shoreline.
		d.	Determine limnology at location of milfoil sites.
		e.	Design site-specific management recommendations.
		f.	Document plant community response during years of deeper drawdown.
6.	Determine any large impact of changed lake levels on riparian vegetation and waterfowl as per	a.	Photo documentation of representative shoreline vegetation will be made during and after years of high water.

Obj 1,2,3	Objective	Task a,b,c	Task
	Councils request.		
		b.	An annual waterfowl count will be made from a fixed wing aircraft.

Objective schedules and costs

Obj #	Start date mm/yyyy	End date mm/yyyy	Measurable biological objective(s)	Milestone	FY2000 Cost %
1.	10/1996	12/2001	Adult kokanee population of 3.7 million fish		35%
2.	06/1998	09/1999	Area of spawning habitat remains 1.7 million sq. ft.		14%
3.	01/1999	12/2000	Relative abundance of warm water fish increases 7 fold over previous study.		17%
4.	10/1996	12/2001	Determine if predation and competition reduce kokanee survival to less than 80%.		17%
5.	07/1997	12/2001	Milfoil density remains low enough that it is not a biological or social problem.		16%
6.	1/1997	12/2001	No large change occurs in riparian vegetation or waterfowl.		1%
				Total	100%

Schedule constraints
Project requires the cooperation of the U.S. Army Corps of Engineers to change lake levels each winter. Cooperation has been excellent through the first 2 years of study and is expected to be so during the last year of lake level changes in the winter of 1998-99. Severe flooding during test years could delay documenting the benefits of higher lake levels. Last year, the ISRP recommended that the lake be held higher for 10 winters. We are actively pursuing this extension. A letter was sent from the Director of the Idaho Department of Fish and Game to the Colonel of the Corps of Engineers in Seattle making this request. So far there has not been any response which would indicate a change in our current proposed schedule.
Completion date
FY 2002 (a low cost fish monitoring program is proposed after this date).

Section 5. Budget

FY99 project budget (BPA obligated):	$361,000

FY2000 budget by line item

Item	**Note**	**% of total**	**FY2000 ($)**
Personnel			101,000
Fringe benefits			35,000
Supplies, materials, non-expendable property			18,000
Operations & maintenance			19,000
Capital acquisitions or improvements (e.g. land, buildings, major equip.)			14,000
NEPA costs			0
Construction-related support			0
PIT tags	# of tags:		0
Travel			5,000
Indirect costs			67,000
Subcontractor			120,000
Other			
		TOTAL BPA REQUESTED BUDGET	379,000

Cost sharing

Organization	**Item or service provided**	**% total project cost (incl. BPA)**	**Amount ($)**
none			
		Total project cost (including BPA portion)	

Outyear costs

	FY2001	**FY02**	**FY03**	**FY04**
Total budget	398,000	120,000	120,000	120,000

Section 6. References

Watershed?	Reference
	Argyle, R.L., G.L. Curtis, and G.W. Fleischer. 1993. Development and implementation of an integrated (acoustic and trawl) prey fish assessment strategy for Lake Michigan. 1992 Interim Progress Report, U.S. Fish and Wildlife Service, National Fisheries Research Center-Great Lakes, Ann Arbor, Michigan.
	Dupont, J.M., and D.H. Bennett. 1993. The effects of drawdown on fishes in the Pend Oreille River, Idaho. Master's Thesis. University of Idaho, Moscow, Idaho. (in press)
	Fredericks, J. P., M.A. Maiolie, and S. Elam 1995. Kokanee impacts assessment and monitoring on Lake Pend Oreille, Idaho. Idaho Department of Fish and Game, Annual Progress Report, Prepared for Bonneville Power Administration, Project number 87-099, Portland, Oregon.
	Gregg, R.E. 1976. Ecology of Mysis relicta in Twin Lakes, Colorado. U.S. Bureau of Reclamation REC-ERC-76-14.
	Hassemer, P.F. 1984. Spawning ecology and early life history of kokanee (Oncorhynchus nerka) in Coeur d'Alene and Pend Oreille Lakes, Idaho. Master's Thesis. University of Idaho, Moscow.
	Maiolie, M.A. and S. Elam. 1993. History of kokanee declines in Lake Pend Oreille, Idaho. Annual Progress Report, Dworshak Dam Impacts Assessment and Fisheries Investigation Project Number 87-99. Bonneville Power Administration, Portland, Oregon.
	Maiolie, M. A., W.J. Ament, S. Elam, and B. Harryman. 1998a. Kokanee impacts assessment and monitoring on Lake Pend Oreille, Idaho. Annual Progress Report 1996. Contract number 94BI12917, Bonneville Power Administration, Portland, Oregon.
	Maiolie, M. A., W.J. Ament, and B. Harryman. 1998b. Kokanee impacts assessment and monitoring on Lake Pend Oreille, Idaho. Annual Progress Report 1997. Contract number 94BI12917, Bonneville Power Administration, Portland, Oregon.
	Paragamian, V.L. and V.L. Ellis. 1991. Kokanee stock status and contribution of Cabinet Gorge Hatchery, Lake Pend Oreille, Idaho. Idaho Department of Fish and Game, Progress Report to Bonneville Power Administration, Project 85-339, Boise.
	Paragamian, V.L. and V.L. Ellis. 1992. Kokanee stock status and contribution of Cabinet Gorge Hatchery, Lake Pend Oreille, Idaho. Idaho Department of Fish and Game, Progress Report to Bonneville Power Administration, Project 85-339, Boise.

PART II - NARRATIVE

Section 7. Abstract

Lake Pend Oreille is the largest natural lake in Idaho; 90,000 acres. Sport fisheries in the lake have been severely impacted by hydropower development on both the inflow and the outflow of

the lake (Maiolie and Elam 1993, Fredericks et al. 1995 , Paragamian 1991). Since the 1960's, the lake has been drawn down 6 feet to meet the flood control rule curve and then drawn down an additional 5 feet for electric power production. This last 5 feet of draw down has significantly impacted kokanee, predatory fish which feed on kokanee, and warm water fish species in 23 miles of the Pend Oreille River (Maiolie and Elam 1993). This project experimentally raises the lake level 4 feet during 3 winters to determine whether or not lake levels (developing new rule curves) could be used to recover these impacted fisheries. A second part of the project is to determine if predation, competition with shrimp, or competition with hatchery kokanee contributes to the low fish populations.

The goal of the project is to "improve the Lake Pend Oreille ecosystem to the benefit of fish and wildlife, thereby enhancing fishing, recreational opportunities, and other resource values, while managing the lake levels for the balanced benefit of fish, wildlife, flood control, and power production". Our objectives is to return the fisheries to 75% of their historic level. These goals are relevant to the 1994 Fish and Wildlife Program because it mitigates the impact of the federal hydropower system on the lake's resident fish populations.

This project uses an adaptive management methodology; draw downs of the lake are changed for 3 years and the resulting changes to the ecosystem (habitat and fish populations) are monitored. The project is designed to run for 5 years, with the lake level changing during the first three. This will give kokanee a chance to grow for an additional 2 years and become more vulnerable to our sampling gear. We will estimated fish abundance by mid-water trawling, hydroacoustics, gillnetting, and electofishing (see tasks in section 4). Our expected outcome is to see statistically significant increases in both cold and warm water fish abundance, and improvements in fish survival rates.

Section 8. Project description

a. Technical and/or scientific background

Overall problem: Lake Pend Oreille was the most productive resident fishery in the state of Idaho until the mid-1960's. An average of one million fish were caught annually between 1952 and 1966. Albeni Falls Dam was built on the outflow of the lake in 1952 and Cabinet Gorge Dam was built on the inflow the same year. Blocking the Clark Fork River (by Cabinet Gorge Dam) caused immediate declines in Bull trout abundance since spawning areas became limited. The lake remained an exceptional fishery for kokanee and Kamloops rainbow trout until the mid-1960's when Albeni Falls Dam began lowering the lake 11 feet each fall for additional power production.

Maiolie and Elam (1993) reported that deeper draw downs in 1957, and 1959 reduced the kokanee fishery five years later. Conversely, higher water levels in the winter of 1958, 1959, and 1960 produced better fisheries five years later. They also found that somewhat higher lake elevations in 1982, 1983 and 1985 produced 39% more kokanee recruited to the fishery than years before or after these years. Fredericks et al. (1995) found that the two best years on record for egg-to-fry survival were 1982 and 1983 when the lake was 3 to 4 feet higher than normal during the winter. A second important factor is that the lake cannot be lowered once kokanee spawning has taken place (Hassemer 1984, and Maiolie and Elam 1993). Draw downs of less than 1 m can have a noticeable effect on the resulting fisheries if they occur during the egg incubation period; December to May.

The mechanism for why lake levels control fish abundance can be explained rather simply. Shoreline gravels around the lake rely on wave action to remain clean. This gravel occurs at various depths below the summer pool level (full pool) but is nearly non-existent below depths of

11 feet (Maiolie and Elam 1993) . When the lake is drawn down 11', clean gravel around the shorelines is unavailable to spawning fish. Surveys of potential spawning areas around the lake found that an additional 1.8 million square feet of gravel would be available for kokanee spawning if the lake were held 4 feet higher throughout the winter (Fredericks et al. 1995). Fredericks et al. 1995 estimated only 380,000 square feet of gravel were below the low pool elevation.

A different situation exists on the Pend Oreille River. This 23 mile long river bottom is flooded during the summer and contains good habitat for warm water species such as bass and perch. Drawdowns during winter drop the water into the old river channel. This area then becomes a cold flowing river with little over winter habitat for warm water species. Bennett and DuPont (1993) calculated overwinter habitat would increase by 7.5 times if the winter elevation were 5 feet higher than normal.

It is clear that kokanee declines in the mid 1960's to mid-1970's were caused by lake level changes. Since this time, other changes have occurred in Lake Pend Oreille. The uncertainty that is tested by this project is whether or not modifying lake levels now can be used to return kokanee to their former level of abundance. It will also test whether the fisheries of the Pend Oreille River can be substantially enhanced. The only way to answer these questions is to change the lake level on an experimental basis and determine how fish populations respond.

Last years review of this project by the ISRP recommended that this project extend the lake level changes for 10 years instead of three. Idaho Department of Fish and Game agrees. Director Mealey of the Department recently sent a letter to the Corps requesting this extension, but there has not been any response at the time of this writing.

b. Rationale and significance to Regional Programs

How this project relates to the goals of the FWP can best be stated by comparing it to the criteria used by the CBFWA. The project does address specific Council Program measures specified in 10.6E. It is also consistent with management objectives of the State which are presented in Idaho Fish and Game's 5 year management plan. It also conforms to Council prioritization process according to program measure 10.1B. This measure gives a high priority to projects which rebuilding native fish populations injured by the hydropower system. Bull trout in Lake Pend Oreille declined sharply after the construction of the Cabinet Gorge Dam (a federally licensed project) which blocked most of their upstream spawning areas. Bull trout also feed on kokanee as a main part of their diet. Recovering kokanee will help to recover the lake's predatory species such as bull trout. Section 10.1B also gives high priority to fish "populations that support important fisheries ", projects that " develop biological and integrated rule curves","provide benefits for anadromous fish", and "protect the health of existing resident fish populations"; all of these items are met by this project. The benefits to anadromous fish are stated in Section 5.4D.7 which says increased flows because of this project are to go to salmon flows in the Columbia River. Biological objectives of the project have been developed (see section 4), but they have not be adopted into the Councils Program at this time. Data from this project will be used in the development of biological/integrated rule curves. By keeping the lake higher during winter, we are actually testing a changed rule curve for the lake. Thus, the actual effect of a new rule curve will be known.

This project directly enhances fish populations that support important fisheries. The kokanee fishery was once the largest resident fishery in the State with a harvest of 1 million fish annual. It is still important with a harvest of around 100,000 fish. Bull trout sustained a fishery of several thousand fish annually, but it is now closed. Kamloops rainbow trout support a catch of about 14,000 fish annually. The project also provides direct benefits to non-target species. Better kokanee populations mean better foraging for 100 -200 eagles which winter on the lake. Higher winter water levels provides a direct benefit to several species of warm water fish, including bass crappie and perch, in the Pend Oreille River.

The project also has demonstrated that all reasonable precautions have been taken not to adversely affect other fish populations. Prior to changing lake levels, the US Army Corps of Engineers studied potential effects and gave the project a finding of "no significant impact".

Rationale for the project- Lake Pend Oreille during the 1950's and 1960's had sportfish harvests in excess of one million fish annually. This project will determine if changing lake levels can be used to recover fisheries impacted by the federal hydropower system. If this proves to be the case, a some what more natural hydrographic could be designed which would meet the demands of power production, flood control, recreation, and the needs of fish populations. These could be incorporated into new rule curves for Albeni Falls Dam. By using this adaptive management approach, we will have strong empirical evidence for these new rule curves. But, the first step is to resolve the uncertainty of the impact of lake level changes.

Keeping the lake higher in the winter means that less water can be stored during spring run-off. Thus, more water will pass downstream which could be used to help anadromous fish flows lower in the drainage (see section 5.4D.7).

This project clearly meets the goal of "protecting, mitigating and enhancing the health and viability of resident fish populations to meet consumptive and non-consumptive needs in the Columbia River Basin (10.1 Resident Fish Goal)." Pend Oreille has a very active sport fishery with both a consumptive and non-consumptive need. The FWP (10.1A) also has a principle to "protect, mitigate and enhance resident fish populations to the extent they were or are affected by construction and operation of dams". The largest impacts to the fisheries have come from the damming of both the lake's inflow and outflow. Clearly this project falls within the FWP goals.

c. Relationships to other projects

This is the only project currently funded for Lake Pend Oreille. As such, it is not dependant on another projects efforts. Project does require the cooperation of the US Army Corps of Engineers to change the lake levels during winter. They have done this the last two winters and we expect they will continue during the last year of higher water levels.

Findings of this project should have strong implications to the management of other reservoirs in the drainage. It could demonstrate the effects of changing drawdowns and the benefits to forage fish, predatory fish, aquatic vegetation, and warm water fish species. It may also help to develop a more system-wide approach to managing flows for resident and anadromous fish. This project may show that flood control constraints can be met, more water during spring run-off can be passed for downstream interests, and still improve lake level management for resident fish.

d. **Project history** (for ongoing projects)

Our project number has not changed.

Adaptive management implications- Finding a good biological basis for changing the lake levels, changing them, monitoring the effects on fish populations, and then incorporating the results into new operating criteria (rule curves), is a good adaptive approach. The implication of this is we will learn much quicker and with much greater certainty the role of lake levels in determining fish abundance.

Project reports and technical papers- Maiolie et al. 1998a. Maiolie et al. 1998b.

Years underway - Two.

Summary of major results achieved - We have mapped kokanee spawning areas around the entire 100+ miles of the lake's shoreline. We found kokanee are heavily using the new gravels that were made available by the higher water level. We also found that kokanee were spawning in new areas of the lake which contain newly inundated gravel. Population estimates of all five age classes of kokanee were made in 1997 and 1998 by both hydroacoustics and mid-water trawling. However, flooding and high dissolved gasses have reduced most age classes of kokanee to record or near record lows. This has masked any numerical response of kokanee to the improved spawning habitat. During 1998 an additional significant finding was determined. Net pen experiments proved that competition between Mysis shrimp and newly emerged kokanee fry did not cause high mortality of the fry. This strengthens the argument that spawning habitat is controlling kokanee fry abundance.

Past costs- $315,480 in 1997 and $360,000 in 1998, $361,000 in 1999.

e. Proposal objectives

Objective 1. Recover kokanee abundance so that a harvest of 750,000 fish can be maintained on an annual basis. This would require an adult kokanee population of 3.7 million fish. This harvest level would be approximately 75% of the historic level for this lake.

Hypotheses: Survival rates from eggs to fry will be significantly higher in years of higher winter water levels than previous years of low winter lake levels.

Kokanee abundance during test years of higher water levels will define a higher, more resilient, stock-recruitment curve.

The abundance of kokanee in each year class produced under higher lake levels will show a significant increase when compared to kokanee abundance in the last 7-14 years (taking into account the spawning population of adults).

Estimates of fry produced at historic spawning areas will be significantly higher in years of a higher winter elevation.

Assumption: Kokanee will find and utilize the new spawning gravels that become available. Compensatory responses of predators to the increase in kokanee density will not mask the improvement in fry abundance.

Objective 2. Have no net change in the amount of shoreline spawning gravel (maintain 1.7 million sq. ft.) due to erosion or siltation during this experiment.

Hypotheses: There will be no net change in area of usable spawning gravels below the test elevation.

There will be no net increase in the silt content of the available spawning gravels below the test elevation.

Assumption: This assumes that wave action and lake currents determine the siltation and cleaning of shoreline gravels. Secondly, it assumes that the siltation rate on newly inundated gravel is low and will not make the gravel unusable in the 3 years of this test.

Objective 3. Increase the warm water fish population in the Pend Oreille River seven fold.

Hypothesis: Younger age classes of warm water will increase during years of higher winter water levels in the Pend Oreille River above Albeni Falls Dam.

Assumption: Warm water fish will respond to the amount of winter habitat available to them.

Objective 4. Determine whether other factors could be limiting the kokanee population by either competition or predation. Specifically, does natural mortality due to predation exceed 50%. And, do Mysis shrimp increase kokanee fry mortality more than 20%.

Hypotheses: Predation is not a limiting factor for the kokanee population. Food is not limiting kokanee of any age class at this time. Mysis shrimp consumption of zooplankton is not sufficient to reduce kokanee fry abundance. Timing of thermal stratification of the lake (particularly epilimnetic waters over 14 C) will not change and affect fry survival.

Assumption: Good kokanee abundance can be maintained with mortality rates less than 50%. Competition with shrimp can be tested using net pen experiments which regulate the amount of zooplankton available to kokanee fry.

Objective 5. Keep Eurasian milfoil from becoming a significant problem in Lake Pend Oreille. Our objective is to have no areas where milfoil blocks access to boat ramps and docks, or interferes with established swimming areas.

Hypothesis: Eurasian milfoil will not become established in Lake Pend Oreille during the course of this study, or if it does, that it can be managed below problem levels.

Assumption: Eurasian milfoil will survive and grow in Lake Pend Oreille.

Report products: Annual progress reports and quarterly reports will be submitted to BPA. The project leader will also present annual updates on research findings to BPA at their project review meetings. Findings will be presented annually at the International Kokanee Workshop. Results from the completed project will be peer-reviewed and published in scientific journals, where appropriate. Findings will be incorporated into the Coordinated Information System (CIS) of the Bonneville Power Administration.

f. Methods

Objective #1.

Tasks:

b. The numerical abundance of each age class of kokanee will be estimated by mid-water trawling during August. A stratified random sampling scheme will be used. Lake will be divided into 3 sections with 12 trawls conducted within each section; n=36. Estimates will be added to previously collected results. Normal statistics will be applied to determine whether statistically significant differences have occurred in the kokanee population at the 90% confidence level. Previous trawling has shown that a sample size of 36 trawls gives a 90% confidence interval of +/- 25%.

c. Mobile hydroacoustic surveys will be conducted on Lake Pend Oreille to determine kokanee abundance and age 0 distribution during the month of July or August. Emphasis will be placed on developing correction factors for mid-water trawling and determining whole-lake abundance estimates. Sixty survey transects will be randomly located in a stratified survey design. This design has been shown to produce a 90% confidence interval of +/- 15%. We also intend to develop an integrated method of trawling and hydroacoustics (Argyle et al. 1993). By using the best aspects of either trawling or hydroacoustics we should be able to avoid the bias inherent in either method. Hydroacoustic data will also be analyzed to determine the abundance of large fish which may be predators. If feasible, predator abundance will be compared to kokanee survival.

d. Data sets will be compiled from previous investigations, which relate each age class of kokanee to the lake's winter elevation and the changes in elevation.

e. Standardized kokanee spawner counts will be conducted along seven tributary streams and nine shoreline sections. Historic counts will be compared to post-treatment counts.

f. The survival rate of kokanee by age class will be compared to survival rates before lake level changes.

g. The location of kokanee spawning along the entire 120 miles of lake shore will be mapped during this study. Redds and spawning fish will be counted, the depth to the center of the redd will be measured, and the area of redd will be estimated by measuring its length and width.

h. Kokanee eggs will be placed into Vibert-type boxes and buried in the substrate at historic spawning sites and present-day spawning sites at elevations above and below the historic pool level. Approximately, 50 eggs will be placed in each of 30 boxes. Five boxes will be placed above the old pool level (2051') and five will be placed below it. Study areas will include: the north shoreline near East Hope (as a sample of an area being brought back into production), Scenic Bay (as an area that is currently producing kokanee fry), and Idlewild Bay (an area that could quickly be recolonized). The quality of the substrate will be determined at each location. The test will determine the improvement in fry survival that is expected with higher lake levels.

i. All hatchery kokanee stocked into the lake will be marked in order to distinguish between wild and hatchery fish. Newly emerged kokanee fry from the hatchery will have their otoliths "cold branded" by subjecting them to periods of warm and cold water. After the marking, a 10 fish sample of the fry will be examined to verify the marking. Kokanee collected by trawling will have their otoliths removed and a 100 pairs of otoliths from each marked year class of fish will be sectioned and examined for the marks.

j. At the Council's request, we will build a diagrammatic model of the lake showing the various species and arrows which connect species to their food sources. Feedback loops will be included. This is not to be a functioning computer simulation. Rather, it will show the various interconnections between species and indicate what determines their survival.

Product:

1. For each year of the study, a comprehensive table of kokanee abundance by year and by age class will be constructed and significant differences determined. The abundance and survival rates of hatchery produced kokanee will be estimated separately from wild produced fish.
2. Annually, a comprehensive table of the spawner counts, at standardized locations, will be developed. Counts will be analyzed for significant changes attributable to lake level management.
3. Graphs of fry abundance versus lake elevation, and change in lake elevation, will be constructed and presented in the annual report. Tables will be updated throughout the

study.

4. Population estimates and distribution of kokanee will be made annually using split-beam hydroacoustics, compared to the trawl data, and analyzed for significant changes between years. Distribution of age 0 kokanee will be monitored.
5. Maps will be constructed to show the amount of spawning activity along the shorelines of the lake. One map will show the location of redds and the other will show the amount of area of redds in each lake section.
6. Tables of kokanee survival rates, by age class, will be constructed and analyzed for changes.
7. Stock recruitment curves, from each age class to that age class in the next generation, will be constructed and analyzed for changes.
8. Survival of eggs through the incubation period will be calculated and compared to substrate quality and elevation. The amount of potential improvement in egg survival will be determined.
9. A figure will be drawn to show the various interactions and feedback loops between species within the lake.

Objective #2.
Task:

1. We propose to monitor the quality and location of shoreline gravels. Eighty substrate samples (20 at each of four sites) will be collected in known and historical spawning areas and analyzed for quality. Samples will be collected using SCUBA techniques. Gravel sizes and silt content will be compared to previously collected data (Maiolie and Elam, 1993).

Product:

1. Elevation and quality of spawning gravel will be compared to that at previously documented locations. Graphs of substrate quality, by elevation, will be presented in annual reports and discussed as to whether or not the new lake levels have caused erosion or sedimentation of potential spawning areas.

Objective #3. Tasks:

1. Evaluate year class strength of warm water game fish produced under higher winter pool levels in the Pend Oreille River above Albeni Falls Dam.
2. Assess over-winter mortality of warm water game fish in the river during winters of higher and lower pool levels.

Product:

The benefit of higher winter water levels for warm water game fish will be determined. Over winter survival will be assessed and compared to that under winter water levels of 2051'.

Objective #4. Tasks:

1. Develop an energy budget model for zooplankton, <u>Mysis</u> shrimp, kokanee, and predators to define the potential for interspecific competition and the role of predation. We will determine if a significant number of kokanee are lost to predators in the lake. (Kokanee annual survival rates below a mean of 50% over the test years, ages 1 to 4, would also indicate high predation.) Zooplankton availability for both larval and adult kokanee will

be examined separately by sampling in the near-shore and pelagic areas of the lake. Zooplankton netting will be conducted on a weekly schedule during spring and fall, and will be conducted on a monthly basis during the winter to obtain a clear picture of annual food abundance for kokanee.

2. Standardized sampling for Mysis shrimp and zooplankton will be conducted during each year of study. Shrimp will be collected using a Miller sampler equipped with a flow meter, or more standardized gear such as a one meter hoop nets. Eight samples will be collected in each of three sections of the lake (n=24). Samples will be analyzed to estimate shrimp density. Shrimp will be classified as juveniles, immature males and females, and mature males and females (Gregg 1976).
3. Predator abundance will be estimated by using mark and recapture methodology. Fish will be tagged during their spawning runs or by angler caught fish. Angler diaries will be distributed to fishermen and guides to keep track of recaptured fish and predator catch rates. Size related-sampling bias will be examined by comparing the size distribution of recaptured fish with those of the overall marked population. In addition, the food habits of rainbow trout and lake trout will be examined from angler harvested fish to determine the proportion of kokanee in the diet.

   We will electrofish along the shorelines of the lake in suspected kokanee spawning areas at the time of kokanee emergence to assess the significance of squawfish predation. Stomachs of squawfish will be examined to determine the amount of kokanee in their diet.
4. Kokanee survival rates in Lake Pend Oreille will be estimated to determine the maximum level of predation that is occurring. Survival rates will be compared to other lakes where predation is thought to be a problem and to lakes with few predators.
5. All hatchery fry stocked into the lake will be marked by "coding" the otoliths while they are in the hatchery. (This method involves changing the temperature of the water the fry are reared in to form a series of dark rings on the otoliths.) Population estimates of wild and hatchery kokanee will be kept separate. Growth and survival of wild kokanee fry will be compared to the number of hatchery fry in the lake to determine the effects of hatchery fish.

Product:

1. Production and consumption of forage and foragers will be defined.
2. Whether or not adult or larval kokanee are food-limited will be determined.
3. The trend in shrimp densities, from its earliest documented occurrence to the present year, will be graphed and compared to trends in the kokanee population. Trends will be analyzed to determine if it had any effect on the lake level experiment.
4. We will construct a size-frequency distribution of shrimp, by life stage to indicate changes in population structure.
5. Model results will be used to indicate whether or not kokanee are being over-exploited by the predator population in the lake.
6. Kokanee survival rates in Lake Pend Oreille will be compared to other large lake systems to determine predation problems.
7. We will determine whether or not the density of hatchery fry stocked into the lake is correlated to wild fry growth or egg to fry survival.

Objective #5.Tasks:

1. We will conduct a literature review of the life history of Eurasian Milfoil in north

temperate waters. From the literature, the habitat requirements of depth, water transparency, water velocity, water column and sediment nutrients (especially nitrogen and phosphorus), and sediment particle size. These factors are considered to be the major controlling factors of rooted aquatic macrophytes in the lake.

2. The areas of the lake, which meet these habitat requirements, will be determined and mapped. Particular attention will be paid to the Pend Oreille River above the dam (the outlet arm of Lake Pend Oreille), Scenic Bay, Bottle Bay, Ellisport Bay, Pack River Delta, and Camp Bay. GIS mapping will be used to determine and show areas where milfoil will likely become established and where milfoil will likely become a problem.
3. We will conduct searches for milfoil around the lake with emphasis on areas meeting habitat requirements.

If milfoil is discovered, the following tasks will be conducted.

4. The site limnology at each cluster of plants will be sampled; including, milfoil density, physical and chemical conditions of the water column, sediment composition and nutrient content, and associated plant community conditions.
5. Given site descriptions of milfoil, we will design site-specific management recommendations.
6. During years of deeper drawdowns (years 4 and 5), the response of plant communities will be followed.

Product:

Large-scale GIS maps will be prepared showing the location and depths of where milfoil is likely to become established and likely to become a problem. Predictions about the development and recommendations on the control of Eurasian milfoil will be incorporated into long term plans to change lake levels.

g. Facilities and equipment

Currently on the project we have the most expensive pieces of kokanee monitoring equipment such as the 29 ft. diesel trawler, split beam echosounder, and survey boat. We also have a crew that is trained to use these items. We have three vehicles and four computers and are currently renting a field office on the south shore of Lake Pend Oreille.

There is a considerable amount of other equipment within the Department of Fish and Game which is available to our project if it is needed. The Department can, and does, provide volunteer workers, administrative and computer help, manpower, equipment and storage space, bunk facilities at the State fish hatcheries, and expertise on many subjects.

h. Budget

Personnel- The amount here covers the principal investigator, technicians, and bio-aides.
Fringe benefits- These are determined by the state of Idaho and vary from 11 to 36% depending on position.
Supplies, materials, non-expendable property- This category covers the normal material expenses of operating a project of this size.
Operations & maintenance- covers expenses associated with operating two boats, three trucks, two boat slips and an office.
Capital acquisitions or improvements (e.g. land, buildings, major equip.)- Capital outlay items include replacing worn-out equipment and purchases of new sampling gear and electronics.

NEPA costs- none.
Construction-related support- none.
PIT tags- none.
Travel- travel costs were calculated at the State's current rate of $20/day.
Indirect costs - set by the state of Idaho, currently at 22.5%
Subcontractor- amount here covers three projects with the University of Idaho. One project will put together a bioenergetics model which incorporates kokanee-shrimp-rainbow interactions. Another project will research Eurasian Watermilfoil and develop management strategies to prevent it from becoming a problem. The third graduate study will document the changes in warm-water fish populations in the Pend Oreille River.
Other - none

Section 9. Key personnel

The principal investigator on the project is Dr. Melo A. Maiolie, Principal Fishery Research Biologist. He has been working for the Department of Fish and Game for 13 years, with 8 of those years in fisheries research. He received a B.S., M.S. and Ph.D. in Fisheries and Wildlife Management from West Virginia State University (1973), and Colorado State University (1977,1985). Dr. Maiolie works half time on this project and half time on the Dworshak Impacts Assessment Project. He has been working on reservoir projects, and projects involving the federal hydropower system for over 16 years. His Ph.D. work was on the impacts of a pumped-storage power plant on the fish community of a high mountain lake in Colorado.

Bill Harryman, Sr. Fisheries Technician, works 6 months per year on this project. Bill has been with the Department of Fish and Game for 15 years. His areas of expertise include: conducting hydroacoustic population estimates, trawling, and conducting egg incubation studies. Bill is certified scuba diver and experienced field technician.

Bill Ament, Sr. Fisheries Technician, works 6 months per year on this project. He has been with the Department of Fish and Game for 3 years. Bill worked for 2 years on both the rainbow trout and burbot portion of the Kootenai River research project. Prior to this, he worked for 1 year on Lake Pend Oreille doing kokanee population monitoring. He received a B.S. in Wildlife and Fisheries from the University of Idaho in 1977. His particular expertise on this project include: mid-water trawling, shoreline gravel sampling, scuba diving for egg incubation studies, and ageing kokanee by otoliths and scales.

Section 10. Information/technology transfer

The findings of this project will be distributed several ways. First, quarterly reports on our findings are mailed to interested parties and placed on the Department's internet home page for immediate access. Next, annual reports are written and are available from the BPA library. We also present the findings of our project at review meetings held by BPA, when they occur. Presentations on our research work are also given at meetings of the Idaho Chapter of the American Fisheries Society about every other year. Recommendations from our project are discussed directly with the Regional Fishery Managers in the State to determine whether regulation changes or changes in management direction are needed. Lastly, we present an update of our work annually at the International Kokanee Workshop. Every fourth year, we host the

International Kokanee Workshop and showcase our projects. At the completion of the project one or more journal articles will be written.

Congratulations!