Alternative Mitigation Actions to Offset Survival Impacts of Reduced Summer Spill Operations

January 2004

The following information was developed in conjunction with the Offset Team established through the CBFWA-led Spill Subcommittee. This document is a compilation of the information developed through the Offset Team's efforts. It contains descriptions of potential alternative mitigation actions, or offsets, as well as estimated survival or productivity benefits, costs and implementation requirements. Offset actions contained in this document include the following:

- Northern Pikeminnow Management Program Heavy-Up (Offset Action 1)
- Smallmouth Bass Control (Offset Action 2)
- Commercial Harvest Reduction (Offset Action 3)
- Avian Predation Research (Offset Action 4)
- Pile Dike Removal (Offset Action 5)
- Anti-Stranding Flow Fluctuation Limits in the Hanford Reach (Offset Action 6)

In addition, the Offset Team developed a set of principles or criteria for consideration by policymakers as they contemplate alternatives to the current summer spill operation. These principles are located in the Appendix to this document.

Offset Action 1 – Northern Pikeminnow Management Program Heavy-Up

Description of Proposed Action

One of the primary non-operational actions to improve in-river survival of fall chinook is the management of predatory fishes. The Northern Pikeminnow Management Program (NPMP) is a multi-year effort to reduce pisciverous predation on juvenile salmon through public angler-driven system-wide removals of predator-sized northern pikeminnow.

Bonneville Power Administration (BPA) funds the NPMP. Since program inception, over 2 million northern pikeminnow have been removed throughout the system with an estimated benefit of reducing predation mortality by 25 percent (Friesen and Ward). This equates to over 4 million juvenile fish not eaten by pikeminnow each year. This has been achieved through annual harvest of northern pikeminnow since 1990. Currently, multi-year annual average harvest is approximately 12 percent, with annual harvest ranging between approximately 8 percent and 14 percent (14 percent harvest was achieved in 2001 as a result of the "heavy-up" that was implemented during the drought/power emergency). While the benefit of annual removals accrue over time, removals within a year can also have significant immediate benefits to fish survival within the same year.

More aggressive and focused removals could provide substantial survival benefit to reduce the impact of the conditions that inriver outmigrants face in 2004 and beyond. The NPMP is now a turnkey operation with demonstrated success in adaptively managing to changed conditions and responding to special circumstances.

a. Location

The NPMP is a system-wide predator control program in the Columbia Basin. Open waters include the mainstem lower Columbia River up to Priest Rapids Dam in Washington and the Snake River up to Hells Canyon Dam in Idaho. Also open within this reach are backwaters, sloughs, and up to 400 feet into tributaries on the Columbia and Snake rivers.

b. Affected Species

Juvenile salmonids are the major dietary component of northern pikeminnow grater than 250mm fork length. The importance of salmonids in the diet of northern pikeminnow varies seasonally. Research conducted between 1982 and 1988 in John Day Reservoir indicates that juvenile salmonids were of greatest importance in the diet during July (82 percent) when the run of subyearling chinook salmon peaked. (Poe 82-3).

c. Statement of Feasibility and Certainty of Implementation

Increasing removals due to a program heavy-up is feasible utilizing current program infrastructure. The most effective and logistically feasible approach to increase the fishery performance would be to increase the basic reward structure using the 2001 increase in the NPMP reward structure as a model.

d. Coordination Needs and Additional Requirements

Coordination of activities associated with a NPMP heavy-up would occur utilizing existing program coordination and review processes. The NPMP has a separate Biological Opinion and NEPA documentation to cover program activities. A program heavy-up is not inconsistent with the existing BiOp for NPMP.

Estimated Survival or Productivity Increase

Using the 2001 Power Emergency NPMP heavy-up as a model for 2004 and beyond, the objective for the heavy-up is that a modified reward structure for the 2004 season could reasonably increase catch by 20,000 to 40,000 fish. An increase in the annual harvest of northern pikeminnow within this range (approximately a 1 percent to 2 percent increase in average annual exploitation) would result in an additional savings of approximately 1,400,000 to 2,800,000 smolts across the lifespan of the northern pikeminnow caught. Sustaining this increased catch would, over time, result in a similar annual savings in smolts at equilibrium (in approximately 8 to10 years). To the extent that most of such improvements in survival would be achieved in the lower Columbia River where northern pikeminnow abundance and predation losses are highest, the survival benefit would be similar to all stocks (proportional to their abundance).

Additional benefits to juvenile salmonids migrating during the 2004 season are calculated by taking the anticipated additional catch resulting from program heavy-up incentives in 2004 and dividing it by the average percentage catch contribution by statistical week and multiplying by the average smolt consumption rate for the remaining duration of the open season. Based upon the objective of increasing catch by between 20,000 to 40,000 northern pikeminnow, a within-year benefit of between 200,000 to 400,000 smolts not consumed by pikeminnow would be realized. (Beamesderfer et al)

Estimated Cost, Duration, and Proposed Funding Source

The heavy-up approach is two-pronged. The approach will provide substantial incentive while simultaneously minimizing potential abuse of the program. The most effective and logistically feasible approach to increase the fishery performance is to increase the basic reward structure. An additional reward of $500 per tagged northern pikeminnow caught provides substantial incentive to successful anglers and to minimize potential fraud on the program. In addition, modification across all three tiers provides nominal but certain reward for successful anglers. Increasing tier 2 from $5 to $6 per fish, and tier 3 from $6 to $9 per fish, would substantially increase the monetary incentive to those who have already demonstrated their ability to contribute substantially to the program's catch. Increasing tier 1 from $4 to $5 per fish would provide additional incentive for less effective anglers to continue to participate and increase fishing effort in order to graduate to the next tier. Also, past productive anglers who are not currently fishing in the program may choose to return. Finally, increasing the reward will result in modest additional recruitment of new anglers into the program if the treatment is coupled with minimal advertising.

Total cost would be dependent on its effectiveness, but likely on the order of between $500,000 and $1,000,000.

Additional opportunity exists for stock-specific survival benefit through initiation of a removal fishery in the lower reaches of the Yakima River. Available data suggest significant losses of juvenile outmigrants to northern pikeminnow in the Yakima River.

Process for Implementation and Schedule

Logistics associated with modifying the current NPMP to accommodate a program incentive increase would occur during pre-season program and contract discussions. The contract for the 2004 performance period is up for renewal at the end of March 2004. The new agreement for the performance period of the contract would be modified to reflect changes to the NPMP for purposes of an offset to summer spill. The field season for the NPMP Sport-Reward season typically starts in early May and runs through the majority of September in a given year.

Lead Entity

The Bonneville Power Administration funds the NPMP. The Pacific States Marine Fisheries Commission and the Washington Department of Fish and Wildife together have the responsibility for administration and record keeping for the Sport-Reward fishery. The Oregon Department of Fish and Wildlife has responsibility for biological evaluation of program accomplishments in terms of the annual exploitation rate on Northern pikeminnow and impacts on juvenile salmonid predation by northern pikeminnow and other resident fishes.

Friesen, T.A., and D.L. Ward. "Management of Northern Pikeminnow and Implications for Juvenile Salmonid Survival in the Lower Columbia and Snake Rivers." *North American Journal of Fisheries Management*, 19:406-420.1999.

Poe, T. "System-Wide Significance of Predation of Juvenile Salmonids in Columbia and Snake River Reservoirs," BPA project. 1982-003-00.

Beamesderfer, R, D. Ward, and A. Nigro. *Evaluation of the Biological Basis for a Predator Control Program on Northern Squawfish (Ptychocheilus oregonensis) in the Columbia and Snake Rivers*, Volume 53, Number 12, 2898-2908.1996.

Offset Action 2: Smallmouth Bass Control

Description of Proposed Action

a. Location

Lower Columbia R. reservoirs, especially hot-spots near The Dalles Dam; Lower Granite Reservoir.

b. Affected Species

Primarily summer-migrating fall chinook (ChF), but also spring-migrating juveniles of other ESUs. Implementation in Columbia River reservoirs would benefit all listed and unlisted (e.g., Hanford Reach brights) ESUs originating from upstream areas, particularly areas downstream of collection/transport points. Action in Lower Granite Reservoir would benefit Snake River ChF and other Snake River ESUs, all listed (with the exception of hatchery and reintroduced stocks).

c. Statement of Feasibility and Certainty of Implementation

Depends on control method (table below). Control by removal is very feasible with sanction by fishery managers (particularly the states of Oregon and Washington). Retention of smallmouth bass (SMB) incidentally caught by Oregon Department of Fish & Wildlife (ODFW) during northern pikeminnow electrofishing is most feasible. Additional removal probably would be implemented by contracts to state fish and wildlife agencies (perhaps through the Northern Pikeminnow Management Program). Control by manipulating reservoir level probably is most feasible for Lower Granite Reservoir and probably not feasible for the Lower Columbia R. Manipulation of reservoir levels would probably require considerable public input/process.

d. Coordination Needs and Additional Requirements

State fishery agencies, interested public. Control by removal probably would not require additional NEPA; reservoir manipulation probably would.

Estimated Productivity Increase (juveniles saved) and Costs

Each large (e.g., >200mm) SMB may consume one juvenile salmon per day in some seasons and areas, although precise estimates of predator abundance and impacts on salmon populations are lacking. The following table contains estimates of juvenile increases, adult equivalents (AEQ), and costs by location and by control method for actions in 2004. The biological evaluation surveys/tagging by ODFW under the Northern Pikeminnow Management Program (Agency electrofishing) will occur in 2004, which could retain its catch and perhaps increase its effort in the target locations. Juvenile and AEQ increases are estimated for 2004 only (i.e., no benefits are assumed from fewer predators in subsequent years), and accrue to the mix of stocks migrating through the target locations.

Location Control method		Juv. Saved 1st year	AEQ (basis: 0.5%-4.0% SAR)	Cost
Lower Columbia reservoirs				
Agency electrofishing:	*Retain survey catch*	9,000	45-360	0
	Add 5 days in spring @ hot-spots	5,000	25-200	$12,000
Lower Granite Reservoir				
Agency electrofishing:	*Retain survey catch*	4,000	20-160	0
	Add 5 days in spring @ hot-spots	9,000	45-360	$17,000
Public bass derby fishery (3-5 days in June)		4,000	20-160	$30,000
Reservoir manipulation (effects begin 2008)		75,000	375-3,000	??

Process for Implementation

1. ***Agency electrofishing.*** SMB captured during ODFW predator-control tagging and surveys or other management activities in 2004 could be retained, rather than returned to the river, at no additional cost or process (e.g., ESA permits). Additional electrofishing effort could be targeted on SMB removal at certain times and locations (hot-spots) at moderate cost, but may require additional ESA process. These actions would require the full support and concurrence of Oregon Department of Fish & Wildlife, Washington Department of Fish & Wildlife (WDFW), and Idaho Fish &Game (IDFG) for actions at the head of Lower Granite Reservoir.
2. ***Lower Granite public bass derby fishery.*** This derby would encourage fishing pressure in a relatively limited and discrete location (e.g., Lower Granite Reservoir, or portions thereof). Concurrence by WDFW and IDFG is necessary and may be difficult, depending on regulations regarding game fish. Derbies often require that participants use live-wells to allow the catch to be released alive. For this purpose, anglers could be encouraged to retain their (dead) catch or surrender it live to be stocked into a closed-system pond where youth, disabled, and/or other anglers might enjoy recatching them. The derby could be sponsored by a state agency, perhaps in conjunction with WDFW's northern pikeminnow sport reward fishery or by a private event organizer under contract.
3. ***Lower Granite Reservoir manipulation.*** Periodic short-term (hours) and limited (perhaps < 10 feet) drawdown of Lower Granite Reservoir during the spawning season of SMB could significantly reduce their reproductive success. This action could be controversial and costly. The effect on the SMB could be significant (perhaps >50 percent reduction in the 2004 brood year), as could the eventual benefits to salmon survival. The benefits to salmon would lag 4 to 6 years, because of the time required for the affected (diminished) brood year of SMB to recruit to predaceous size. The effect would endure 2 to 3 years. This action assumes that SMB spawn in shallow littoral margins of the reservoir during a relatively short (e.g., 2 to 4 weeks) season and that incubating eggs would be vulnerable for several days (e.g., ≥ 7 days). It is essential to review research and local knowledge of SMB reproductive behavior beforehand. Significant regulatory and public information processes may be necessary. Expected physical, biological, economic, and social costs of this action could be gleaned from the Lower Granite drawdown study of the early 1990s.

Lead Entity

Bonneville Power Administration for removal fisheries; the Army Corps of Engineers (Corps) for reservoir manipulation.

Offset Action 3 – Commercial Harvest Reduction

Description of Proposed Action

Harvest reductions in various forms are one of the few human impacts on salmon that resource managers can directly control in the short run that have immediate and direct effects on escapement. This feature allows managers to conserve when necessary and increase allocation when stock abundance warrants it. As an offset measure, it has the potential to significantly boost adult returns and recruitment to the terminal area for inriver harvest or additional spawning escapement. Most fisheries that significantly impact Columbia Basin stocks consist of commercial troll, net, and recreational sport fisheries.

The development of salmon aquaculture the last two decades has pushed the wholesale price of salmon downward to its lowest level in 20+ years as its market share now approaches 60 percent. (Knapp). This has put tremendous pressure upon traditional wholesale suppliers (commercial net and troll) as prices have fallen, while operational costs have increased. In addition, markets put pressure on fisheries to become more efficient, develop niche markets, and in some cases drop out of the fishery. This attrition can have positive ecological benefits in cases where wild fish are a significant or important proportion of mixed stock fisheries provided that other fisheries do not increase their catch to compensate. This unique market condition may make it viable to enable some fishery reductions through easements or other agreements on a willing buyer/willing seller basis to pay for forgone catch.

Harvest reductions, as an offset, do not necessarily have to occur during the same juvenile outmigration year as a modified spill program since the juveniles do not mature and become vulnerable to harvest until subsequent years (i.e., after 1 to 4 years in the ocean); this allows time for development and coordination of reasonable alternatives. Another feature of harvest reductions is that they can be scaled to achieve a broad range of survival objectives, as deemed necessary; this provides the additional advantage of selective management alternatives that do not compromise the viability of the overall fishery.

a. Location

There are multiple ocean and inriver fisheries that impact significant proportions of Columbia River fall bright chinook, as illustrated by the catch distribution of Hanford Reach fall chinook (figure 1). These fisheries include as far north as Southeast Alaska and Canadian troll fisheries and terminal areas such as Columbia River management zones 1 through 6. Determining the appropriate location to focus depends upon a number of policy, market, and technical considerations.

b. Affected Species

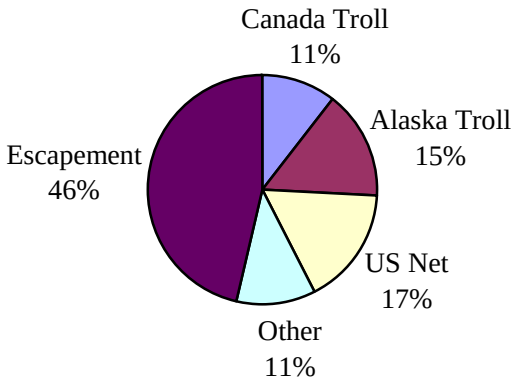
Most commercial fisheries in the ocean and in the Columbia River occur on a mixed aggregate of multiple species and stocks as exemplified by the pie chart on Southeast Alaska Commercial Troll fishery (figure 2). Typically, fisheries that target Columbia River upriver bright stock also impact to varying degrees other species/stocks, including Snake River bright, Mid-Columbia bright, Bonneville upriver bright, Deschutes natural chinook, A and B run steelhead, Bonneville Pool Hatchery stocks, and coho. Other non-Columbia hatchery and natural stocks could be affected in ocean commercial harvest reduction scenarios as well.

Methods

Market and/or regulatory-based harvest reduction programs have been employed by the United States and Canadian governments through permit buy-back programs to reduce fishing capacity. If the recent market trend toward more farm-raised salmon continues its growth, additional opportunities may exist for further voluntary harvest reductions through the use of harvest easements that reimburse fishers for the market value of forgone harvest. In addition to direct payment to fishers, opportunities also exist to develop new markets or invest in infrastructure to better compete with other supplies of salmon through value-added processing. Assistance from government and local trade organizations in determining participation and payment schemes or general programs to distribute the funds gained from such agreements among fishers and processors is essential.

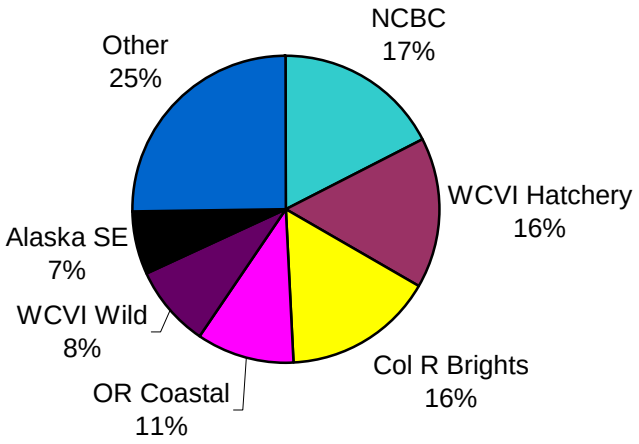
Over a dozen distinct commercial and sport fisheries impact Columbia Basin stocks that may be affected by summer spill reductions (figure 2), but a few fisheries with higher proportional catch offer the most feasible opportunities in which to pursue harvest easements. Modification to harvest for purposes of offsetting potential impacts of summer spill is scalable, depending on objectives and subject fisheries. For example, if modifications to fisheries are designed to limit the impact to no more than 5 percent of the total catch, then the benefit to Columbia River fall chinook escapement may range between approximately 1,000 and 6,000 adults at an estimated economic value (market value * 2x multiplier) of $125,000 to $275,000.

Figure 1. Hanford Wild Brights Distribution of Total Fishing Mortalities



Source: Pacific Salmon Commission, Report TCCNINOOK (01)-2, Table H.58, August 9, 2001

Figure 2. Stock Composition of Southeast Alaska Troll Fishery



Source: Columbia River Inter-Tribal Fish Commission

Knapp, G. *Challenges and Strategies for the Alaska Salmon Industry,* December 20, 2001. p.31.

Offset Action 4 – Avian Predation Research

Description of Proposed Action

Additional caspian tern and double–crested cormorant research activities in the Columbia River estuary and upriver at Crescent Island to support development of an EIS to evaluate alternatives to address avian predation on migrating juvenile salmonids.

a. Location

Research activities would take place in the estuary and at Crescent Island.

b. Affected Species

Sub-yearling salmon stocks.

c. Statement of Feasibility and Certainty of Implementation

The additional research has been scoped and would supplement work already planned and funded for this year. The activities would be a continuation of work initiated in prior years and, with funding, could readily by implemented.

d. Coordination Needs and Additional Requirements

Funding is the only significant requirement at this time.

Estimated Survival or Productivity Increase

This research would support an Environmental Impact Statement (EIS) developing alternatives to reduce avian predation on salmonid species. No direct benefit to the 2004 migration would be achievable. The schedule for the EIS completion is mid-July 2004 and subsequent implementation of selected alternatives could begin in 2005 or 2006. The preliminary objective for caspian tern population in the estuary would be a reduction to 2,500 to 4,500 pairs from the current level of 8,000 to 9,000 pairs. If achieved, this reduction could provide for an estimated 3 to 4 million reduction in total salmonid juveniles consumed. Based on 2003 data, the sub-yearling component could be a reduction of 350,000 to 500,000 consumed. The future benefits for summer migrants resulting from yet to be determined cormorant management actions cannot be estimated at this time.

Estimated Cost, Duration, and Proposed Funding Source

The estimated cost for the additional research in 2004 is $300,000. Funding may come from BPA or the Corps.

Process for Implementation and Schedule

The research would be initiated in the spring of 2004, under contracts with the Corps of Engineers or BPA.

Lead Entity

The Army Corps of Engineers.

Offset Action 5 – Pile Dike Removal

Description of Proposed Action

This action would entail removal of some existing Corps of Engineer constructed pile dikes in the lower Columbia River. Pile dikes slated for removal were identified based on an evaluation from a previous Corps study, which evaluated their function with respect to their original purpose. Their removal could benefit migrating salmonids. Pile dikes provide perches and enhanced foraging opportunities for double-crested cormorants and result in establishment of backwater predator habitat.

a. Location

For offset purposes, pile dikes between river miles 52 and 136 would be removed. It is assumed that cormorant use of pile dike fields below river mile 52 are already addressed in the existing 40-foot channel BiOp**.** Habitat improvement associated with removal of specific pile dikes in that reach may be creditable under RPA action 160 of the NOAA Fisheries FCRPS 2000 BiOp.

b. Affected Species

Sub-yearling salmon stocks.

c. Statement of Feasibility and Certainty of Implementation

Removal of unnecessary pile dikes is a feasible action. However, accomplishment of their removal soon enough to benefit 2004 summer outmigrants may be difficult.

d. Coordination Needs and Additional Requirements

Funding would be needed in January to complete an Environmental Assessment and contract for the removal action. A waiver from in-water work timing restrictions would be necessary.

Estimated Survival or Productivity Increase

The action would reduce opportunities for cormorant perching and associated foraging for juvenile salmonids, reduce fish predator habitat, restore natural flow velocities, and potentially improve benthic invertebrate/fisheries habitat conditions in the immediate location of the removed pile dikes. A quantitative benefit in terms of reduced predation on migrating salmonids and habitat improvements cannot be readily derived.

Estimated Cost, Duration, and Proposed Funding Source

The estimated length of pile dikes in this reach of the lower Columbia is about 45,000 linear feet, constructed with approximately 18,000 pilings. The estimated cost to remove all of the pilings (at an estimated $69/piling) would be about $1.4M. This project could be funded by BPA.

Process for Implementation and Schedule

Preparation of an Environmental Assessment (EA) and to prepare and award a contract is optimistically estimated to require 90 days. Before July 2004 (the assumed summer spill season), it may be possible to remove 4,500 pilings.

Lead Entity

The Army Corps of Engineers.

Offset Action 6 – Anti-Stranding Flow Fluctuation Limits in the Hanford Reach

Description of Proposed Action

The Action is intended to protect Hanford Reach fall chinook juveniles as they rear and pass out of the Hanford Reach in the spring. The action limits flow fluctuations from Priest Rapids.

a. Location

Mid-Columbia River.

b. Affected Species

Hanford Reach fall chinook.

c. Statement of Feasibility and Certainty of Implementation

Relevant parties have not signed the Hanford Reach Fall Chinook Protection Program that Grant PUD has proposed of which this action is a part. Grant PUD has stated that if the Mid-Columbia operators and WDFW do not sign the agreement for the program, there is no guarantee of an operation to protect the Hanford Reach fall chinook during the rearing period.

d. Coordination Needs and Additional Requirements

Grant, Douglas, and Chelan Public Utility Departments (PUDs), BPA, WDFW, NOAA Fisheries, and the Colville Tribe are very close to reaching an agreement on the terms of the Hanford Reach Fall Chinook Protection Program**.** When the agreement is reached, Grant and BPA will sign a separate agreement to cover delivery of energy to mitigate losses at Grant PUD projects.

Estimated Survival or Productivity Increase

In preparation for Grant PUD's Priest Rapids FERC relicensing application, Battelle-Pacific Northwest Division produced a study of Hanford Reach fall chinook spawning and rearing (McMichael et al, 2003). That study describes a methodology for estimating mortality of rearing fry based on counts of stranded fish for 1999 to 2003 provided by WDFW. Grant PUD limited flow fluctuations, following predetermined criteria to protect fry from stranding, in all of those years.

The year 1998 was the only year for which WDFW counts of stranded fish were available and no flow fluctuation limits were in place at Priest Rapids. Using that data, BPA applied the Battelle methodology to estimate rearing fry mortality to establish a baseline for the operation without fluctuation limits. The result was an estimate that 20 percent of the rearing fry may have died as a result of unlimited flow fluctuations at Priest Rapids.

The Battelle estimates of fry mortality from stranding for the years 1999, 2000, 2002, and 2003 were averaged (0.45 percent) so that it could be used to make estimates for future years' operations when the flow fluctuation limits are in effect. The mortality estimate for 2001 was not included in the average. 2001 flows have an extremely low probability of recurrence (less

than 5 percent) and would have skewed the average significantly if equally weighted with the other years.

The difference in pre- and post-flow fluctuation limit stranding mortality rates (20.23 vs. 0.45) was then used in the determination of additional adults returning to the Hanford Reach as a result of limited flow fluctuation operation of Priest Rapids. A 20% reduction in mortality of rearing fry translates directly to a 20% increase in the number of adults expected to return.

Key assumptions in the procedure used by Battelle (McMichael et al, 2003) are:

Percent of adults that are females: 58.7 (average of 1999-2003)
Number of eggs per female: 4,500
Percent of egg to fry survival rate: 63.2
Percent of fry mortality due to stranding: 0.45 (average of 1999, 2000, 2002, 2003)
Percent of fry to smolt survival rate: 75.0
Percent of smolt to adult return rate: 0.52

Results using these assumptions and an average return of 44,000 adults are:

total adults previous fall	44,000
total females	25,837
total eggs	116,265,600
rearing fry	73,479,859
fry stranding mortality	331,910
smolts	54,860,962
expected adult return	285,277
adult savings from limits	56,428

Estimated Cost, Duration, and Proposed Funding Source

BPA will deliver Grant PUD amounts of energy to mitigate losses at Grant projects while Grant PUD limits flow fluctuations to protect juvenile fish. The losses at Grant projects are the incremental head losses attributable to the operation of the federal projects upstream. BPA has estimated the cost of the energy to be delivered to Grant to be an annual average of approximately $100,000.

Process for Implementation and Schedule

The program must be signed before the fall chinook rearing period begins (about May 1) if any offset credit is to be accounted in 2004.

Lead Entity

Bonneville Power Administration.

A P P E N D I X

D R A F T

Potential Offsets to Summer Spill Reduction

Discussion

The Northwest Power and Conservation Council's Mainstem Amendment of 2003 calls for an evaluation of summer spill. Based on analyses of research performed in conjunction with the FCRPS 2000 Biological Opinion, spill generally provides the highest passage survival at most mainstem hydro facilities. Therefore, any reduction in spill is presumed to result in some level of reduced survival to listed Snake River fall chinook and other stocks migrating through the lower Columbia at the time spill is ceased or reduced. Many believe the resulting increase in juvenile mortality can be compensated through "offsets" designed to enhance survival in one or more life stage. Thus, whatever survival was associated with the spill can potentially be offset through implementation of additional non-spill measures.

Offset Principles:

1. Offset measures should be designed to provide equal or greater survival, as measured or estimated, than provided by current BiOp spill requirements.
2. Offset measures should be temporally consistent, i.e., as a priority they should provide survival benefits to juveniles or adults of the affected brood years.
3. Offset measures should capture the diversity of the affected stocks, i.e., provide survival benefits to the portion of the outmigration suffering the loss.
4. Offset measures should address anticipated losses to each of the affected stocks, whether listed or not.
5. Offset measures for fall chinook should be over and above those currently contemplated by the BiOp for implementation and whose survival benefits are included in the analysis of jeopardy, now or in the future.
6. Offset measures must be implementable or committed to in writing in the year spill is reduced including provisions for NEPA, Consultation, etc.
7. Offset measures should be funded or implemented over an above the current fish and wildlife spending caps or programs.

Potential Offsets – The following have been mentioned as potential offset measures.

1. Increases in predator control measures
    a. Pikeminnow Program
    b. Terns
    c. Cormorants
    d. Walleye
    e. Smallmouth Bass
    f. Marine mammals
2. Changes in operation (e.g., flow augmentation) or system configuration (e.g., RSWs)
3. Commercial harvest reductions
4. Increased law enforcement
5. Habitat improvement

6. Supplementation

Potentially Impacted Stocks

Deschutes River fall chinook*	Mid-Columbia fall chinook
Klickitat River fall chinook	Umatilla River fall chinook
Yakima River fall chinook	Marion Drain fall chinook
Mid-Columbia summer chinook*	Hanford Reach fall chinook*
Priest Rapids Hatchery fall chinook	Snake River fall chinook**
Upper Columbia steelhead adults	Snake River steelhead adults
Ringold Springs Hatchery fall chinook	Upper Columbia steelhead adults***

* Denotes an indicator stock for U.S.-Canada PST Chinook management
** Listed as threatened under ESA
*** Listed as endangered under ESA