Report of the Independent Scientific Advisory Board Regarding a Research Proposal for Inclusion in the Columbia River Basin Fish and Wildlife Program

Proposal Reviewed: **Lake Pend Oreille Fishery Recovery Project**

Independent Scientific Advisory Board
Northwest Power Planning Council
National Marine Fisheries Service
851 SW 6th Avenue, Suite 1100
Portland, OR 97204

Richard N. Williams, Chair
Peter A. Bisson
Charles C. Coutant
Daniel Goodman
James A. Lichatowich
William J. Liss
Lyman McDonald
Phillip R. Mundy
Brian E. Riddell
Jack A. Stanford
Richard R. Whitney, Co-Chair

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Background

Lake Pend Oreille is Idaho's largest (86,000 ac) and deepest (1,200 ft) natural lake and is economically important for the tourism and sport fisheries it supports. The lake was formed after recession of continental glaciers but the Pend Oreille River was dammed in 1952 at Albeni Falls, 25 mi downstream from the natural lake outlet, resulting in a reservoir that extends upstream to Lake Pend Oreille. The dam allows the lake level to be regulated for power production and flood control. The major inflowing tributary to the lake, Clark Fork River, was dammed at Cabinet Gorge, also in 1952.

Fishery resources in Lake Pend Oreille are estimated to be potentially worth millions of dollars (Maiolie and Bennett 1996). Native salmonids in the lake include westslope cutthroat trout and bull trout. In 1942, the Gerrard strain of rainbow trout was introduced and world record-class rainbow trout were caught in the '40s, '50s, and '60s. Lake trout have become established in Pend Oreille, and another non-native species, kokanee, entered the lake in the 1930s by migrating downstream from Flathead Lake. After invading Pend Oreille, the newly established kokanee prospered. By the early 1950s, sport fishing pressure on kokanee exceeded 100,000 angler days per year and there was a commercial kokanee fishery, resulting in a combined sport and commercial harvest often in excess of 1,000,000 fish. Kokanee also served as an important forage species for the lake's large predator populations.

Beginning about 1964, the Pend Oreille kokanee population began a steady decline (Maiolie and Elam 1993). By 1976, annual harvest had dropped from one million to approximately 200,000 fish. The population has remained at depressed levels since that time, although interannual variation in harvest is high. Over the last decade, harvest levels have ranged between 82,000 in 1985 and 227,000 in 1991.

Idaho Department of Fish and Game (IDFG) believes that regulation of winter lake levels by the operation of Albeni Falls Dam has been the primary factor contributing to the decline of kokanee (Maiolie 1993). Prior to dam construction the lake was low in winter and spring (average elevation ~ 2,048 ft), rising to ~ 2,063 ft in late spring and early summer with snowmelt runoff, and then falling back rapidly to low levels in July. After the dam was built the lake was maintained at high, stable levels (~2,062 ft) throughout the summer and then drawn down to ~ 2,056 ft in winter from 1952 to 1965. Beginning in late 1966, Pend Oreille was drawn down to a lower level of 2,051 ft throughout the winter.

IDFG notes that the winter drawdown to 2,051 ft corresponded with the onset of the kokanee decline. They believe the cause of the kokanee population reduction has been reduced reproductive success caused by loss of spawning gravel along the lake shoreline (Maiolie and Bennett 1996). According to this hypothesis, kokanee spawning was highly successful when winter lake levels were maintained at ~ 2,056 ft, which resulted in ample amounts of clean, wave-washed gravel being available at key spawning locations. However, when winter drawdown lowered the lake to 2,051 ft, IDFG believes many of the preferred spawning areas became unavailable and kokanee were forced to spawn in gravels of inferior quality, i.e., gravels that contained more fine sediment. They found that year class strength was greater than average in 1968, 1982, 1983, and 1985 – years when the winter pool was held at higher than average levels. Overall, the relationship between winter drawdown and kokanee harvest five years later has been significantly negative ($r = -0.71$, $P < 0.005$). IDFG is concerned that the kokanee population in Lake Pend Oreille is at considerable risk. They believe it is possible that the stock may be driven so low that a "predator trap" might develop, in which the kokanee population level becomes limited by predation on fry to the extent that it cannot be rebuilt.

Assignment

A series of multi-agency and interest group meetings in early 1994 led to the proposal of a work plan submitted to the NPPC, and amended in August 1996, to conduct an adaptive management study in which winter lake levels would be experimentally held higher (2, 055-2,056 ft) for three years starting in late 1996, followed by at least two years of deeper drawdowns. The work plan called for a joint study by IDFG and the University of Idaho (U of I) of various aspects of the Lake Pend Oreille ecosystem, most of which were related directly to kokanee population recovery (Maiolie and Bennett 1996). Efficacy and cost-effectiveness of the study plan has been questioned by several organizations. The Corps of Engineers and the utilities believe that the experiment would result in an annual power revenue losses averaging $10 million. The tribes have expressed concerns over the potential impacts of the altered water storage regime on anadromous salmonids downstream from Albeni Falls Dam. Different groups have offered different explanations for the kokanee decline, claiming that the IDFG/U of I drawdown proposal rests on several key assumptions that have not been rigorously examined. In contrast, the Sand Point Chamber of Commerce, which strongly supports the proposal, has completed an economic evaluation of the consequences of maintaining a higher winter pool and has concluded that the higher level would yield a net economic benefit to Bonner County of about $30 million, most of which comes from increased shoreline property values that would spur additional real estate development around the lake (Appendix A, Maiolie and Bennett 1996).

Through a series of queries, the Council was asked to review the study proposal and has referred the issue to the ISAB. The Corps of Engineers decided to proceed with the 2,055-2,056 ft winter drawdown experiment in 1996-97. Although the project has begun, ISAB has been requested to complete it's review of the study plan (Appendix 1) for scientific merit.

Summary of ISAB Findings and Conclusions

Will the study design demonstrate a cause-effect relationship between manipulated winter lake levels and recovery of the kokanee population?

The ISAB believes that the current study plan is not likely to answer this question with reasonable certainty.

There are several reasons for this conclusion. First, a number of potentially confounding factors exist that could mask the effects of winter lake level manipulation, including predation and competition (from/with other naturally spawning and hatchery produced salmonids, and opossum shrimp *Mysis relicta*). These other factors are not adequately evaluated by the current study design. Second, there is insufficient information in the proposal to demonstrate (1) that shoreline spawning gravels in Pend Oreille are being negatively impacted by fine sediment specifically related to a lack of wave-washed substrate caused by deep winter drawdown, (2) that the cause of sedimentation, if it occurs, is fully understood, and (3) that the location and utilization of shoreline spawning areas by kokanee in Pend Oreille are well known. Finally, there are some tasks (e.g., determining risk of Eurasian watermilfoil invasion; effects of higher winter lake levels on warm water fishes) that are only weakly linked to the central issue and are unlikely to contribute to the resolution of the question concerning effects of the winter drawdown regime on Pend Oreille kokanee recovery.

Specific Comments on the Proposal

1. Alternative hypotheses

Before reviewing the specifics of the IDFG/U of I monitoring proposal, we summarize other factors that could have influenced the kokanee decline. These factors should be included in the monitoring program. The IDFG/U of I plan includes a helpful discussion of various hypotheses that could explain recent changes in the kokanee population. These are noted below, including conclusions put forward by IDFG to support the belief that kokanee recovery is limited by winter lake levels.

1. Cabinet Gorge and Albeni Falls Dam Operations

Completion of Cabinet Gorge Dam on the Clark Fork River in 1952 completely blocked upstream migration of adult kokanee. Large numbers of kokanee were known to have entered the Clark Fork prior to dam construction but the percentage of the total lake population is not known. IDFG believes that the relatively high levels of kokanee in Pend Oreille over the next three generations (15 years) argue against this blockage having a major impact on overall abundance in the lake.

Some kokanee are known to have been entrained at Albeni Falls Dam. However, sampling upstream from the dam in Box Canyon Reservoir, essentially a large arm of Lake Pend Oreille, has indicated that few kokanee use this area, leading IDFG to conclude that entrainment losses are not a significant factor.

2. Water Quality

According to IDFG there have been no major changes in water quality in the lake since limnological studies were carried out in the early 1950s (specific studies were not cited in the study plan). Lake Pend Oreille remains cold with summer surface temperatures averaging 9^oC from May-October. No substantial changes in Secchi-depth, pH, alkalinity, dissolved oxygen, nutrients, or chlorophyll a have been recorded. IDFG sees no evidence that water quality could have caused the population decline.

3. Hatchery Production

Of the information made available to the ISAB, there was no summary of total hatchery kokanee production in the lake system prior to or after completion of Albeni Falls Dam. IDFG suggests that the increased harvest of kokanee (227,000) in 1991 was related to the 13 million hatchery fry produced in 1988. Large numbers of kokanee fry are currently released by hatcheries in the Pend Oreille drainage, but current production levels ("5-6 million") are below those of the late 1980s. IDFG does not apparently believe that hatchery kokanee could be a factor in the decline of wild populations, but no data on the overall percentage of hatchery fish in the lake's population are given.

4. Fishing

IDFG contends that the harvest rate of about 1,000,000 kokanee during the 1950s and early 1960s represented a sustainable exploitation rate and that fewer than 50% of the available fish were taken by sport and commercial fishers. Comprehensive population estimates were not conducted during this time, however, so the actual harvest rate remains somewhat speculative. The commercial fishery ended in 1973 and sport fishing pressure has apparently declined over the years. The current sport harvest rate is believed by IDFG to range from 10-30% (the 227,000 fish caught in 1991 represented an estimated 28% of the adult population). IDFG suggests that Lake Pend Oreille is capable of supporting an annual harvest of 750,000 kokanee with improved spawning conditions.

5. Loss of Tributary Spawning Habitat

Kokanee are known to spawn in a number of the lake's tributaries and IDFG conducts one-time spawning counts during the peak of the run (early December) in 13 tributary streams. Current estimates of tributary spawners range from 0.7-5.9% of the total population. An additional tributary – Sullivan Springs Creek – supports 11-17% of the total population. This stream has undergone considerable habitat rehabilitation, but it is also stocked with 3.5 million fry each year so it is impossible to partition the effects of habitat improvement from the effects of fry plants. Considering that most Pend Oreille kokanee are believed to be shoreline spawners, IDFG concludes that stream habitat losses have been responsible for the long-term decline. Likewise, they do not believe that additional spawning channels will significantly increase the population.

6. Primary and Secondary Production

According to the IDFG/U of I proposal, a recent US Geological Survey study (Woods 1991) found no significant changes in open water primary and secondary production, leading to the conclusion that the lake's productivity had not diminished. However, it is not clear what changes have occurred in near shore areas where kokanee fry emerge. IDFG zooplankton sampling in 1992 indicated that one of the lake's bays had more large zooplankton than open water areas.

7. Predation

No quantitative data were provided to the ISAB to document the significance of predation. IDFG believes that predation has not been an important factor because declines of predators (rainbow trout, lake trout, and bull trout) occurred concurrently with kokanee declines. Fishing restrictions on rainbow and lake trout have resulted in increases in these species' populations in recent years, but IDFG claims that older year-class kokanee survival has been good "indicating that predation is not a problem in Lake Pend Oreille".

8. Mysis relicta

Opossum shrimp were first observed in Lake Pend Oreille in 1966, about the same time the kokanee population began its decline and winter lake levels were drawn down to 2,051 ft. By 1972, shrimp densities were estimated at 0.1 mysids/m^2. Soon afterward, densities increased sharply, reaching 1.2 mysids/m^2 in 1974 and 35 mysids/m^2 in 1976-77. Currently, shrimp densities range from 5-60 mysids/m^2. Both opossum shrimp and kokanee prey on zooplankton, and competition from mysids has been known to have a negative impact on kokanee in a number of western lakes (Rieman and Falter 1981; Spencer et al. 1991). IDFW acknowledges that mysids "appear to have changed the abundance of some types of larger zooplankton in the lake, although total zooplankton abundance has not been found to change".

IDFW believes that *Mysis relicta* has not been the principal cause of kokanee declines in Pend Oreille. They base this conclusion on two observations. First, shrimp populations apparently remained low for about nine years after *Mysis* was introduced, during which time kokanee were undergoing the most significant population reduction. By the time *Mysis* began to undergo a rapid increase, kokanee were already significantly depressed. Second, comparison of kokanee fry survival in Pend Oreille (with *Mysis*) with Lake Coeur d'Alene (without *Mysis*) revealed that fry survival rates in the two lakes were quite similar, and net pen experiments with fry in Pend Oreille did not show that fry were starving and "failed to show that food was limiting".

Although they believe that spawning gravel availability is the major limiting factor for Pend Oreille kokanee, IDFG admits that *Mysis* could have contributed to the decline. They state "The most definitive test for the effect of shrimp is the lake level experiment. By changing this one factor and monitoring the effect on fish stocks, we will be able to determine which factor (shrimp or lake level) is currently limiting production."

2. Critique of the work plan assumptions

The hypothesis that kokanee in Lake Pend Oreille are limited by spawning gravel and that raising the winter lake level from 2,051 ft to 2,055-2,056 ft will significantly increase the population rests on several assumptions. We examine each of these assumptions below.

1. *Lowering the lake level from high summer levels by 10 ft or more abruptly in late fall results in clean, wave-washed gravel being unavailable, with kokanee being forced to spawn in fewer areas with clean gravel or in lower elevation gravel with a higher fine sediment content.*

The ISAB was not furnished with information on the actual percentage of fine sediment in “clean, wave-washed gravel”. That summer wind storms cause wave action that could cleanse nearshore gravels seems plausible, but specific data that could have helped support the assumption (e.g., fine sediment content of gravels in stormy vs. relatively calm summers) were not provided and apparently not obtained.

The IDGF/U of I work plan does not consider a different physical process that could cause sedimentation of nearshore areas. In nearby Flathead Lake, dam operations have sustained high lake levels throughout summer, as has been the case in Pend Oreille. The high summer level, in combination with wind action, has resulted in extensive shoreline erosion (Lorang et al. 1993a, 1993b; Lorang and Stanford 1993) during which the lakeshore is constantly being reconfigured and local sedimentation rates are influenced by docks. As a result, historical kokanee spawning areas are now heavily sedimented and the entire depositional delta of the Flathead River has eroded into the lake (Stanford and Ward 1992). Even though this mechanism of sedimentation differs from the one postulated by IDFG for Pend Oreille, extensive research on the kokanee population in Flathead lake for 17 years indicates that loss of shoreline spawning sites has *not* been the principal cause of population declines (Spencer et al. 1991).

Likewise, the concentration of fine sediments with decreasing elevation, i.e., increasing lake depth, is not given -- although it is an element of the proposed study. The ISAB has no objective basis at present to judge whether the increase in fine sediment at greater depth, if it occurs, is sufficient to result in significantly reduced spawning success, even after fines are purged from gravels during redd construction.

Quantitative estimates of the area of usable spawning gravel at different lake level elevations are also not given, nor was the ISAB provided with maps showing the locations of major shoreline spawning areas during periods of high and low winter lake levels. Excluding the gravel quality question, it seems likely that the actual amount of lake bed with gravels suitable for kokanee spawning will change as the lake is drawn down due to exposure of gravel shoals and other morphometric changes with increasing depth. It is very difficult to judge whether either gravel quantity (on an areal basis) or clean gravel are actually in short supply relative to the number of adult kokanee that would spawn in shoreline areas. The ISAB notes that prior to Albeni Falls Dam, kokanee apparently spawned very successfully when lake levels were quite low (< 2,050 ft), but the lake had been low since August, nearshore gravels may have been adequately cleansed, and shoreline erosion was probably much less that at present.

Without more quantitative information, the central hypothesis of the work plan that kokanee in Lake Pend Oreille are limited by both the amount and quality of near shore spawning gravels must be considered highly uncertain. The main evidence in support of this hypothesis seems to be a significant positive correlation during the 1980s between winter lake level and the strength of that kokanee brood year in the lake population. IDFG nevertheless acknowledges that estimates of egg survival in Lake Pend Oreille are very similar to estimates of kokanee egg survival in Lake Coeur d'Alene, which has "an over-abundant kokanee population with an abundance of high quality spawning gravel" (average egg survival is 2.41% in Coeur d'Alene, n = 14 yrs, vs. 2.46% in Pend Oreille, n = 7 yrs), leading us to wonder if the apparent decline in cohort survival during winters with lower lake elevation in Pend Oreille (which, according the assumption, has poor spawning gravel quality when the lake is low) is well understood.

2. *Kokanee egg survival is significantly impaired when adults are forced to spawn in areas of Lake Pend Oreille with less than favorable spawning gravels.*

No evidence was given that kokanee actually spawn in heavily silted regions of the shoreline, as opposed to simply moving to areas with relatively clean gravel such as stream mouths or gravel shoals with upwelling groundwater. The comparison of wild kokanee survival rates in Pend Oreille vs. Coeur D'Alene suggests there is not a large difference between egg mortality between these two systems. If in fact Lake Coeur D'Alene does possess an abundance of clean gravel, similarities in egg-to-fry survival suggest that Pend Oreille kokanee may not be limited by fine sediment levels. It would have been especially helpful to have comparative measurements of egg survival in areas where winter drawdown has led to spawning in gravels with different fine sediment concentrations. Studies of sockeye spawning in Lake Illiamna, Alaska, have shown that beach spawning adults may display remarkable site fidelity to the exact locations where they were spawned (Tom Quinn, School of Fisheries, University of Washington), so it does seem possible that kokanee will attempt to use sub-optimal gravels for redd construction. Again, the ISAB was left with the conclusion that this assumption is uncertain.

Further uncertainty is introduced by the observation that the kokanee population has continued to decline in spite of an apparently aggressive effort to supplement the wild population with hatchery fry. If egg and alevin survival regulates cohort strength as IDFG believes, then large releases of hatchery fry in the late 1980s should have had a dramatic effect on the lake population because fry releases would have effectively bypassed the presumed limiting factor -- intragravel survival. The large harvest of kokanee in 1991 compared to other years in the last decade was ascribed in part to the 13 million hatchery fry released in 1988, but IDFG acknowledges that the survival of wild fry in 1988 was also relatively high. The ISAB was not furnished with any data that demonstrated a significant improvement in the Pend Oreille kokanee population in response to hatchery releases, although hatchery production figures were not provided.

3. *Predation does not limit kokanee in Lake Pend Oreille.*

No specific information regarding the food habits of potential predators over the period of kokanee decline was provided. A list of species (salmonid and non-salmonid) that could prey on kokanee fry and sub-adults was not given. IDFG appears to base this assumption chiefly on the observation that an increase in rainbow trout in response to fishing restrictions has not resulted in significant changes in the survival rates of age 1 and older kokanee.

Several non-native warm water species have been established in the reservoir above Albeni Falls Dam. Some of these could potentially prey on young kokanee; however, their presence or abundance in the open waters of Lake Pend Oreille was not reported.

The ISAB regards the assumption that predation does not limit kokanee as speculative. Given that the lake is famous for its populations of large-bodied salmonids, it seems surprising that more is not known about the seasonal food habits of rainbow, cutthroat, lake, and bull trout. We are also surprised that a careful examination of predator food habitats is not included in the proposed study plan. Even if predator populations are currently depressed relative to historical levels, it is possible that they could still influence on kokanee fry distribution and abundance during certain seasons.

4. *Competition does not limit kokanee in Lake Pend Oreille*

As with predation, no data directly indicating the strength of competition, e.g., behavioral interactions with other fishes, diet overlaps with fishes and *Mysis*, are given. We are encouraged that surveys of the abundance of other species and *Mysis* are included in the study plan, but we feel the evidence for the absence of competition as a limiting factor is lacking. Specifically, we would have liked to have seen a comparison of the diet of different age kokanee and *Mysis*. The concurrence of the kokanee decline with the first introduction of *Mysis*, even though this was also the period when deeper drawdowns were initiated, is such a strong coincidence that it should receive careful and thorough investigation. We also wonder if any studies have examined the potential interaction between hatchery and naturally spawned kokanee in the lake to determine if compensatory growth or survival related to hatchery releases might be taking place. Given the magnitude of hatchery kokanee fry releases, this must be considered a possibility. Because these questions are apparently unanswered, the ISAB is reluctant to dismiss the possibility of competition with hatchery produced kokanee as an important limiting factor at this time.

Furthermore, the work plan does not address the possibility of an interactive effect of competition with hatchery fry and predation on naturally spawned kokanee by lake trout, bull trout and rainbow trout. Food web effects are highly complex, but have been shown to be very important in other western lakes. In virtually all oligotrophic lakes where *Mysis* and kokanee co-occur, opossum shrimp drive kokanee populations to very low levels unless lake trout are absent from the system (Spencer et al. 1991). The chief means by which kokanee have been maintained at fishable levels in any of these lakes is by extensive hatchery augmentation; in lakes where hatchery augmentation has been less than 1,000,000 fry annually (e.g., Flathead Lake), kokanee have essentially disappeared. Time series data and models (J. Stanford and C. Levitan at University of Montana Flathead Lake Biological Station, D. Beauchamp at Utah State University, and C. Walters at University of British Columbia) suggest that mysids mediate competitive exclusion which exacerbates predation on kokanee by lake trout during the non-stratified period of lake mixing when shrimp, kokanee, and lake trout are not thermally segregated. In large lakes such as Pend Oreille, this occurs most of the year except late summer. During late summer stratification, *Daphnia* increase substantially in the epilimnetic thermal refuge and stocked kokanee tend to prosper. Apparently, mysids do not penetrate the thermocline and enter the epilimnion. When turnover occurs and mysids have access to *Daphnia*, the large zooplankton population declines, probably leading to competitive exclusion of kokanee from their preferred food resource (Stanford and Ward 1992). The main point, however, is that trophic effects are highly complex and involve both top-down (predation) and bottom-up (food availability) influences on kokanee that are not addressed in sufficient detail in the work plan to provide a clear understanding of population regulation in Lake Pend Oreille.

5. *Kokanee population abundance is related directly and quantitatively to harvest*

Although it seems intuitive that population abundance and harvest by fishers should be strongly correlated, no independent verification was provided to the ISAB. We wonder if declining catch per unit effort has occurred, and if so, how this has affected fishing pressure and overall catches. Since no confidence intervals around the catch statistics were provided, we had no way of assessing their relative precision.

Suggestions for the study design

The ISAB recognizes the difficulty of sampling large lake systems and believes the research would be improved with a clear description of how the adaptive nature of the study design has been laid out. We also believe that greater emphasis should be given to experiments and monitoring efforts that identify relationships between kokanee and *all* potentially important limiting factors, and that provide the information to enable prediction, within reasonable limits, of the effect of changing winter lake levels on spawning success. Specifically, we recommend that the study plan include:

- *A clear rationale for the proposed experimental drawdown*.

The current proposal is for three years of shallow winter drawdowns followed by two years of deep drawdowns. We are concerned that the duration of this experiment may not yield clear, unambiguous results given the other factors (e.g., weather, fishing pressure, hatchery practices, competition and predation) that are changing simultaneously and a kokanee population whose interannual variability is relatively high. The ISAB was not furnished with information that gave us confidence that the effects of the lake level manipulation could be detected in the kokanee population within a 5-year period. The study plan should justify why this period was selected, or select a period long enough to yield a satisfactory probability of success.

- *A quantitative investigation of the relationship of spawning location to egg survival*.

The ISAB strongly recommends that major shoreline spawning areas for kokanee in Lake Pend Oreille be mapped, if they have not been mapped already. Quantitative measurements of egg to fry survival should be undertaken in areas with both clean and sediment-rich gravel. Gravel quality measurements should include estimates of the % fines (< 1 mm) as near the egg pocket of redds as possible, as well as determinations of intragravel dissolved oxygen. One way to examine survival would be to estimate egg deposition at individual redds and trap emergent fry. An alternative method might involve placing Vibert-type egg boxes in different substrates at known spawning areas and measuring survival (approach suggested by Chris Wood, Pacific Biological Station, Nanaimo, B.C.).

The study should also include a determination of the importance of shoreline erosion caused by high summer lake levels.

- *An estimation of how much additional gravel would become available with increased winter lake levels, and how many additional fry such an increase might be able to contribute to the population if the increased areas were fully utilized by adult kokanee*.

This suggestion actually has two parts. First, the investigators could determine the area currently available under low drawdown (2,051 ft) as well as the area actually used by kokanee adults for spawning. This in itself would help to answer the question of whether spawning gravel quantity is limiting if it turned out that the area of good quality spawning gravel was well below the area needed by the existing population. Second, using bathymetric maps of the lake basin as well as locations of known groundwater seeps and tributary mouths, additional spawning area made available by increasing the winter lake elevation to 2,055-2,056 ft could be modeled. If the naturally spawning population were known, it might be possible to estimate how many additional fry could be produced in the additional area, and, given current survivorship assumptions, extend the model a few generations to estimate how long it would take for the population to rebuild.

- *A determination of the percentage of hatchery-produced kokanee in the population*.

Without knowing the hatchery contribution to the total population it will be difficult to interpret trends in population size. Methods exist (e.g., scale analysis) for identifying fish of hatchery origin. Additionally, it may be possible to cold-brand otoliths of all early hatchery fry (short-term exposure to cold temperatures) to make identification of hatchery fish highly accurate. It should not be hard to obtain otolith samples from sport-caught fish; however, this would be based on the assumption that hatchery and naturally-spawned kokanee were equally vulnerable to angling.

- *An expansion of the bioenergetics samples from summer to year-round*.

Limiting the zooplankton sampling to summer months ignores a potentially important time of the year – winter and early spring. Since the first fry will be emerging in early spring and age 1 and older kokanee are present year-round, it makes sense to find out what is happening to food resources during all seasons. This is particularly important if a bioenergetics model will be constructed. If a bioenergetics model is attempted, it should explicitly include the effects of interspecific interactions, e.g., D. Beauchamp's energetics model of kokanee in food webs.

- *A detailed description of predator abundance estimation procedures*.

The ISAB believes the study plan should contain a more detailed description of predator sampling methods. The following questions should be addressed: How will fish be captured for marking, and will there be size-related bias in capture techniques? Which species will be marked? How will marking-related mortality be estimated? How will fish be recaptured? How many fish will be marked, and will this be enough to yield sufficient recaptures? Where will anglers return tags from recaptured fish and who will manage the records? Given the experience of other investigators in large lake systems, where it has been difficult to complete successful mark-recapture studies, these questions are not trivial.

- *Study of the food habits of hatchery kokanee, Mysis, and other abundant organisms that might interact with naturally spawned kokanee as predators or competitors*.

There is no substitute for direct knowledge of what these organisms are eating (during all seasons, if possible). It is possible that changing the winter lake level might affect the outcome of competitive or predator-prey interactions, perhaps by influencing near-shore food availability or cover. Without knowing more about the lake's food web, inferences regarding the importance of competition and predation will be very uncertain.

- *An explicit estimate of sample sizes needed to answer key questions*.

Appendix D in the work plan does provide quantitative estimates of how many additional kokanee of different age classes would need to be produced in order to show that elevated winter lake levels were successful and we are grateful this information was included. What is now needed are determinations of sample sizes required to be able to estimate these population levels, and what confidence levels will be considered acceptable. The ISAB is concerned that insufficient information was provided to assure that sufficient numbers of samples will be taken to have a reasonable chance of detecting true treatment differences (changes in lake level). The same concern applies to many other aspects of the study in which organism abundance or reproductive performance was to be evaluated. Because the budget for this study is significant, it is important that the questions being asked can be answered with the proposed sampling regimes. This is even more important when the economic implications of the study are considered.

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Appendix 1

Proposed Study Plan and Budget

The IDFG/U of I study plan includes five objectives, each with one or more separate study elements. Each objective is summarized below. The study elements do not strictly correspond to the elements in the work plan, but represent the ISAB's attempt to combine tasks with similar orientation.

Objective 1. Determine if increased gravel at higher winter lake levels results in improved kokanee production.

Tasks:

a. Estimate numerical abundance of each kokanee year class

b. Hydroacoustic surveys of kokanee distribution

c. Relate historical data sets (winter lake level) to age class strength

d. Conduct "standardized" spawning counts

Products:

a. Comprehensive table of kokanee abundance by year class

b. Comprehensive table of spawning counts

c. Graphs of fry abundance vs. lake elevation and change in elevation

d. Age class mortality tables

e. Stock-recruitment curves for each age class

Objective 2. Determine if lake level changes cause only a short-term increase in spawning habitat, but affect the long-term stability of shoreline gravels at higher elevations.

Task:

a. Monitor quality and location of shoreline gravels

Product:

a. Elevation and quality of spawning gravels will be compared to historical data at same locations. Graphs of substrate quality, by elevation, will be presented to determine whether new lake levels have changed patterns of erosion or deposition

Objective 3. Determine effects of higher winter lake levels on warm water fishes upstream from Albeni Falls Dam (this objective does not appear to be directly related to the kokanee issue, but rather to the question of what will happen to warm water fisheries in response to higher winter pools).

Tasks:

a. Determine year class strength of warm water game fishes at higher winter levels

b. Assess overwinter mortality (this survey would be carried out only once after the third year of higher winter drawdown)

Product:

a. Analysis of the benefit to non-native warm water fishes of raising winter lake elevation from 2,051 ft to 2,055-2,056 ft.

Objective 4. Determine whether other factors could be limiting kokanee, specifically, zooplankton availability, predation by fishes, or *Mysis* abundance.

Tasks:

a. Develop an energy budget model for zooplankton, *Mysis*, kokanee, and predators to define potential for interspecific competition and the role of predation

- Mysis and zooplankton sampled with trawls and paired hoop nets
- Predator abundance to be estimated by mark-recapture: "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"

b. Kokanee survival will be compared to other lakes where predation is thought to be a problem and to lakes with few predators

Products:

a. Production and consumption of predators and prey will be estimated

b. Determination of whether or not kokanee are food limited

c. *Mysis* trends analyzed and compared to trends in the kokanee population

d. Size frequency distribution of *Mysis* by life stage

e. Model that will allow determination of whether kokanee are being overexploited by predators

f. Comparison of kokanee survival rates in Pend Oreille with other large lake systems

Objective 5. (1) Determine the likelihood of Eurasian watermilfoil invasion with higher winter pool levels, (2) Identify areas of the lake most likely to develop milfoil populations and project likely plant densities, and (3) Develop a site-specific management plan to minimize problems in the event milfoil does become established (this is another objective that does not address the kokanee issue directly, but was included in response to a concern that Eurasian watermilfoil might enter Lake Pend Oreille if winter lake levels were raised to 2,055-2,056 ft).

Tasks:

a. Conduct literature review of habitat requirements of Eurasian watermilfoil
b. Using GIS, map areas of Lake Pend Oreille where these habitat requirements exist
c. Conduct surveys to determine if milfoil becomes established; if so:
d. Determine specific limnological conditions at each plant cluster
e. Design site-specific management recommendations
f. Follow progress of milfoil clusters during years of deeper drawdown (years 4 & 5)

Product:

a. GIS maps showing the location and depth where milfoil is likely to become established

Budget

The following summary is for the first year of the project. Detailed budgets for subsequent years were not provided.

Item	**Amount**
Personnel	
Idaho Dept. Fish & Game	$76,604
University of Idaho	$75,431
Operating Expenses	
Idaho Dept. Fish & Game	$24,725
University of Idaho	$31,985
Overhead Costs	
Idaho Dept. Fish & Game	$24,927
University of Idaho	$26,424
Capital Equipment	
Idaho Dept. Fish & Game	$55,384
University of Idaho	0
Project Total	**$315,480**

The projected budgets for all years of the study are as follows:

Year	**Amount**
1st Year	$315,000
2nd Year	$345,000
3rd Year	$330,000
4th Year	$280,000
5th Year	$280,000
Total	**$1,550,000**

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