9.0 REASONABLE AND PRUDENT ALTERNATIVE

9.1 OVERVIEW OF THE ALTERNATIVE

This reasonable and prudent alternative (RPA) for the FCRPS and for BOR's 31 projects, including the entire Columbia Basin project, identifies actions that, combined with other ongoing and anticipated measures in the Columbia River basin outlined in the All-H Paper,[1] is likely to ensure the long-term survival of listed species with a moderate to high likelihood of recovery. Based on the best available scientific information, the following fundamental components of the RPA would allow the FCRPS to avoid jeopardizing the listed species.

9.1.1 Performance Standards

The RPA defines certain performance standards that will meet the jeopardy standard described in Section 1.3.3.1 now and as it is fully implemented by 2010. There are several distinct types of performance standards described in Section 9.2:

- Programmatic standards will be used to assess whether anticipated actions are being implemented.
- Biological standards will be used to assess the status of the ESUs and the effectiveness of implemented measures. Biological standards are further broken down into hydrosystem and offsite standards.
- Physical performance standards will be used to express ecological and management indicators in terms of habitat attributes such as water quality.

Hydrosystem performance standards include specific adult and juvenile survival levels (direct and indirect) expected to result from implementing the best or most aggressive actions that NMFS and the Action Agencies agree are biologically and technically feasible and within the authority of the Action Agencies. The Action Agencies are committed to attaining the hydro standards by 2010. Sections 6.1.2, 9.7.1, and Appendix B describe how the hydro performance standards were derived.

Offsite mitigation standards include the implementation of specific measures identified in the All-H Paper and in Sections 9.6.2, 9.6.3, and 9.6.4. The Action Agencies are committed to implementing the offsite mitigation measures described in these sections. The All-H Paper

[1] NMFS is issuing an All-H Paper that outlines expected improvements in all Hs (hydro, habitat, hatcheries, and harvest) needed to meet the goals of the ESA at the same time as this Biological Opinion. The All-H Paper is a conceptual recovery plan that NMFS intends to use as a guideline for evaluating actions that affect the listed species. Consistency with the All-H Paper assures that actions are both avoiding jeopardy and enabling the recovery of listed species.

describes the level of additional improvements to be attained through actions that address other life stages (including, but not limited to, improvements made through offsite mitigation by the FCRPS Action Agencies).

9.1.2 Hydro Actions

Section 9.6.1 of this RPA describes a set of specific, aggressive hydro actions that NMFS has determined, on the basis of available scientific information, will achieve the FCRPS hydro performance standards. Most of the measures are aimed at improving passage survival through FCRPS dams and reservoirs by changing project operations and improving project configuration. The measures include:

- Enhanced spill and spillway improvements to facilitate higher spill levels without exceeding dissolved gas standards
- Improved flow management
- Physical improvements to both juvenile and adult fish passage facilities
- Increased use of barges and less reliance on trucks to transport summer migrants
- Continuation of spill at collector projects to maximize the survival rate of inriver migrants

As determined through the planning process described in Section 9.5, NMFS may deem other combinations of measures sufficient to meet the performance standards and avoid jeopardy.

9.1.3 Offsite Mitigation Actions

Additional measures call for offsite mitigation, as discussed in Sections 9.6.2, 9.6.3, and 9.6.4. These additional actions are included to improve the productivity of the listed salmon populations beyond what would be possible through hydro actions alone. Even with survival improvements in fish passage at and between dams, significant mortality associated with FCRPS/BOR operations will continue to occur. NMFS, therefore, advises the Action Agencies that additional offsite mitigation for habitat, hatcheries, and harvest is needed to avoid jeopardy. Action Agency implementation of measures in these other areas will increase the certainty and reliability of attaining the increased survival rate of listed ESUs.

Offsite mitigation provided by the Action Agencies will not preclude the need for improvements in habitat, hatcheries, and harvest by other Federal or Non-Federal parties, nor does it diminish the obligation of these other parties to seek improvements in furtherance of Section 7(a)(1) or Section 7(a)(2). Offsite mitigation is intended to complement, not displace, actions by other entities to address habitat, hatcheries and harvest. Where there are overlaps between offsite mitigation activities of the Action Agencies and the responsibilities of other Federal and non-Federal entities costs and implementation responsibilities will be shared and coordinated as appropriate.

9.1.4 One- and 5- Year Plans

An annual, multi-year planning process to refine, implement, evaluate, and adjust ongoing efforts is critical to achieving the FCRPS hydro and offsite performance standards within the timeframe covered by this Biological Opinion. This will be accomplished through development and implementation of 1- and 5-year plans to achieve both hydro performance standards and offsite mitigation performance standards. The plans will cover all operations, configuration, research, monitoring, and evaluation actions. The plans will also describe habitat, hatchery and harvest actions to be funded or otherwise carried out by the Action Agencies as offsite mitigation. The RPA allows for revision of the specific measures throughout the term of the RPA, as long as the Action Agencies make steady progress toward meeting performance standards and remain on track for full attainment of the hydro standards by 2010. The 2003 annual plan will contain a comprehensive assessment of the success of the action agencies in obtaining the funding and authorizations and in implementing the actions called for in this RPA. NMFS will reinitiate consultation if there is lack of adequate progress at that time. The annual planning process is outlined in Section 9.5.

9.1.5 Comprehensive 5- and 8-Year Check-ins

Any assessment of future conditions presents the risk that the actions identified under this RPA will not be adequate to ensure long-term survival of the listed ESUs. To manage that risk, NMFS has included critical monitoring evaluation, and performance measures, as well as action levels to trigger additional measures if needed. The region must be prepared to move forward with these alternative measures, given the possibility that onsite and offsite measures will not have the predicted results, or that subsequent information will show the predicted improvements to be inadequate. Section 9.2 describes the performance standards and measures. Section 9.4 describes the steps for review and decision-making regarding the adequacy and effectiveness of the RPA. This RPA calls for annual progress reports, major progress evaluations in 2005 and 2008, and pursuit of other ways to avoid jeopardy in the future, including possible breaching of dams if necessary.

Another key element of the annual progress evaluations in 5 and 8 years is progress on resolving critical uncertainties. Resolution on critical uncertainties is necessary to assess progress, as described above, and to provide guidance on pending actions.

9.1.6 Monitoring, Evaluation, and Progress Reporting

Monitoring and evaluation is not merely the periodic collection of data. Rather, properly designed monitoring programs will provide data for resolving a wide range of uncertainties, including determining population status, establishing causal relationships between habitat (or other) attributes and population response, and assessing the effectiveness of management actions. The information gained through monitoring programs will be a cornerstone in identifying alternative actions and refining recovery efforts. Such programs are therefore critical to the successful implementation of this RPA.

For example, there is considerable uncertainty even in assessing the status of listed ESUs under current conditions. It is quite apparent that these risks were high under the baseline conditions that led to their listing, and they appear to remain quite high under current conditions. However, precisely quantifying population trends is dependent on knowing both the proportion of hatchery fish spawning naturally, and the relative reproductive success of those fish. This information, particularly the latter point, is largely lacking. As a result, the range of uncertainty associated with our current estimates of risk is large. An important component of any monitoring program will therefore be resolving the status of the populations.

In addition, despite full use of the best science available, substantial uncertainty remains about the effectiveness of measures available to meet the biological requirements of listed ESUs. In hydro, for example, the projected effect of the hydro measures, or of the alternative of breaching dams, is highly dependent on the degree to which there is a delayed mortality associated with juvenile fish passage at those dams either in-river or with barge transportation, and the degree to which that delayed effect would be mitigated with breaching of any particular dam or dams. The potential for delayed, pre-spawning mortality of adults and for survival effects related to estuary or plume conditions created through water management practices are also highly critical uncertainties. In habitat, there are critical uncertainties associated with the feasibility of implementing protective measures in light of the existing institutional frameworks (e.g., addressing in-stream flow needs in over-appropriated streams). There is also uncertainty about the magnitude of the expected biological response to habitat actions that achieve their physical objectives, and with the time frame for that biological response. In the area of artificial propagation, effectiveness of hatchery supplementation as a means of speeding recovery is a critical unknown, as is the impact of hatchery supplementation on wild populations.

To resolve these uncertainties, specific scientific studies must be undertaken with rigorous monitoring and evaluation, focusing on determining population status, and the mechanisms that regulate salmon populations. The results from these studies and monitoring should provide for a better understanding about the status of the ESUs and about which measures work and do not work. NMFS also requires monitoring and evaluation of measures to assess an Action Agency's progress in implementing its RPA and the benefits resulting from the Action Agency's implementation. The RPA establishes a schedule of measures, milestones, standards and decisions, subject to updating and refinement through annual planning, to ensure that this evaluation process is disciplined and rigorous. Progress on resolving these uncertainties will be a primary consideration in the annual and 5-year planning process as well as in the 5-, and 8-year check-ins. Monitoring and evaluation may lead to revisions in measures the Action Agencies undertake to meet performance standards, or in the performance standards themselves, to ensure that the overall program is sufficient to avoid jeopardy to listed ESUs.

9.1.7 Advance Planning for Breach or Other Additional Actions

NMFS has given significant consideration to the options involving breach of the lower Snake and possibly other dams. Generally, any action that removes or eliminates a source of adverse effects from the listed species' life cycle increases the odds that survival rates will improve. By reducing the effects of one type of human activity, breaching the four lower Snake River dams would provide more certainty of long-term survival and recovery than would other measures.

This RPA requires Action Agencies to take specific actions to ensure that alternative approaches are available. Such actions will allow for the possibilities that the hydro and offsite mitigation actions described here will not provide the anticipated survival rate increases, or that subsequent information shows the predicted improvements are inadequate. Although the RPA does not rely on breach of any dams to avoid jeopardy, it does require further development of breach as an option in the event that future conditions warrant it. NMFS recognizes that breach is a major action requiring NEPA compliance, congressional authorization, and appropriations before it can be implemented. This RPA, therefore, calls for the FCRPS Action Agencies to conduct or continue analyses preliminary to seeking authorization from Congress, such as impact and mitigation studies. The specific actions described in Section 9.6.1.9 will reduce the time needed to seek congressional authorization for breach, and reduce the time needed for possible implementation, thereby avoiding delay should breach become a preferred approach.

9.1.8 Breach Triggers

The RPA establishes a schedule for determining whether to pursue breach as a means of avoiding jeopardy. This schedule addresses possible breach of one or a combination of hydroelectric projects. The schedule provides for a rigorous mid-point review of progress in 2005, another comprehensive review in 2008, and a determination under certain conditions to pursue breach if NMFS issues a failure report on the RPA following one of these reviews. The mid-point evaluation process is described in Section 9.4.

9.1.9 Independent Peer Review

It is important that the public and the courts have confidence in the actions that the Action Agencies are taking, and in the science that supports the RPA. Accordingly, the RPA requires that the implementation progress reports the Action Agencies develop in years 5 and 10, and any recommendations by NMFS for alternative actions in the event of a failure in this RPA be subjected to independent peer review.

9.1.10 Immediate Actions and Benefits

Because listed Columbia basin anadromous fish are in such fragile condition, an immediate focus on areas and measures that provide gains within 1 to 10 years is essential.

Section 9.6.1 describes the hydrosystem measures intended to provide these short-term gains. Section 9.7.1 describes the expected effects of those actions on juvenile and adult survival levels. The Action Agencies are committed to implement the specified hydro measures and/or additional measures as needed to fully attain these system survival levels by 2010.

For offsite mitigation, the discussions of habitat (Section 9.6.2), hatcheries (Section 9.6.3) and harvest (Section 9.6.4) describe early action items to produce immediate improvements. The offsite action items allow for a thorough assessment of the overall strategic approach by the mid-point progress reviews. For habitat these include restoring tributary flows, screening water diversions, providing passage at obstructions, and securing additional riparian, wetland, floodplain, inter-tidal or shallow water habitats. Short-term gains in hatcheries are expected through implementation of conservation hatchery "safety nets" and hatchery reform, as explained in Section 9.6.3.

9.2 PERFORMANCE STANDARDS

NMFS' purpose in this RPA is to establish a course of action for the Federal Columbia River Power System and BOR operations that avoids both jeopardy to the listed stocks and destruction or adverse modification of critical habitat, and thus meets the standards of ESA Section 7(a)(2). Toward that end, this section establishes initial management goals, or performance standards, and the associated performance measures that will be used to evaluate the suite of actions identified as adequate to satisfy ESA standards. The overall effectiveness of the actions will depend on three factors:

- The validity of the standards
- The accuracy of current knowledge about the actions and their biological effects
- Progress the Action Agencies make in implementing the actions

This section also describes the process and techniques NMFS will use in evaluating these three factors.

9.2.1 Programmatic Performance Standards

Programmatic performance standards are the actions and the schedule for those actions that are defined in the annual planning process, the Biological Opinion, and the accompanying All-H Paper. In essence, the measure of performance is the success of the Action Agencies in implementation of actions defined in the Annual Plan. Evaluation of progress relative to this standard will be formalized through NMFS' review of the annual progress reports prepared by the Action Agencies, the annual NMFS findings letter, and the 5- and 8-year mid-point evaluations. Further information on the 1- and 5-year planning process can be found in Section 9.5.

9.2.2 Biological Performance Standards

Biological performance standards fall into two categories:

- Standards intended to evaluate the status of the stocks
- Standards intended to evaluate how effectively the actions produce an expected biological response.

Both types of evaluation depend heavily on a robust and comprehensive research, monitoring and evaluation program.

9.2.2.1 Standards Related to Status of the ESUs

The standards used to evaluate stock status are values describing the biological requirements of the ESUs that are consistent with maintaining a high likelihood of survival and a moderate to high likelihood of recovery. Recovery standards will ultimately include measures of abundance, productivity trends, species diversity, and population distribution. Until these recovery standards are established, evaluating the likelihood of survival and recovery will rely on estimates of life stage survival increases and productivity (lambda) for each identifiable population within the ESU, as well as previously defined interim recovery goals (see Table 1.3-1). Estimates of lambda will be generated using standard techniques (McClure et al. 2000). These estimates and techniques will be refined by NMFS as we gain additional information over time and through researching critical uncertainties, such as the effectiveness of hatchery spawners in the wild. NMFS will continually reassess the analytical foundation of its analysis and will retest the validity of the standards. NMFS recognizes that the lambda values express just one of several characteristics of a salmon population to examine when judging the health or risks facing that population. Others include genetic diversity, life history diversity, and geographic distribution. NMFS intends to apply these principles to the listed ESUs in the basin through its recovery planning process, which will develop more specific recovery goals for these ESUs within 3 years. NMFS expects that these more refined goals may provide a scientific foundation to further refine these performance measures.

As a starting point, a summary of current estimates of lambda is provided in Table 9.2-1. These estimates, the upper and lower confidence limits, the spawning aggregations from which they are derived, and additional, more detailed information can be found in Section 4 and Appendix A.

For purposes of the 5- and 8-year reviews, this RPA establishes two action levels. A lambda level of 1.1 or higher means a population will double in 8 years. At lambda values of 1.1 or higher, the ESUs would be considered on the path to recovery, and implementation of the RPA would continue unchanged.

A lambda value of 0.95 means a population will halve in 14 years. If lambda vales are still below 0.95 by 2008, ESUs would be considered at risk of extinction and the RPA will be considered to have failed. Between these two points, NMFS would request a reinitiation of consultation to more formally consider the risks and appropriate next steps. Section 9.4 describes this decision process in more detail.

Table 9.2-1. Average Populations Growth Rates (Lambda) for Eleven Columbia River Basin ESUs (Excluding Snake River Sockeye Salmon)[1]

		Lambda			
Species	**ESU**	**0%**	**20%**	**80%**	**100%**
Chinook salmon	SR spring/summer-run[2]	0.94	0.87	0.70	0.51
	SR fall-run	0.93	0.84	0.64	0.49
	UCR spring-run	0.87	0.85	0.80	0.69
	UWR	1.01	0.50	0.20	0.13
	LCR[1]	0.95	0.86	0.66	0.49
Steelhead	SR (A+B-run)	0.90	0.49	0.21	0.13
	UCR	0.90	0.63	0.34	0.25
	MCR[1]	0.87	0.65	0.37	0.30
	UWR	0.91	0.84	0.70	0.59
	LCR[1]	0.98	0.72	0.41	0.32
Chum salmon[2]		1.03	1.03	1.03	0.94

1 Source: McClure et al. (2000). This analysis incorporates the proportion of natural spawners that were of hatchery origin and assumes a range of effectiveness of hatchery spawning (0%, 20%, 80% and 100%).
2 The spawning aggregations (i.e., variously identified as spawning, index, or subbasin populations) used in these analyses may not constitute a sample that represents the status of the ESU as a whole. For example, the estimate of the growth rate of the SR spring/summer chinook salmon ESU is based on six index stocks, out of a much larger number of identified spawning aggregations. In comparison, the estimate for UWR chinook salmon, based on counts at Willamette Falls, is based on as complete count for the ESU as possible.

9.2.2.2 Standards Related to Effectiveness of Actions

The standards related to effectiveness of actions are the assumptions implicit in the All-H Paper that the suite of actions addressing hydro, habitat, hatcheries and harvest — the allocation of the recovery burden, if you will — are adequate to meet ESA standards. The approach for evaluating progress will vary for actions in different areas. In all cases however, evaluations of the biological effectiveness of actions will be compared to the physical standards described below.

9.2.2.2.1 FCRPS Hydro Performance Standards. These standards are clearly quantitative (i.e., adult and juvenile survival levels) and include a timeline of 10 years for attainment. The hydro standards are defined as the estimated juvenile and adult survival levels that are expected as a direct or indirect result of implementing the best or most aggressive actions that NMFS and the Action Agencies agree are biologically feasible and within the authority of the Action Agencies. The hydro standards are described in Table 9.2-2. There is a great deal of uncertainty and annual variation in these estimates. Because an assumption about future survival rates is inherent in any projection of the likelihood of survival and recovery (i.e., a jeopardy analysis), NMFS believes it is important to be as explicit as possible about the assumptions on which the analysis is based.

Table 9.2-2. FCRPS Hydrosystem Survival Performance Standard

	Adult Survival Rate		Juvenile Survival Rate[3]		
			FCRPS Inriver Only		FCRPS Combined[4] (Transport + Inriver + Delayed Mortality)
	FCRPS System	Per FCRPS Project[2]	System	Per Project[2]	
Chinook Salmon					
SR spring/summer	85.1	98.0	48.8	91.4	56.7
SR fall	72.1	96.0	15.6	79.3	13.5
UCR spring	92.2	98.0	66.0	90.1	66.0
UWR	N/A	N/A	N/A	N/A	N/A
LCR	98.0	98.0	0.79	0.79	0.79
Steelhead					
SR	85.1	98.0	49.5	91.6	49.6
UCR	92.2	98.0	66.4	90.3	66.4
MCR	92.2	98.0	66.4	90.3	66.4
UWR	N/A	N/A	N/A	N/A	N/A
LCR	98.0	98.0	89.2	89.2	89.2
CR chum salmon	N/A	N/A	N/A	N/A	N/A
SR sockeye salmon	85.1	98.0	N/A	N/A	N/A

1 Survival rates (%) cover affected life stages

2 Per-project inriver survival rate calculated as the xth root of the system inriver survival rate (where x = number of FCRPS projects encountered). They are provided for illustrative purposes only. They are NOT intended to be interpreted as project-specific standards, or to be used in any way to support curtailment of survival improvement measures at an individual project.

3 Values represent averages over the water years and "D" values in Table 9.7-1.

4 Values in last column and also across "D" values shown in Table 9.7-2.

Source: Adult Standards are taken from Table 9.7-2.
Juvenile Standards are taken from Table 9.7-1.

Wide annual variations, and the sensitivity of the estimate to conditions in any one year, mean that the standards are not intended to provide for annual adjustments in RPA measures, but rather to provide a benchmark against which progress can be evaluated and assumptions validated in the mid-point evaluation. In year 5, for example, NMFS would compare the 2000 through 2005 average to those average values, which represent our best estimates of survival in 1994 through 1999. Due to annual variability noted above, particularly in relation to environmental and hydrologic conditions, and the limited number of years included in the forthcoming progress evaluation, it may also be necessary to account for differing conditions between the base period and the period for which progress is being assessed. That is, if conditions during the two periods are dissimilar, then some factoring may be necessary to ensure that the progress evaluation is truly assessing progress of actions undertaken and the results are not masked by ambient conditions (e.g., environmental or hydrologic).

9.2.2.2.2 FCRPS Offsite Mitigation Performance Standards. The goal for offsite mitigation is to provide enough improvement in survival over the life cycle to make up for any shortfall in meeting the biological requirements of the ESUs up to the level at which the adverse effects of the action and the associated environmental baseline have been fully mitigated. The estimated level representing full mitigation thus serves as a cap on the Action Agencies' responsibility for offsite mitigation. However, the Action Agencies may be able to satisfy their responsibilities under Section 7(a)(2) of the ESA, to avoid jeopardy and adverse modification of critical habitat, with a lesser level of offsite mitigation. The lesser level would be defined as that which NMFS has determined, when taken together with the effects of achieving the hydro survival standard and the estimated effects of other ongoing and anticipated measures, will provide a high likelihood of survival and a moderate-to-high likelihood of recovery.

NMFS determined that there was enough information available to conduct quantitative analyses to estimate offsite mitigation goals for 5 of the 12 ESUs: SR spring/summer chinook, SR fall chinook, UCR spring-run chinook, UCR steelhead, and SR steelhead. Even for these however, substantial uncertainty still exists about the estimated level of improvement needed, the estimated survival benefit of offsite mitigation actions, and the estimated effects of other ongoing and anticipated actions. As a result, NMFS' determination of the level of improvement needed from offsite mitigation is primarily qualitative and is informed, to the extent possible, with a standardized quantitative analysis.

For those ESUs with enough information to conduct a life cycle analysis, NMFS has developed an analytical approach to estimate the overall level of additional improvement needed after achieving the hydro survival standard. The methodology is described in Section 6.1.2 and its application to the RPA is described in Section 9.7.2. There are four standardized extinction/recovery metrics considered in this approach. They are the estimated levels of improvement over the life cycle of the population that are necessary to have (1) less than 5% risk of extinction in 24 years, (2) less than 5% risk of extinction in 100 years, (3) greater than 50% probability of recovery in 48 years, and (4) greater than 50% probability of recovery in 100 years. The critical metric or standard is then the level of improvement needed to achieve either the highest of the four extinction/recovery metrics or the full mitigation standard, whichever is lower. In this way, where recovery planning is not available to apportion the life-cycle level improvement needed to specific life stages, including the migratory corridor relevant to hydro, the level of improvement needed for any single action would not exceed the full mitigation standard.

A summary of the low end of the range for the critical metrics derived from the analysis in Section 9.7.2 is provided in Table 9.2-3. This is different than an offsite mitigation standard for the Action Agencies under this consultation because some increment of the needed improvement is expected to occur independent of actions taken under this opinion. Specifically, NMFS is unable to account for the anticipated effects of ongoing conservation efforts by other Federal agencies and non-Federal entities that are identified in recovery planning and likely to occur.

Table 9.2-3. Minimum Estimated Percentage of Additional Improvement in Life Cycle Survival Needed to Meet NMFS' Jeopardy Standard After Achieving Aggressive Hydro Survival Levels Identified in Table 9.2-2.

Species	ESU	Stream	Minimum % Improvement Needed
Chinook Salmon			
	SR Spring/Summer ESU		
		Bear Valley	0
		Imnaha	45
		Johnson	0
		Marsh	14
		Minam	45
		Poverty Flats	0
		Sulphur	9
	SR Fall ESU		19
	UCR Spring ESU		31
Steelhead			
	UCR ESU		13
	SR ESU		
		A-Run	35
		B-Run	35

These are NMFS' best estimates of the minimum survival improvements needed over the life cycle of each ESU or population based on the analysis in Section 9.7.2. They represent either the low end of the ranges estimated in that section or the equivalent of full mitigation for hydropower actions and are presented primarily as a benchmark. Due to substantial uncertainties, as noted above, NMFS is not placing a great deal of weight on this quantitative analysis. However, NMFS did consider these estimates together with information on potential improvements in habitat, hatcheries, and harvest described in the All-H paper, in drawing its conclusion on the availability of enough potential to support the reliance of the RPA on offsite mitigation. Specifically, NMFS has concluded that the habitat, hatchery, and harvest actions described in the relevant sections of Volume 2 of the All-H Paper provide enough potential for offsite mitigation to achieve the additional survival improvements for those ESUs for which quantitative estimates were possible as they are described in Table 9.2-3. Further, because these ESUs are upriver stocks that are generally at the greatest risk of extinction, NMFS has further concluded that the offsite mitigation actions likewise provide enough potential for the other ESUs that are evaluated qualitatively and not included in Table 9.2-3.

There are also additional caveats discussed in Section 9.7.2. NMFS considered them in using these lower bounds, and they are highlighted here. Key among them are two critical uncertainties.

First, uncertainty about the proportion of hatchery fish spawning naturally, and the relative reproductive success of those fish, significantly affects the calculation of the extinction and recovery metrics. As a result, the analysis for populations where the hatchery proportion is high suggests rates of needed improvement that appear well beyond reason. NMFS has little confidence in these estimates. Since they also exceed the full mitigation standard in most of these cases, NMFS relies instead, on that standard anyway under the rules for determining the critical metric described above.

Second, uncertainty about delayed mortality of in-river migrants, and particularly about the amount of such mortality that may be attributable to passage of juvenile at the dams, results in an extremely broad range of estimates for the full mitigation standard. The upper end of this range assumes the existence and magnitude of this effect, as described by the PATH process, and attributes it all to the passage at the dams (PATH also offered alternative explanations for this additional mortality). The NMFS' analysis also applied the same value to the Upper Columbia River ESUs and SR steelhead without an analysis comparable to what the PATH group did for SR chinook. As a result, the upper end of this range for the full mitigation standard suggests rates of needed improvements that, as above, seem well beyond reason.

In short, NMFS' effort to capture the full range of scientific uncertainty has given it upper ranges of the level of improvement needed that NMFS considers highly unlikely. If the further research, monitoring, and evaluation required under this RPA validates the assumptions associated with the high end of either of these ranges of uncertainty, then the initial set of actions called for in this RPA will surely fail at the midpoint evaluation. This RPA is set up to provide for necessary and appropriate additional actions at that time. However, NMFS does not believe that this uncertainty should provide a basis for concluding jeopardy without an RPA at this time.

In making this determination, NMFS is mindful of the view by some that breaching of the four lower Snake River dams is the answer. NMFS respectfully disagrees. Breaching lower Snake River dams would only affect the four Snake River ESUs. It would have no effect on the other eight ESUs considered in this biological opinion. Furthermore, even if breaching were put forth as an alternative for the Snake River ESUs, it has the same limitation of relying on an assumption about the existence and cause of the delayed mortality of inriver migrants. It also relies on the assumption that the additional mortality would disappear if dams were breached. NMFS does not currently believe that the scientific support for these assumptions is sufficient to accept the premise that breaching is the only or best available path to survival and recovery. Rather, NMFS has determined that the success of the offsite mitigation measures and the additional research monitoring and evaluation called for by this RPA are critical to the long-term survival and recovery of the listed ESUs. It may be possible that dam-breaching will also be needed, but it ranks as a lower priority than other available options at this time. In NMFS' opinion, it is adequately preserved by this RPA as a potential future measure.

9.2.3 Physical Performance Standards

Physical performance standards supplement and, in some cases, serve as surrogates for biological performance standards. In the case of hydro actions, for example, there are some physical targets or objectives directed at measures such as mainstem flow objectives and water quality that are intended to guide water management decisions. These are described with the individual hydro actions in Section 9.6.1. In the case of tributary habitat, physical standards might include in-stream flows; the amount and timing of sediment inputs to streams; riparian conditions that determine water quality, bank integrity, wood input and maintenance of channel complexity; and habitat access.

The Federal agencies, working with CRI and EDT analysts, need to establish hypotheses linking habitat strategies and measures to key habitat attributes. The next step will be to establish an initial set of performance standards and measures – ecological and management indicators – expressed as desired habitat trends. These are to be completed for inclusion in the first 5 year plan as described in Section 9.5, due by January 31, 2001. They will then be developed and refined through subbasin assessments and finer scale analysis. Finally they will be integrated into a monitoring and evaluation program that:

- Tests and improves measures and standards through targeted research
- Enables policy makers to evaluate and refine hypotheses, make adjustments to habitat measures, and make further decisions on the contribution of habitat protection and restoration to recovery

It is critical that the initial 5-year plan include some focused efforts on intermediate stage survival (e.g., egg to parr, parr to smolt) in some carefully selected places that could provide an initial check on the effectiveness of habitat actions within the first 5 to 8 years. As long as these efforts achieve ecological and management targets, the habitat element of the program will be deemed an appropriate contribution to survival and recovery. If the habitat goals are not met, NMFS will reinitiate consultation or trigger additional actions.

9.3 SUMMARY OF OFFSITE MITIGATION PROGRAM

Offsite mitigation is used in this Biological Opinion to mean actions in the areas of habitat, hatcheries, and harvest that are expected to provide biological benefits to the listed stocks. In combination with aggressive efforts to reduce hydro mortality, improvements expected from other ongoing Federal actions, and the cumulative effects of state or private activities that are reasonably certain to occur, these actions should be sufficient to allow the FCRPS and BOR operations to meet the jeopardy standard. Offsite enhancement includes only measures that are within the current authorities of the Action Agencies.

Each of the Action Agencies currently has some current authorities to implement programs to benefit listed stocks that are outside of the scope of hydrosystem operations. BPA has authority pursuant to the Northwest Power Act to protect, mitigate, and enhance fish and wildlife affected by the construction and operation of the FCRPS. BPA implements this authority and responsibility through the Northwest Power Planning Council’s fish and wildlife program. Measures implemented under the program include actions in the areas of habitat, hatcheries, and to a more limited extent, harvest. The Corps has existing authorities that provide opportunities for some hatchery and habitat improvements pursuant to the Lower Snake River Compensation Plan, the Columbia River Fish Mitigation Program, and other continuing authorities. The Corps is currently seeking authority to carry out habitat improvement activities in the estuary. The BOR is authorized, pursuant to the Reclamation Act of 1902, to provide technical assistance to others to address instream habitat improvements; however, BOR currently lacks authority to fund or implement such improvements. BOR’s participation in implementing tributary habitat improvement actions is contingent upon acquiring such authority from Congress or acquiring funds to implement the actions from sources other than BOR appropriations.

The Action Agencies will exercise these authorities to implement offsite mitigation actions outside the operation of the hydrosystem. This will be an important contribution toward achieving the standards for offsite mitigation.

Offsite mitigation measures are identified in the RPA in the areas of habitat (Section 9.6.2), hatcheries (Section 9.6.3) and to a more limited extent, harvest (Section 9.6.4). These measures are intended to complement, not substitute, for actions on Federal lands by Federal land management agencies or actions in the hatchery and harvest arena by other Federal agencies consistent with the All-H Paper and related biological opinions. The measures identified as offsite mitigation in this Biological Opinion are targeted at providing biological benefits for the listed ESUs that are the subject of this consultation and will be credited toward achievement of the offsite mitigation performance standard.

9.4 DESCRIPTION OF MID-POINT EVALUATION PROCESS

Because there is substantial uncertainty about the expected results of the onsite and offsite mitigation measures included in this RPA, careful monitoring and evaluation is essential. The region must be prepared to move forward with alternative measures, given that it is possible onsite and offsite measures will not have the predicted results, or that subsequent information will show the predicted improvements to be inadequate. NMFS believes that alternative approaches should be available, including dam breaching as a future option should these adverse circumstances occur.

NMFS will use the following steps for monitoring and evaluation, review and decision-making regarding the adequacy and effectiveness of these measures. This RPA calls for regular progress reports, major progress evaluations in 2005 and 2008, and pursuit of other options, including possible breach if necessary, to avoid jeopardy in the future (see Figures 9.4-1 and 9.4-2).

9.4.1 Performance Standards with Monitoring and Evaluation

The performance standards applicable to the FCRPS, both hydro and offsite (see Section 9.2), are designed to satisfy the FCRPS Action Agencies' responsibility to avoid jeopardy to listed species. To resolve uncertainties regarding survival and recovery of the listed species, and to assess the effectiveness of measures to benefit these species, the Action Agencies shall provide for research and hypotheses testing to resolve critical uncertainties and ongoing monitoring and evaluation of their actions under this Biological Opinion.

9.4.1.1 Progress Reports

As part of preparation for the annual planning process described in Section 9.5 of this Biological Opinion, the Action Agencies shall prepare progress reports for NMFS review. These annual progress reports shall address the following:

- Compliance by the FCRPS Action Agencies with the measures and schedules described in this Biological Opinion and in 1- and 5-year plans, including a thorough discussion of any impediments to full implementation (e.g., lack of necessary authorization or appropriation)

- Progress toward meeting performance standards established in this Biological Opinion (Section 9.2)

- Anticipated progress toward full achievement of performance standards through future actions, or through future benefits of ongoing actions

- Lessons learned, new information gleaned, and related adjustments made in actions, standards, or monitoring and evaluation

The Action Agencies, working through the Regional Forum and the ISAB, will obtain independent scientific review of their 5-year and 10-year progress reports and submit such reviews to NMFS together with the reports. The progress reports will better enable NMFS and the Action Agencies to assess progress and the possible need for additional measures.

To the extent the actions or programs are not being implemented as described in the RPA, or are falling short of meeting performance measures such as needed improvements in hydrosystem survival, the Action Agencies shall propose additional measures to address the shortcomings in achieving the 1- and 5-year plan objectives.

9.4.1.2 NMFS Midpoint Evaluations in 2005 and 2008

NMFS will perform a midpoint evaluation of improvements by the FCRPS Action Agencies, as well as others, toward avoiding jeopardy to listed stocks. By September 1, 2005, and again by September 1, 2008, NMFS will assess the Action Agencies' current and expected progress toward long-term performance standards. This adequacy assessment will include a specific review of the jeopardy standard and performance standards. As part of that review, NMFS will work with regional technical experts on populations representative of each ESU to update the extinction risk analyses, the estimates of lambda from 1980 to the present, and the related estimates of survival gains necessary to achieve recovery/survival goals. NMFS will incorporate any additional information available through the 2004 returns, then again through the 2007 returns. Specific factors in these midpoint evaluations will include the following:

- The Action Agencies' compliance with the actions identified in this Biological Opinion and in annual plans

- Progress toward meeting the interim and long-term performance standards for hydro and offsite mitigation established in this Biological Opinion

- Updated information on expected progress toward meeting the survival and recovery standards through future actions or through anticipated benefits of ongoing actions

- Lessons learned, new information gleaned, and related adjustments made in actions, standards or monitoring and evaluation, including current adult returns and populations trends

The midpoint evaluations will address the following questions.

Question 1: What is the status of the stocks? Are the FCRPS performance standards established in the 2000 Biological Opinion still relevant?

To answer this question, NMFS will update the applicable models with new data and rerun the jeopardy analysis. The evaluation would then compare the merits of the FCRPS standards under new and old analysis. For this comparative analysis to be informative, the survival and recovery criteria and analytical methods for determination of performance standards should be consistent with the initial year 2000 evaluations (see McClure et al. 2000). A potential finding is that the status of the stocks has changed enough to reinitiate consultation or to warrant revision of the FCRPS performance standards.

Question 2: What is the effectiveness of hydrosystem actions?

The response to question 2 should entail a review of hydrosystem actions taken, an update on juvenile and adult hydrosystem survival, an update on delayed mortality of transported fish, and an update on delayed mortality of inriver migrants. As a result, the evaluation could define more clearly the potential effectiveness of breach, transport, and inriver alternatives. The answer to this question must determine if the Action Agencies are making adequate progress to reach full attainment of the hydro performance standard by 2010.

Question 3: What is the effectiveness of offsite mitigation?

The response to question 3 should entail a checklist review of offsite actions and a projection of expected benefits (EDT) to the extent possible. As a result, the midpoint evaluations could define more clearly the effectiveness of offsite mitigation actions.

Figure 9.4-1 presents a timeline for the evaluations. Figure 9.4-2 diagrams the decision processes involved.

FIGURE 9.4-1. TIMELINE FOR MIDPOINT EVALUATIONS

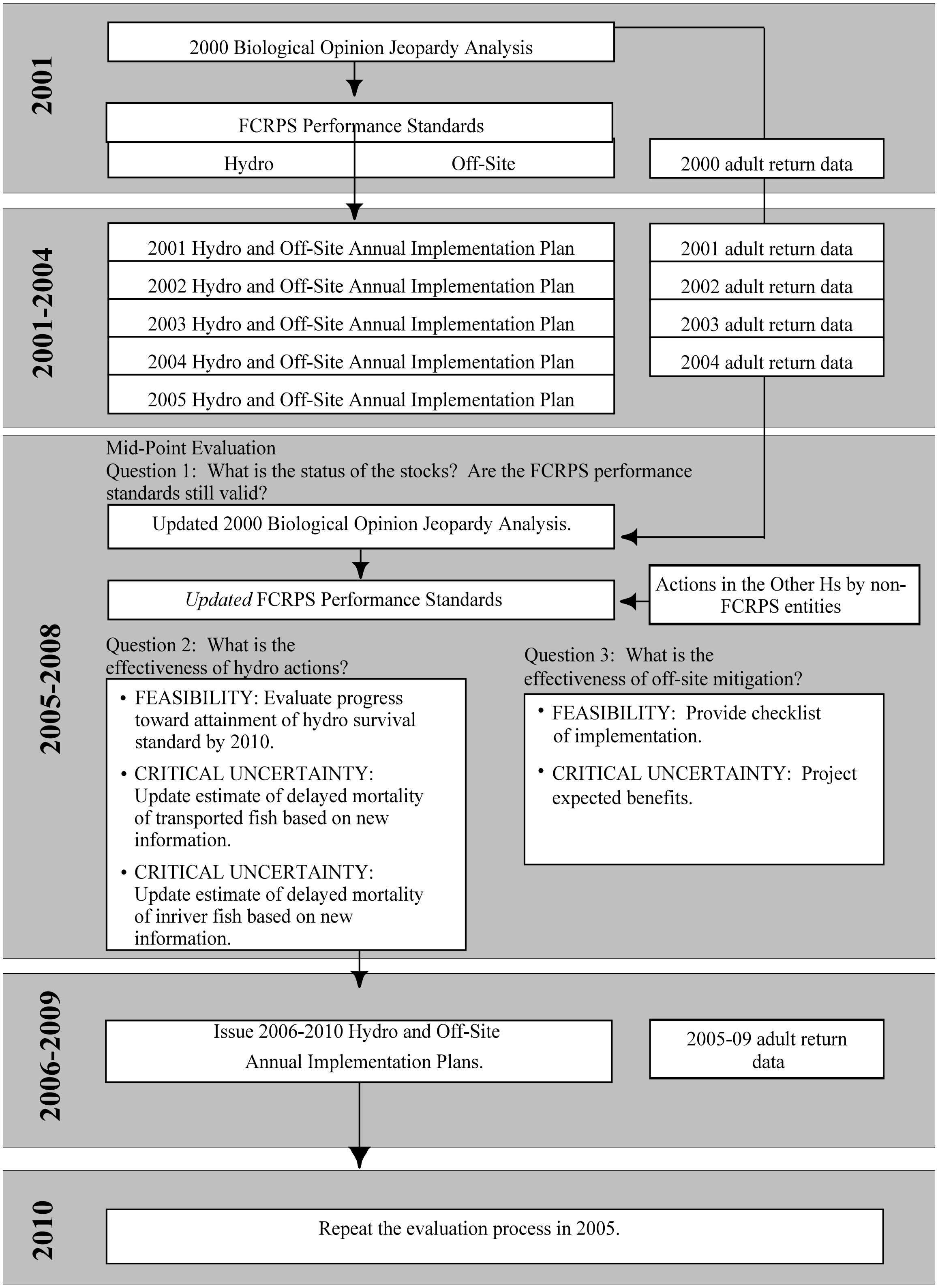
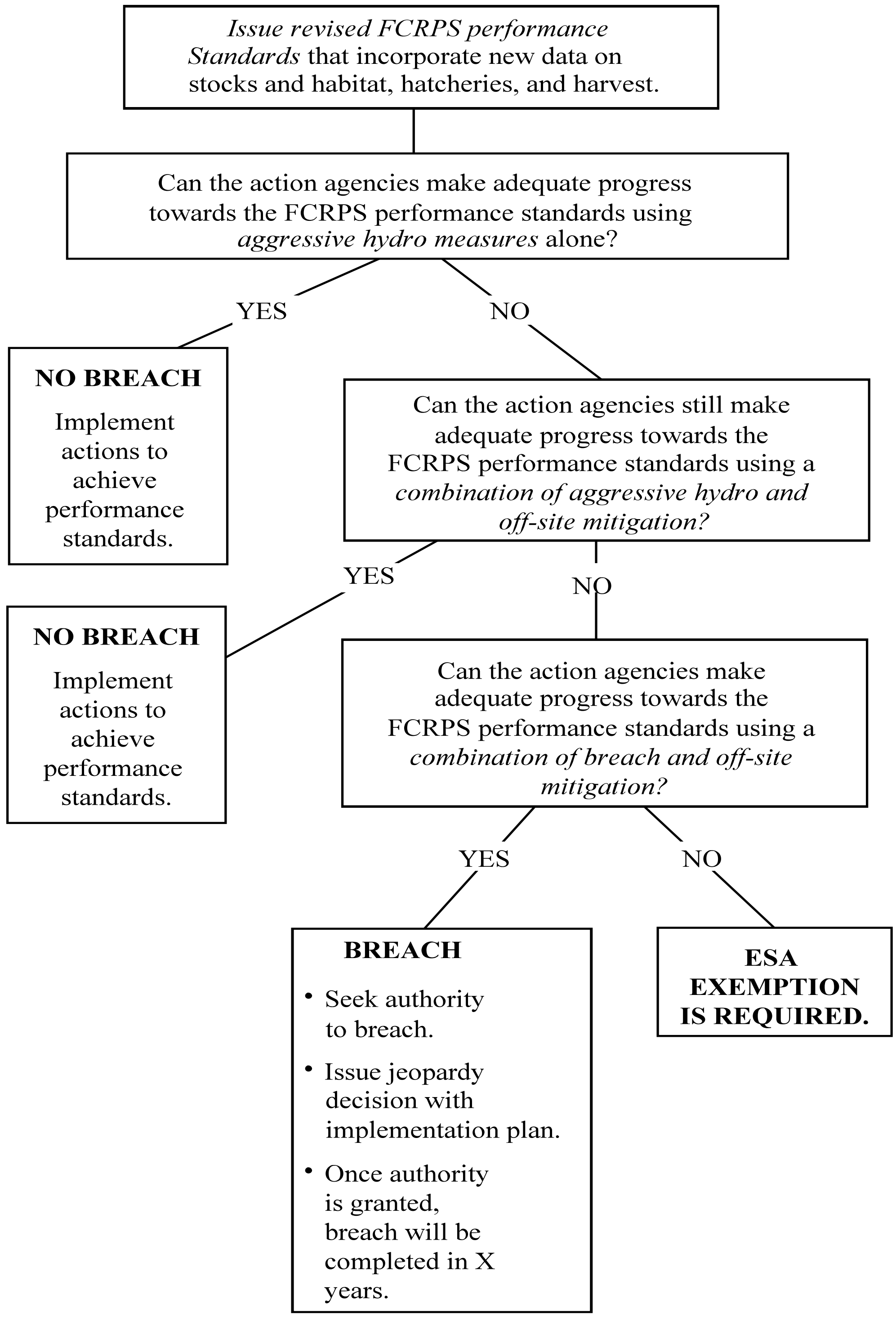


FIGURE 9.4-2. MIDPOINT EVALUATION QUESTIONS RELATED TO FCRPS ACTIONS



9.4.1.3 Assessment of Standards Related to Status of ESUs

For the purposes of the year 5 and 8 evaluations, NMFS will use the complete updated extinction analysis described in Section 9.4.1.2 and apply threshold levels for further action. The specific threshold levels and actions for year 5 are as follows:

lambda > 1.1	Continue implementation of this RPA until year 8 with no reinitiation of consultation.
lambda < 1.1	Continue implementation, but reinitiate consultation to formally reassess the no-jeopardy conclusion.

If the decision in year 5 reaffirms the no-jeopardy conclusion for the aggressive All-H dams-in approach, then a second comprehensive re-evaluation should be conducted in year 8. If on the other hand the review under this section or under Section 9.4.1.4 reveals lagging implementation, poor biological performance, or inadequate improvements in the interim physical standards, NMFS will reinitiate consultation and consider necessary adjustments in the program, including dam breaching. NMFS shall also examine and employ the full use of its ESA authorities under section 7 for Federal actions and section 9 for non-Federal actions to secure the needed additional improvements.

For purposes of a year 8 review, the threshold levels for further action under this Biological Opinion would be as follows:

lambda > 1.1	Continue implementation of this RPA until year 10 with no reinitiation of consultation.
0.95 < lambda < 1.1	Continue implementation, but re-initiate consultation to formally reassess the no-jeopardy conclusion.
lambda < 0.95	NMFS shall notify the Action Agencies in writing that the RPA is failing to avoid jeopardy to listed species (by ESU). In this notification, NMFS shall propose a specific plan for changes to avoid jeopardy, including breaching one or more dams as appropriate. The plan should include a justification for the measures it proposes and should be submitted for independent peer review.

The assumption implicit in this approach is that this RPA, including the adaptive management process for its implementation, is sufficiently broad and flexible to allow refinements in any actions that NMFS and the Action Agencies determine, on the basis of additional information reviewed in the annual process, are necessary to continue to avoid jeopardy while providing adequate potential for recovery. The scope is limited only by agency authority. Thus, if at the end of year 8, lambda values remain below 0.95, NMFS' written report will be a finding that the RPA has failed for those ESUs. NMFS will determine if any other RPAs exist and whether dam breaching would avoid jeopardy if authorized. In response, the Action Agencies must either seek additional authority (e.g., to breach dams) or seek an exemption from the ESA for those ESUs.

Section 9.4.1.5 further describes the decision process in the event of a failure report.

9.4.1.4 Assessment of Standards Related to Implementation and Effectiveness of the RPA

If NMFS' evaluations in 2005 and 2008 show that the action agencies are meeting programmatic commitments and the necessary improvements are being observed in the interim physical and biological standards, then NMFS will advise the Action Agencies to continue to implement the RPA with further adjustments provided though annual planning. If the evaluation demonstrates that the Action Agencies are failing to meet implementation commitments or there is a failure to observe necessary improvements in the interim biological or physical standards, then NMFS will:

- Request the Action Agencies to reinitiate consultation to formally reassess the no-jeopardy conclusion, or

- Notify the Action Agencies in writing that the RPA is failing to avoid jeopardy to listed species (by ESU). In this notification, NMFS shall propose a specific plan for changes to avoid jeopardy, including breaching one or more dams as appropriate. The plan should include a justification for measures it proposes and should be submitted for independent peer review.

Section 9.4.1.5 further describes the decision process in the event of a failure report.

9.4.1.5 Guidelines for Alternative Actions in the Event of a Failure Report

It is NMFS' current working assumption that if this RPA fails to meet the biological requirements for Snake River ESUs, then NMFS would recommend that the Action Agencies seek authority to breach those dams. NMFS expects significant improvements in estimates of delayed mortality associated with the transportation system and inriver passage, which will lend considerably more confidence in the estimates of the potential benefits associated with breaching at that time. NMFS will base its conclusions and recommendations on the best scientific information available at the time of its findings and recommendations.

If NMFS determines that a combination of aggressive hydro measures and offsite mitigation can still avoid jeopardy, NMFS' plan will provide for a non-breach approach for the remaining period of this Biological Opinion (through 2010). At the time, NMFS will also examine and employ the full range of its ESA authorities through consultations with other Federal agencies to secure the improvements needed to address critical factors limiting attainment of biological and physical performance standards.

If NMFS determines that an aggressive hydro measure and offsite mitigation approach fails to avoid jeopardy, and the Action Agencies can avoid jeopardy through a combination of breach and offsite mitigation, the plan will identify an option for breach under the following conditions:

- If NMFS' preferred option involves the breach of only one or more of the lower Snake projects, the plan will recommend that the Action Agencies immediately seek authorization to breach.

- If NMFS' preferred option involves the breach of dams other than the lower Snake projects, the plan will provide a schedule throughout the remaining term of this Biological Opinion for conducting additional analysis and determining whether, according to what schedule, and which particular dams to recommend for breach. This approach acknowledges that the listings of Columbia River species occurred several years after the listings of Snake River species. Therefore, the lower Snake projects have been studied more thoroughly, and are further ahead in studies that would be required preliminary to breach.

NMFS has not, therefore, pre-determined whether breaching the four lower Snake River dams, if authorized, would be sufficient to avoid jeopardy to listed Snake River ESUs. The analysis of the breach option in Section 9.7.3 suggests that it is significantly more likely to avoid jeopardy to these ESUs if delayed mortality to inriver migrants is caused by the four Snake River dams, and the delayed mortality would end with removal of the dams. This is a critical uncertainty.

If NMFS determines that no combination of measures avoids jeopardy, then NMFS will inform the Action Agencies that no RPA is likely to avoid jeopardy or adverse modification of critical habitat.

In all of the above conditions, NMFS' failure report and recommended plan will be submitted for independent peer review.

9.4.1.6 Action Agency Response to NMFS Notification of Failure to Avoid Jeopardy

After receipt of NMFS' notification of failure to avoid jeopardy, the Action Agencies shall pursue authorizations consistent with NMFS' recommended plan for additional analysis and changes in FCRPS operation and configuration (including breach, as appropriate). Action Agencies shall pursue this approach in combination with other activities affecting listed species. If the Action Agencies do not receive authorization and appropriations within 2 years, or if the Action Agencies earlier choose not to seek such authorization, NMFS will issue a jeopardy biological opinion with no reasonable and prudent alternative for avoiding jeopardy, and the Action Agencies will pursue an exemption under section 7(g) of the ESA.

9.5 DEVELOPMENT AND IMPLEMENTATION OF 1- AND 5-YEAR PLANS

This section outlines an annual process for developing and implementing 1- and 5-year plans for achieving both FCRPS hydro performance standards and offsite mitigation performance standards. The plans will cover all operations, configuration, research, monitoring, and evaluation actions for the FCRPS. The plans will also describe habitat, hatchery and harvest actions to be funded or otherwise carried out by the Action Agencies as offsite mitigation. The advance planning process outlined in this section is critical to achieving the FCRPS hydro and offsite performance standards within the timeframe of this Biological Opinion.

The annual planning process is expected to provide the following key benefits:

- A comprehensive plan that identifies progress made and actions needed to achieve FCRPS hydro and offsite mitigation performance standards
- Integration of all FCRPS operations, configuration, research, monitoring, and evaluation actions
- Specific actions to be carried out as offsite mitigation for the effects of the FCRPS and how they will be credited
- Priorities to guide regional planning and in-season actions
- A comprehensive plan to support funding requests

To the extent possible, the plans will be coordinated through established local, regional, and Federal processes. USFWS is referenced in this process to ensure coordination on actions that may affect USFWS hatchery and resident species responsibilities. However, the responsibility for meeting the performance standards in this Biological Opinion rests with the Action Agencies. The responsibility for determining the adequacy of their 1- and 5-year plans rests with NMFS.

The planning and implementation process described in this section has the following elements:

- The Action Agencies, with assistance from NMFS and USFWS, will develop a 5-year implementation plan that includes FCRPS measures and offsite mitigation measures. The first 5-year plan should be completed by January 31, 2001, and annually thereafter by September 1 (or as mutually agreed upon by the Action Agencies, NMFS and the USFWS). The FCRPS portion of the initial 5-year plan will include those specific measures in this RPA. The offsite mitigation portion will include those specific measures from the All-H Paper that are the responsibility of the Action Agencies to fund or carry out.

- Using the 5-year plan as guidance, NMFS, USFWS, and the Action Agencies will participate in regional planning processes. Those processes include, but are not limited to the Council's prioritization process, Action Agency budget requests, and production discussions within *U.S. v. Oregon.*

- The Action Agencies, with assistance from NMFS and USFWS, will complete a 1-year plan. The first 1-year plan will be completed by September 1, 2001, and annually thereafter on a date that is mutually agreed upon by the Action Agencies, NMFS and the USFWS. The 1-year plan will incorporate, to the greatest extent possible, the measures developed in regional planning and prioritization processes. Where differences exist, the plan will explain the differences.

- NMFS will review the 1-year plan for consistency with the Biological Opinion and issue a finding as to whether the plan is adequate.

- The 1- and 5-year plans will be implemented through a variety of processes. The FCRPS hydro action portion of the plans will be implemented through the existing NMFS regional implementation forum process. The offsite mitigation portions of the plans will be implemented through the BPA funding process, Action Agency budget requests, and other processes as appropriate.

9.5.1 Expectations for the Development and Implementation of the 1- and 5-year Plans

The following action describes in more detail the expectations for the development and implementation of the 1- and 5-year plans.

Action: The Action Agencies, coordinating with NMFS and USFWS, shall annually develop 1- and 5-year plans to implement specific measures in hydro, habitat, hatcheries, harvest, research, monitoring, and evaluation needed to meet and evaluate the performance standards contained in this Biological Opinion.

The 5-year plan will focus on the middle to long term, describing the Action Agencies' programs and how they are intended to meet FCRPS and offsite mitigation performance standards. The plan will describe as specifically as possible the measures in those programs, together with schedules and budgets. The first 5-year plan will be completed by January 31, 2001, and annually thereafter by September 1 (or as mutually agreed upon by the Action Agencies, NMFS and the USFWS). The initial 5-year plan will include specific measures identified in this RPA that are the responsibility of the Action Agencies to fund or carry out. As a long-term planning tool, the 5-year plan will focus on out-year costs of the measures to ensure budgets and budget requests are adequate to carry out planned activities. It is anticipated that the 5-year plan will guide the Action Agencies, NMFS, and USFWS as they participate in various regional planning processes, such as the Council's prioritization process, budget requests, and production discussions within *U.S. v. Oregon*.

The 1-year plan will describe in detail measures that will be funded or carried out during the coming fiscal year. The first 1-year plan will be completed by September 1, 2001, and annually thereafter on a date agreed upon by the Action Agencies, NMFS, and USFWS. The plan will include specific measures for hydrosystem operations, configuration, research, monitoring, and evaluation, as well as measures in habitat, harvest, and hatcheries. When recommendations made in other regional processes are not included the plan will explain why.

The 1- and 5-year implementation plans and their priorities should consider the following factors:

- The current status of the various ESUs
- Recent data or results of research, monitoring, and evaluation actions
- Feasibility and timing of implementing each measure
- Probability of success for each measure. The 5-year plan should explain how all the actions together contribute to meeting the performance standards.

9.5.2 Process for Developing and Implementing Key Elements of the 1- and 5-Year Plans

The following sections define the process of developing and implementing key elements of the 1- and 5-year implementation plans. The major elements of the planning process include the following:

1. Hydrosystem Plan
2. Operations — Water Management Plan
3. Configuration — Capital Investment Plan
4. Water Quality Improvement Plan
5. Off-Site Mitigation — Habitat Plan
6. Off-Site Mitigation — Hatcheries and Harvest Plans
7. Adaptive Management Process
8. Approval of Plans
9. Annual Progress Reports

9.5.2.1 Hydrosystem

Action: The Action Agencies shall coordinate development and implementation of the hydro portion of the 1- and 5-year implementation plans through the Regional Forum, chaired by NMFS.

The hydro portion of the 1-year plan will describe specific actions to be taken in the coming year to achieve the hydrosystem performance and water quality standards. It will incorporate and integrate specific measures developed in the water management plan, capital investment plan, and water quality improvement plan, described below. Section 9.6 of this Biological Opinion describes objectives and a number of operational and structural measures that will serve as the basis for the initial operations and configuration actions in the hydro portion of the 1- and 5-year plans. That section also includes research, monitoring, evaluation, and planning measures that, when completed, will guide future implementation decisions. The RPA anticipates that these research and planning actions, together with future decisions made through the 1- and 5-year planning process, will amend the RPA measures. NMFS will explicitly define and approve all such amendments in its written findings.

Development and implementation of the hydro portion of the 1- and 5-year plans will fall to the NMFS regional implementation forum, established by the 1995 Biological Opinion and led by the implementation team. Membership on the implementation team, and all teams and subgroups operating under the implementation team's guidance, is open to representatives from the states, Tribes, and Federal agencies with technical expertise in hydroelectric operations and/or the effects of hydroelectric operations on fish, particularly on migrating juvenile and adult salmonids and native resident species. In particular, the Action Agencies and NMFS have invited and encouraged participation by the four northwest states and Alaska, 13 Columbia River Tribes, the CRITFC, USFWS, the EPA, the Council, the Mid-Columbia PUDs, and Idaho Power Company. All meetings of the NMFS regional forum teams are professionally facilitated and are open to the public. Meeting minutes are distributed to members and the public, and are available for review at NMFS Hydro Division in Portland, or on NMFS' Northwest Region home page at www.nwr.noaa.gov/1hydrop/hydroweb/default.html.

The implementation team will meet monthly, or otherwise as needed, to oversee the activities and resolve disputes arising through the technical management team (TMT), the system configuration team (SCT), and the water quality team (or its successor). The implementation team and each of the technical teams will regularly review and approve guidelines or procedural rules. Draft guidelines now in place will serve as default rules for the implementation team until it may adopt different rules. Copies of the guidelines may be obtained from the NMFS Hydro Division in Portland, Oregon.

Given the development of the annual planning process, it may be appropriate for the Implementation Team and all technical teams operating under its guidance to review their guidelines, rules of procedure, and meeting structure to ensure that the teams are prepared to address the annual planning process. Further, it is anticipated that new subgroups may be needed to address resident fish and data management issues. Those are not described in this section, but may be developed through the regional forum and the annual planning process.

9.5.2.2 Operations

Action: The Action Agencies, coordinating through the Technical Management Team, shall develop and implement a 1- and 5-year water management plan for the operation of FCRPS.

The annual and 5-year water management plans will define how the FCRPS will be operated to achieve the performance and water quality standards. It will also include a prioritized list of research, monitoring, and evaluation needs associated with implementing the annual water management plans. As an advance planning document, the water management plan will provide clear objectives, evaluation points, decision criteria, and priorities for the objectives. Given these priorities, the plan will address any significant changes from prior year operating plans. It will specify any criteria being used to initiate or cease a particular planned operation. In addition, the annual plan will include consideration of research, monitoring, and evaluation activities that require special operations. The water management plan must be incorporated into the 1-year plan by September 1 of each year, well before run-off projections are available for the coming year. For this reason, the water management plan will need to provide objectives, priorities and decision criteria for various water conditions.

Unlike the current process, this timeline for the water management plan does not allow for consideration of specific water-year information. Therefore, the Action Agencies will coordinate through the Technical Management Team to prepare more detailed spring/summer and fall/winter action plans that address spring runoff, summer flow augmentation, fall spawning, and winter incubation seasons. The spring/summer plan will be initiated with the January 1 forecast, and updated each month as the new forecast information becomes available. The fall/winter plan will be initiated in September using the best currently available hydrologic and oceanographic information and updated as better information becomes available.

Given its emphasis on advance planning, Technical Management Team may only need to meet bi-weekly or monthly during the spring and summer migration and fall spawning seasons to advise the Action Agencies on the status of salmonid migrations and spawning activity, and to review dam and reservoir operations for optimal conditions affecting juvenile and adult anadromous salmonids. The water management plan and the more detailed spring/summer and fall/winter plans, together with the provisions of Section 9.6.1.2, will guide the Technical Management Team in-season management process. When consensus cannot be reached on an issue, a Technical Management Team member may elevate the issue to the Implementation Team for resolution.

9.5.2.3 Configuration

Action: The Action Agencies, coordinating through the System Configuration Team, shall annually develop and implement a 1- and 5-year capital investment plan for the configuration of the FCRPS projects.

The capital investment plan will prescribe investment, research, monitoring, evaluation, and operations and maintenance actions to achieve the performance and water quality standards. As an advance planning tool, the capital investment plan will address specific objectives and priorities for improving fish passage and water quality. Given the objectives and priorities, the plan will define research, development, and implementation of FCRPS facility improvements to improve anadromous fish passage survival. To the extent that any actions require special system or project operations, the implementation dates and operations will be coordinated with the TMT and the development of the annual water management plan. Operations and maintenance needs and budgets associated with the capital investment plan shall also be developed.

The SCT will meet monthly or as needed to consider the results of scientific and engineering studies and to develop and recommend FCRPS fish facility improvements, including their priority, implementation schedule, and budget needs. When consensus cannot be reached on an issue, any member may elevate the issue to the implementation team for further consideration and resolution.

9.5.2.4 Water Quality

Action: The Action Agencies, coordinating through the Water Quality Team, shall annually develop a 1- and 5-year Water Quality Improvement Plan related to the operation and configuration of FCRPS projects.

The Action Agencies, working through the water quality team, will develop a water quality improvement plan that is consistent with the goals defined in Section 9.6.1.7. The water quality improvement plan will describe the objectives, priorities, and decision criteria for actions. Given these objectives and priorities, the plan will recommend FCRPS facility and operational improvements related to water quality, gas and temperature monitoring needs, and studies needed to achieve mainstem Snake and Columbia River water quality standards. In developing the water quality improvement plan, the Water Quality Team will integrate and coordinate its recommendations with the annual water management plan and the capital investment plan.

9.5.2.5 Tribal Coordination on Hydro Actions

The regional implementation forum is an important mechanism for NMFS (and the Bureau of Reclamation) to fulfill its responsibilities under the Secretarial Order on “American Indian Tribal Rights, Federal-Tribal Trust Responsibilities, and the Endangered Species Act.” The order emphasizes the importance of government-to-government consultations with the Tribes when agencies are making ESA decisions that affect Tribal interests, and recognizes that consultation requires working with Tribes on many levels. The first principle of the order provides the following:

> Whenever the agencies, bureaus, and offices of the Departments are aware that their actions planned under the ESA may affect Tribal trust resources, the exercise of Tribal rights, or Indian lands, they shall consult with, and seek the participation of, the affected Indian Tribes to the maximum extent practicable. *This shall include providing affected Tribes adequate opportunities to participate in data collection, consensus seeking, and associated processes*. [emphasis added]

The Action Agencies and NMFS encourage participation by the Tribes and Tribal organizations in all of the technical management team, system configuration team, water quality team, and implementation team processes. This provides abundant opportunity at the technical level to collect, synthesize, and exchange information and to seek consensus on implementing the Biological Opinion. Discussions at the policy level are also important in Tribal consultations and may occur through direct communications with Tribes or through policy level forums such as the Columbia River Basin Forum.

9.5.2.6 Offsite Mitigation - Habitat

Action: The Action Agencies, with assistance from NMFS and the USFWS, shall annually develop 1- and 5-year plans for habitat measures that provide offsite mitigation.

The habitat portion of the initial 5-year plan will include programs and measures from the All-H Paper that are the responsibility of the Action Agencies to fund or carry out. The plan will include schedules and costs associated with the habitat programs. The 5-year plan will also include an analysis of how the habitat measures will meet the performance standards established in this Biological Opinion. Using the 5-year plan as guidance, NMFS, USFWS and the Action Agencies will participate in regional planning and prioritization processes. Those processes include but are not limited to the Council's prioritization process and budget requests.
The 1-year plan will incorporate, to the greatest extent possible, the measures developed in regional planning and prioritization processes. The plan will explain any differences between measures contained in the plan and measures developed in other regional processes.

9.5.2.7 Offsite Mitigation - Hatcheries and Harvest

Action: The Action Agencies, with assistance from NMFS and the USFWS, shall annually develop 1- and 5-year plans for hatchery and harvest measures that provide offsite mitigation.

The harvest and hatchery portion of the initial 5-year plan will include those specific measures and programs from the All-H Paper that are the responsibility of the Action Agencies to fund or carry out. The plan will include schedules and costs associated with the harvest and hatchery programs. The 5-year plan will include an analysis of how the harvest and hatchery measures will meet the performance standards established in this Biological Opinion. Using the 5-year plan as guidance, NMFS, USFWS and the Action Agencies will participate in regional planning and prioritization processes. Those processes include but are not limited to the Council's prioritization process, *U.S. v. Oregon* production discussions, and budget requests.

The 1-year plan will incorporate, to the greatest extent possible, the measures developed in regional planning and prioritization processes. The plan will be consistent with any provisions established by *U.S. v. Oregon*. The plan will explain any differences between measures it contains and measures developed in other regional processes.

9.5.2.8 Unanticipated Actions

***Action*:** The Action Agencies shall develop procedures for carrying out actions that could not be anticipated in the planning process, but which are necessary or prudent to achieve the performance standards.

Even through the most conscientious planning efforts, it is not possible to foresee all needs or potential opportunities. There may occasionally be projects or operational measures of a limited duration and scale that are reasonable and prudent to implement and have been reviewed for scientific merit but, for a variety of reasons, were not considered during the normal planning processes. However, delaying their implementation to conform to those processes might be impractical. To address this concern, the Action Agencies shall, in collaboration with NMFS and USFWS, develop an expedited process for implementing new or unplanned activities that might result from new findings, that constitute "emergency actions," or that present an unforeseen opportunity.

Because the first 1-year plan under this RPA will not be completed until September 2001, it is anticipated that a number of early implementation actions will be added to existing plans for fiscal year 2001. This will be particularly important for research, monitoring, and evaluation needed to assess performance standards.

9.5.2.9 Approval of Plans

Action: The Action Agencies shall coordinate with NMFS and USFWS in the development of the 1- and 5-year plans.

The NMFS and USFWS will participate in the development of the 1- and 5-year plans, considering consistency with their biological opinions, adequacy of the level of effort being undertaken in all of the Hs, priority of actions, and progress toward achieving performance standards or objectives. NMFS and USFWS will issue an annual findings letter to the Action Agencies on the 1-year plan. The letter will address the consistency of the proposed annual plan with the reasonable and prudent alternative of the Biological Opinion and, if appropriate, recommend needed changes.

The plans will be carried forward into the appropriate Federal or regional planning process. The plans will be expeditiously implemented by the Action Agencies unless there are technical or feasibility impediments that cannot be reconciled, or appropriations are not forthcoming from Congress.

9.5.2.10 Annual Progress Reports

Action: The Action Agencies shall report annually to NMFS and USFWS on progress toward achieving the performance standards set out in this Biological Opinion, including comprehensive cumulative reviews in years three, five, and eight.

The report will be quantitative to the extent possible, based on observed or calculated improvements in survival by life stage or smolt-to-adult survival of each ESU. Where it is not possible to quantify results, qualitative descriptions of improvements should be provided. Progress reports should specifically address any impediments to full implementation, such as lack of necessary authorizations and appropriations or other resource limitations that cannot be addressed through other means.

9.6 Measures to Avoid Jeopardy

9.6.1 Hydro Measures

9.6.1.1 Overview

This section outlines operational and structural fish passage improvements at FCRPS projects to increase the survival of listed fish. The objective of this section is to describe the specific hydro measures that, based upon the best scientific information available, NMFS has determined are:

- Biologically feasible and implementable
- Sufficient to achieve performance standards that represent the best the hydrosystem can do without dam breaching
- Sufficient to result in a high likelihood of survival and a moderate to high likelihood of recovery, in combination with offsite mitigation defined in Sections 9.6.2, 9.6.3, and 9.6.4 of this Biological Opinion and with other improvements affecting the listed species described in the All-H Paper

The hydrosystem measures included in this section are expected to reduce juvenile and adult salmonid mortality attributable to passage through the hydrosystem and to attain the hydro performance standards by 2010. The measures are broken down into the following categories:

- Water management—management of natural flows and system storage to meet salmon flow objectives
- Juvenile fish transportation—collection and barge transportation of fish to avoid mortality at mainstem hydro projects and in reservoirs
- Juvenile fish passage—configuration and operational actions and research activities at FCRPS projects that are designed to improve juvenile fish survival at the dams
- Reservoir passage—operations and active management of salmonid predators in the mainstem to improve the survival rates of juvenile fish passing through the reservoirs
- Adult passage and research—configuration and research activities to improve adult passage survival
- Water quality—improvement in total dissolved gas levels and water temperatures within the mainstem while working toward attainment of water quality standards

- Fish facility operations and maintenance—increase commitment and ability to operate and maintain aging and new fish passage facilities to the highest possible effectiveness through enhanced effort and adequate funding

Current activities within the FCRPS include actions in all of these categories. These and additional actions to be taken in each of the categories are identified and described in this section of the Biological Opinion. NMFS has determined that all of these actions are necessary to achieve the hydrosystem performance standard. However, the strategy for achieving the objective stated above relies on the continued monitoring and evaluation of progress and the use of the information gathered to adjust or refine the actions taken. The specific measures may be revised over time through the annual and 5-year planning process.

There are seven areas of particular emphasis, which are discussed in the sections below:

- Improving water management
- Improving juvenile project passage survival
- Improving juvenile reservoir survival
- Improving adult passage survival
- Improving water quality
- Resolving critical uncertainties
- Enhanced operation and maintenance of fish passage facilities

9.6.1.1.1 Improving Water Management. Improved water management provides several direct and indirect survival benefits to salmon. Measures include managing reservoir draft and refill operations so they do not adversely affect salmon, and the use of stored water to improve salmon survival or water quality by augmenting flows. For many ESUs, the benefits are primarily measured in terms of improving the probability of achieving spring and summer flow objectives for migrating fish. Others ESUs, however, are also affected by the spawning, incubation and rearing conditions created by hydro operations. All ESUs may also be affected by estuarine and near-shore ocean conditions, which are in turn influenced by water storage activities. This RPA continues many of the 1995 Biological Opinion and 1998 and 2000 Supplemental Biological Opinion measures, including the following:

- Flow objectives at Lower Granite, Priest Rapids, McNary, and Bonneville dams
- In-season management for operational flexibility and best use of available water volumes

- Guidance on reservoir elevations in early spring, early summer, and at the end of the summer augmentation season
- Coordination with water releases from Canada, the upper Snake River, and the Hells Canyon Complex

In addition, there are several actions to improve water management for salmon, including the following:

- Additional drafts of selected FCRPS reservoirs
- Additional water from other sources
- Shifts of flood control among projects
- Implementation of VARQ flood control operations at Libby and Hungry Horse reservoirs
- Review of system flood control objectives
- Continued research on summer-migrating SR fall chinook salmon population losses

9.6.1.1.2 Improving Juvenile Project Passage Survival. Survival of juvenile salmon during their downstream migration through the FCRPS to the ocean can be further improved by providing more fish-friendly passage alternatives. Different actions are prescribed for different projects depending on their current configuration and survival levels. In general, the following actions are emphasized:

- Increased spillway passage using gas abatement and longer spill hours to allow increased spill volumes, spill pattern refinements and the evaluation of removable spillway weirs to improve spill efficiency
- Spillway passage research to identify additional potential survival and passage improvements
- Increased screen/bypass system effectiveness through extended screens, new outfalls, and improved hydraulic conditions
- Development and testing of surface bypass technology, with implementation as appropriate
- Improved turbine designs and operating guidelines
- Improved passage system operations and reliability

9.6.1.1.3 Improving Juvenile Reservoir Survival. Measures to identify and address mortality factors in the mainstem reservoirs are an important part of increasing the odds for survival of downstream migrating salmon. Actions include hydro operations, predator management, and habitat modifications that may reduce the effect of predators on salmonids. Furthermore, research and evaluation of passage survival through dams and reservoirs will continue, with emphasis on the effect of passage delay at dams and the relationship between dam passage and reservoir mortality. Numerous measures are planned to improve reservoir survival rates, including the following:

- Increased flow augmentation for summer migrants, particularly in the low water years
- Management of reservoir and run-of-river projects to reduce extreme water level fluctuations
- Management of predator populations (fishes, birds, and mammals)

9.6.1.1.4 Improving Adult Survival. Passage improvements are expected to reduce the direct and pre-spawning mortality of upstream migrating adult fish. Actions include a mix of research and configuration measures to identify and correct delay and mortality problems. Areas of emphasis include the following:

- Development of actions to reduce fallback through turbines and over spillways
- Increased facility reliability and the ability to maintain operating criteria
- Investigation of measures to protect steelhead kelts
- Investigation of pre-spawning mortality

9.6.1.1.5 Improving Water Quality. Water quality is vital to the overall health of the aquatic ecosystem as well as to the survival of listed anadromous fish. Two water quality parameters are of particular concern: total dissolved gas supersaturation and water temperature. Dissolved gas supersaturation is primarily a result of spill at dams; therefore, both operational and structural changes to dams are planned to reduce dissolved gas levels. Elevated water temperature is a more complex issue, stemming from land use practices throughout the basin as well as storage impoundments and dam operations. Numerous measures are planned to improve water quality, including the following:

- Structural and operational modifications at spillways (e.g., spillway deflectors, improved spill patterns)
- Development of alternative fish passage measures (e.g., surface bypass)

- Cool water releases from storage reservoirs (e.g., Dworshak Dam)

- Special powerhouse operations (e.g., McNary Dam)

9.6.1.1.6 Resolving Critical Uncertainties. Although we have a substantial amount of information regarding salmonid survival throughout the life cycle, there continues to be unexplained significant mortality that cannot be attributed to specific causal factors. While there are several plausible hypotheses to explain this mortality, many of the possible causes are unrelated to the hydrosystem. Of particular concern are potential delayed effects of hydrosystem actions. If the unexplained mortality is linked to identifiable hydrosystem actions, similar proposed actions could have a much lower survival benefit than predicted by direct survival estimates. Conversely, eliminating those actions (e.g., through breaching) could have a much higher benefit than what might be expected from changes in direct survival alone. Therefore, resolving uncertainties about unexplained mortality is a prerequisite to an estimate the effects of an aggressive non-breach approach or alternative actions.

In this Biological Opinion, NMFS does not propose limits on actions in any of the areas affected by uncertainty. NMFS proposes active investigation to reduce or resolve the uncertainty.

The hypothesis that delayed mortality results from passage through the hydrosystem is the most critical uncertainty regarding the effects of the hydrosystem on fish survival. It is a critical element in evaluating the effectiveness of measures on survival. Several hypothesized forms of delayed mortality are:

- Delayed mortality of transported juvenile migrants (D value when expressed relative to the survival of non-transported migrants below Bonneville Dam). This will affect the degree to which transport improves survival rates.

- Delayed mortality of inriver juvenile migrants (extra mortality). This will affect the degree to which breach, transport, and juvenile dam passage actions could contribute to improving survival rates.

- Delayed mortality and/or passage effects on adults. This includes remedies to reduce unaccounted losses or unsuccessful spawning.

- Estuarine/ocean survival. Differential timing or distribution in the estuary and ocean may help explain mortality that is otherwise attributed to the hydrosystem. Examples of this are the delayed mortality of transported and inriver juvenile migrants, discussed above.

Empirical data on these issues are limited. An improved understanding is critical because decisions on major hydrosystem configurations and/or operations will depend on the magnitude of delayed mortality and factors that contribute to it. For example, if unexplained mortality is significant, and it is solely associated with delayed effects of the hydrosystem, corrective measures within the hydrosystem can be identified to reduce it. However, if unexplained mortality is not significant regardless of its cause, addressing it would be a lower priority. If unexplained mortality is significant, but it is associated with conditions that affect fish before or after they encounter the hydrosystem, relevant non-hydro actions would be appropriate. The potential implications of unexplained mortality, and whether or not it is delayed hydrosystem mortality, make resolution of this issue a central component of the 5-year check-in and breach decision (see Section 9.4)

9.6.1.1.7 Enhanced Operation and Maintenance of Fish Passage Facilities. Fish passage facilities for both juvenile and adult salmon and steelhead are the backbone of a long-term engineering and technological commitment to fish passage survival. As with an automobile, long-term high performance of hydro facilities can only be assured by routine maintenance and replacement of defective parts. In recent years, the Corps' O&M program budget and its resource capability to maintain fish passage facilities at mainstem FCRPS projects has remained nearly static and has failed to meet growing needs. A backlog of deferred maintenance and replacement of aging components has developed due to lack of sufficient funding. New facilities are coming on line, which increases the maintenance needs and budget. Operational changes, such as extension of the fish barging season, also expand the O&M budget. Development of appropriate annual O&M budgets through the flexible 1- and 5-year planning process will help to ensure continued high performance of these facilities. Furthermore, there is room to improve the preventive maintenance planning and day-to-day operation of fish passage facilities through enhanced commitment to excluding debris and operating within identified criteria.

9.6.1.2 Water Management

9.6.1.2.1 Flow Management Objectives in Mainstem Columbia and Lower Snake Rivers

Action: The Action Agencies shall operate FCRPS dams and reservoirs considering the flow objectives (Table 9.6-1) on both a seasonal and weekly average basis for the benefit of migrating juvenile salmon.

This flow-management program uses three strategies:

- Limit the winter/spring drawdown of storage reservoirs to increase spring flows and the probability of reservoir refill.
- Draft from storage reservoirs during the summer to increase summer flows.
- Provide minimum flows in the fall and winter months to support mainstem spawning and incubation below Bonneville Dam.

Table 9-6.1. Seasonal Flow Objectives and Planning Dates for the Mainstem Columbia and Snake Rivers

	Spring		Summer	
Location	**Dates**	**Objective**	**Dates**	**Objective**
Snake River at Lower Granite Dam	4/03 - 6/20	85 - 100[1]	6/21 - 8/31	50 - 55[1]
Columbia River at McNary Dam[2]	4/10 - 6/30	220 - 260[1]	7/01 - 8/31	200
Columbia River at Priest Rapids Dam	4/10 - 6/30	135	NA	NA

[1] Objective varies according to water volume forecasts (see below).
[2] NMFS is contemplating moving the flow measurement location from McNary Dam to Bonneville Dam by creating new objectives for Bonneville Dam.

Under the first strategy, the FCRPS storage reservoirs are operated to ensure a high probability of water surface elevations within 0.5 ft of the flood control rule curve by April 10, and to refill by June 30 except as specifically provided by the technical management team. Before the 1995 Biological Opinion, FCRPS storage reservoirs were routinely drafted well below these levels to maximize hydropower generation during the fall and winter. Meeting the spring flow objectives occasionally requires reservoir drafting, but the spring flow objectives are primarily met by limiting winter drafting and reservoir refill rates. This operation allows for a more natural spring hydrograph by passing spring runoff through the storage reservoirs.

The second strategy is used to facilitate summer operations. FCRPS storage reservoirs are drafted as necessary within specified limits in an attempt to meet the summer flow objectives and to provide colder water for the benefit of migrating juvenile salmonids. These operations may also benefit adults in passage by moderating temperatures.

The third strategy has been recently integrated into the overall flow management objective to provide habitat for mainstem spawning chum and fall chinook. It includes subsequent flows to protect the redds from dewatering through their emergence in the spring, to the extent possible without impacting refill probabilities of FCRPS storage projects and spring flow objectives.

Data collected to date regarding the effects of flow on survival of fall chinook juvenile migrants (NMFS 2000b) indicate that flows in the range of 80 to 100 kcfs measured at Lower Granite Dam during the summer migration period would be optimal for these fish. However, NMFS is not revising the Snake River summer flow objectives established by the 1995 Biological Opinion (NMFS 1995) to bracket these higher levels because such flows could seldom be achieved, and there is limited value in using flow objectives that cannot be achieved as a benchmark for in-season management decisions. Moreover, though juvenile fall chinook survival is correlated with streamflow, survival shows similar correlations to water temperature and turbidity (NMFS 2000b). For this reason, water quality, particularly water temperature, should be considered in determining the optimum use of available stored water volumes for flow augmentation in the Snake River.

Spring Flows at Lower Granite Dam. Based on the April final Lower Granite Dam runoff volume forecast for April to July, spring flow objectives shall be determined as follows:

- When the volume forecast is less than 16 Maf, the flow objective shall be 85 kcfs.
- When the volume forecast is greater than16 Maf and less than or equal to 20 Maf, the flow objective shall be determined by a linear interpolation between 85 kcfs and 100 kcfs.
- When the volume forecast is greater than 20 Maf, the flow objective shall be 100 kcfs.

Summer Flows at Lower Granite Dam. Based on the June final Lower Granite Dam for April to July runoff volume forecast, summer flow objectives shall be determined as follows:

- When the volume forecast is less than 16 Maf, the flow objective shall be 50 kcfs.
- When the volume forecast is greater than 16 Maf and less than or equal to 28 Maf, the flow objective shall be determined by a linear interpolation between 50 kcfs and 55 kcfs.
- When the volume forecast is greater than 28 Maf, the flow objective shall be 55 kcfs.

Spring Flows at McNary Dam. Based on the April final for April to August runoff volume forecast at The Dalles Dam, spring flow objectives shall be determined as follows:

- When the volume forecast is less than 80 Maf, the flow objective shall be 220 kcfs.
- When the volume forecast is greater than 80 Maf and less than or equal to 92 Maf, the flow objective shall be determined by a linear interpolation between 220 kcfs and 260 kcfs.
- When the volume forecast is greater than 92 Maf, the flow objective shall be 260 kcfs.

Spring Flows at Priest Rapids Dam. The spring flow objective at Priest Rapids Dam shall be 135 kcfs.

Summer Flows at McNary Dam. The summer flow objective at McNary Dam shall be 200 kcfs. The best biological information supports flows of 200 kcfs for subyearling chinook salmon in the lower Columbia River. However, if the numbers of juvenile fish migrating during late August decrease sharply, the technical management team should consider preserving some of the flow augmentation water to support the fall spawning operation below Bonneville Dam.

Action: The Action Agencies shall operate the FCRPS to provide flows to support chum salmon spawning in the Ives Island area below Bonneville Dam.

A spawning operation shall be implemented as described below if the best hydrologic data available by early October indicate that precipitation, runoff, and reservoir storage are likely to support the operation from the start of spawning (late October or early November) until the end of emergence (generally through the start of the spring flow augmentation season in April). The spawning operation cannot adversely affect implementation of this RPA or the parties' ability to comply with the Vernita Bar agreement. That agreement protects natural production of unlisted fall chinook in the Columbia River Hanford Reach. If these conditions cannot be met, the Action Agencies shall work with NMFS and regional salmon managers to identify operations that would benefit salmon while maintaining these other fish protection measures. Such operations may include intentional flows below what is necessary for mainstem spawning to discourage redds from being established in the area.

Real-time operating decisions shall be made through the in-season management process described in Section 9.5 the technical management team shall recommend a managed daily average discharge level as information on natural flows and reservoir storage becomes available. The operation for Columbia River mainstem spawning chum salmon shall include the following considerations:

- If the operation complies with the conditions described above, it shall begin when chum salmon are found in the area around Ives and Pierce islands, but no later than November 1. From November 1 through December 31, FCRPS storage shall be used to shape or augment natural flow to a 125 kcfs minimum instantaneous discharge from Bonneville Dam. To prevent spawning in areas that could subsequently be dewatered, the Action Agencies shall maintain peak flows within 5 kcfs of the established minimum. For example, if the minimum flow is 125 kcfs, the instantaneous maximum would be 130 kcfs.

- NMFS recognizes that access to spawning habitat in the Ives Island area is primarily a function of the water surface elevation in the Ives and Pierce islands area. Water surface elevation, in turn, is influenced by tides, flow of the Willamette River, and discharge from Bonneville Dam. If the established managed discharge cannot be maintained on an instantaneous basis (e.g., during a low spring tide), the Action Agencies shall manage FCRPS operations to maintain the water surface elevation in the Ives Island area above the highest redd established by the managed operation.

- When reservoir storage, baseflows, and predicted hydrologic conditions permit, a managed daily minimum discharge greater than 125 kcfs may be adopted through coordination with NMFS and the Regional Forum. If such a higher minimum discharge is adopted, the Action Agencies shall manage storage with natural flow to provide peak flows within 5 kcfs of the established minimum.

- During incubation and emergence (January 1 through the start of the spring flow augmentation program for the lower Columbia River on April 10), the Action Agencies shall manage storage with natural flows to maintain the daily minimum discharge from

Bonneville Dam needed to protect the highest redd established by the operation and to maintain connectivity between spawning habitat and the mainstem for outmigrants. For example, if the highest redd established by the spawning operation was at an elevation corresponding to a Bonneville outflow of 125 kcfs, a discharge of at least 125 kcfs shall be maintained through incubation and emergence. For all managed spawning flows 135 kcfs and above, the highest spawning flow minus 10 kcfs shall be the managed minimum discharge during incubation and emergence. The highest managed daily average discharge that shall be provided during the incubation and emergence period is 150 kcfs.

If in-season data on reservoir elevations and forecasted inflow indicate that operating FCRPS storage reservoirs to provide the flows specified above during chum incubation and emergence would place at risk the ability to meet RPA items above and/or the ability of parties to comply with the Vernita Bar agreement, the instantaneous minimum Bonneville outflow shall be reduced as necessary to meet these requirements. The Action Agencies shall ensure that flow reductions are coordinated through the technical management team to ensure that adverse effects are minimized and to facilitate the development of emergency actions.

The provision of flow to support chum spawning creates a need to provide continual flow through the FCRPS to maintain the redds established below Bonneville Dam during the managed spawning operation. Hydrosystem modeling results suggest that conflicts will occasionally arise between providing the quantity of flow required to maintain established redds and the need to reduce discharge from Grand Coulee to achieve refill to the spring upper rule curve elevation. Resolution of this potential conflict will be determined on an annual basis. In general, achieving upper rule curve elevation by April 10 will be a high priority.

Action: The Action Agencies shall operate the FCRPS to provide access for chum salmon spawning in Hamilton and Hardy creeks.

During years when it is determined that there is insufficient water in storage to maintain a mainstem spawning flow of at least 125 kcfs throughout the spawning season, then sufficient flow shall be provided during the chum spawning season at times to allow access to tributary creeks. Current data indicates a flow of 125 kcfs is required to meet this need.

9.6.1.2.2 Planning and Management of Available Water to Support Mainstem Flow Objectives

Action: The Action Agencies shall coordinate with NMFS, USFWS, and the states and Tribes in preseason planning and in-season management of flow operations. This coordination shall occur in the technical management team process (see Section 9.5.2.2)

Flow objectives serve as a guide to manage available water resources during the juvenile migration season and provide a reference for comparing various operational scenarios that may affect inriver migration conditions. They are not hard constraints. Hydrologic conditions and other constraints may preclude meeting these objectives at all times. These objectives may not represent optimal conditions and therefore may be exceeded if that is deemed the optimal use of water resources after considering the effects on all listed species. Likewise, flow augmentation should not be stopped or diminished once a seasonal average is met. Rather, the flow objectives provide general guidance to the Action Agencies and the technical management team, discussed in Section 9.5.2.2 for its in-season management considerations. Because water resources are insufficient to meet the fish flow objectives at all times under all conditions, in-season water management will strive to provide the greatest possible biological benefit from the available storage volumes and system flexibility. Although meeting the flow objectives is an important consideration, that is not an end in itself. The flow objectives are but one of many factors to consider when making decisions about river operations to benefit listed fish. The dates indicated in Table 9.6.1 are for planning purposes. Actual timing of flow measures will be determined in-season by TMT.

The Action Agencies have multiple responsibilities affecting hydrosystem operations, including flood control, power production, protection of anadromous and resident fishes and wildlife, recreation, and irrigation. In making operational decisions to meet other FCRPS project purposes and regulatory requirements, the Action Agencies will take all appropriate actions within their authorities to protect listed salmonids.

9.6.1.2.3 FCRPS Reservoir Operations to Support Mainstem Objectives

Action: The Action Agencies shall operate the FCRPS during the fall and winter months in a manner that achieves refill to April 10 flood control elevations, while meeting project and system minimum flow and flood control constraints before April 10. During the spring, the Action Agencies shall operate the FCRPS to meet the flow objectives and refill the storage reservoirs (Albeni Falls, Dworshak, Grand Coulee, Hungry Horse, and Libby) by approximately June 30.

In the event that both these objectives cannot be achieved, the TMT will make an in-season decision, weighing considerations unique to each particular year. Because research results indicate that flow augmentation has more direct survival benefits for summer than spring migrants, modest reductions in spring flows to facilitate reservoir refill would generally be preferable to refill failure.

Operating the storage reservoirs to their upper (flood control) rule curve by April 10 will provide a more natural hydrograph, and increase the likelihood that spring flow objectives will be met and reservoirs refilled by June 30. Having reservoirs full on or about June 30, when natural runoff declines, results in the greatest amount of water available for the summer migration period. NMFS recognizes that meeting these flow objectives while refilling reservoirs cannot be achieved every year, particularly in low water years.

Action: The Action Agencies shall operate specific FCRPS projects as follows:

Hungry Horse Dam. The Action Agencies shall implement VARQ (Corps 1999) as a flood control operations strategy by October 1, 2000, and upon completion of coordination with appropriate Canadian entities. The Action Agencies shall limit fall and winter reservoir drafts to achieve a 75% probability of being at the flood control rule curve elevation by April 10 of each year. The 1995 Biological Opinion included the option of deeper summer drafts of FCRPS storage projects in low water years. NMFS is continuing this approach in low runoff years by defining those years with April to August runoff less than 80 Maf at The Dalles as low runoff years[2]. In years when the official July final April-to-August runoff volume forecast at The Dalles is greater than 80 Maf, the Action Agencies shall draft the reservoir as needed for salmon flow augmentation to elevation 3540 feet by August 31. If the official July final runoff forecast is less than or equal to 80 Maf, the Action Agencies shall draft the reservoir a total volume of 481 kaf from its highest elevation on or about July 1, but limit the reservoir draft for salmon flow augmentation to elevation 3530 feet by August 31.

There are three operational constraints at Hungry Horse limiting its ability to refill to full pool by the end of June, thereby increasing the likelihood of deeper summer drafts for salmon (e.g., below elevation 3540 feet). These constraints are:

- Minimum flow requirements of 3500 cfs in the Flathead River at Columbia Falls for listed bull trout and resident fish
- Minimum flow requirements of 1000 cfs in the South Fork Flathead River below the project for bull trout, as called for in the USFWS 2000 Biological Opinion
- Operations to avoid spill at the project during refill, especially if turbines are out of service.

By October 1, 2000, the Corps shall evaluate and recalculate end-of-June upper rule curve refill requirements at Hungry Horse, if necessary, to allow refill of the reservoir to full pool by June 30 more frequently than the 60% currently achievable. BOR shall develop a powerhouse maintenance plan to provide full powerhouse capacity with all units operational during the refill season. The Corps shall coordinate drafts for salmon with the USFWS, the Action Agencies, and other entities through the in-season management process. As a guideline for salmon flow augmentation releases during July and August, Hungry Horse may be operated in a manner that reduces impacts to other listed species while also releasing water to meet salmon flow objectives. Reduction in a "second peak" operation can be achieved by discharging water earlier or at a more constant rate, to provide the full volume available for salmon.

---

2 There are 11 years with less than 80 Maf runoff in the 50-year water record, or 22%.

When a January final April-August forecast of less than 80 Maf at The Dalles occurs, USFWS and NMFS will coordinate and recommend a lower minimum flow than the standard bull trout minimum from Hungry Horse in order to provide a balance between the needs of bull trout and salmon when limited water is available.

Libby Dam. The Action Agencies shall implement VARQ (Corps 1999) as a flood control operations strategy by October 1, 2001, and upon completion of coordination with appropriate Canadian entities. The Action Agencies shall limit fall and winter reservoir drafts to achieve a 75% probability of being at the flood control rule curve elevation by April 10. The Action Agencies shall limit the reservoir draft to elevation 2439 feet by August 31 for salmon flow augmentation. The Corps shall coordinate drafts for salmon with USFWS, the Action Agencies, and other entities through the in-season TMT process. If Libby is below elevation 2439 feet on July 1, the Action Agencies shall provide the USFWS bull trout minimum flow or inflow, whichever is greater, during the July and August salmon flow season.

As a guideline for salmon flow augmentation releases during July and August, Libby may be operated in a manner that reduces impacts to other listed species while releasing water to meet salmon flow objectives. Reduction in a “second peak” operation can be achieved by implementation of a Canadian storage/Libby exchange of water or releasing water earlier. However, operational flexibility should be retained to release water during the salmon flow season water when fish timing or achievement of flow objectives warrant.

Albeni Falls Dam. The Action Agencies shall draft Albeni Falls every alternate year, beginning in the year 2000 through 2006, but no lower than elevation 2051 feet, to meet chum salmon flow needs during November and December. During the fall-winter of 2001, the Action Agencies shall maintain Lake Pend Oreille at elevation 2055 feet and repeat this alternating sequence to conduct a kokanee “draw-up” spawning evaluation. The Action Agencies shall provide a water volume for chum spawning to offset water retained in Lake Pend Orielle between elevation 2051 and 2055 each year the lake is not drafted to 2051 (e.g., for the kokanee production investigation). Such offset water could be stored water or a shaping of flood control releases into the November to December time frame. The Action Agencies shall manage winter operations to provide a 90% probability of being at the flood control rule curve elevation by April 10. The Action Agencies shall coordinate fall reservoir operations through the technical management team. The Action Agencies should not refill Lake Pend Oreille from April 10 through April 30 while downstream flow objectives (Priest Rapids and McNary) are not being met.

Grand Coulee Dam. The Action Agencies shall implement VARQ as part of the system flood control operation as noted above at Hungry Horse and Libby. The Action Agencies shall limit fall and winter reservoir drafts to achieve an 85% probability of being at the flood control rule curve elevation by April 10. The Action Agencies shall draft the reservoir as needed to meet the summer flow objective at McNary Dam. Based on the July final April to August runoff volume forecast, the Action Agencies shall limit the reservoir draft to the following end-of-August elevations: 1280 feet in years when the forecast equals or exceeds 92 Maf; and 1278 feet in years when the forecast is less than 92 Maf.

Dworshak Dam. The Action Agencies shall attempt to refill the reservoir by June 30, while coordinating with the technical management team to meet the spring flow objectives. The Action Agencies shall limit reservoir drafts to elevation 1520 feet by August 31st to benefit the summer juvenile fish migration. The Action Agencies shall manage Dworshak discharge to attempt to maintain water temperatures at the Lower Granite Reservoir forebay dissolved gas monitoring station at or below 20°C (68°F). To facilitate refill and storage for next year's salmon operations, the Action Agencies shall discharge the established minimum 1-turbine flow (about 1,300 cfs at present) following fisheries operations, unless higher flows are required for flood control purposes.

Action: The Corps shall operate the lower Snake River reservoirs within 1 foot of minimum operating pool (MOP) from approximately April 3 until small numbers of juvenile migrants are present, and operate the John Day pool within a 1-and-a-half-foot range of the minimum level that provides irrigation pumping from April 10 to September 30.

The date for implementing MOP conditions may be delayed at the request of the technical management team to facilitate drafting the pools to MOP to increase discharge at Snake River projects when such increased flows would be more beneficial to juvenile fish. Lower pools reduce cross-sectional area, increasing water velocity at a given flow. Because juvenile migrants travel faster with increased water velocities, drawdown to MOP is expected to provide faster emigration and improved survival (NMFS 2000).

Filling the lower three pools allows adult fishways to operate closer to the gate depth criteria of 8 feet at Lower Monumental Dam, 6 to 7 feet at Little Goose Dam, and 7 to 8 feet at Lower Granite Dam. However, recent information indicates that adult salmon pass the Snake projects readily with gate depths of less than 7 feet (5.5 to 7 feet; low flows and low turbidity generally provide decreased passage times for adult migrants) (Blankenship and Mendel 1997, Bjornn et al. 1998). The effect of this operation will be evaluated during 2000 by the ongoing 2000 radio tracking study. A recommendation for refill of the lower three pools by the technical management team near the end of the juvenile fall migration to increase depths at adult entrances should take into consideration the potential increase in water temperatures that can occur with decreased flows. Lower Granite should not be refilled until sufficient natural cooling has occurred in the fall, generally after October 1.

Action: The Corps shall routinely identify opportunities to shift system flood control evacuation volumes from Brownlee and Dworshak reservoirs to Lake Roosevelt and identify such opportunities for the technical management team. The Corps shall implement flood control shifts as necessary to best protect listed fish, as called for by NMFS in coordination with the technical management team, taking into account water quality issues and the concerns of all interested parties.

Flood control shifts afford an opportunity to increase the frequency that Snake River spring flow objectives are met while only slightly affecting mid-Columbia River flow conditions. Lesser flood control drafts would occur at Brownlee and Dworshak through March, affording an opportunity to increase flows in the Snake River during April.

Action: The Corps and BOR shall implement VARQ flood control operations, as defined by the Corps (1999), at Libby (by October 1, 2001) and Hungry Horse (by October 1, 2000) reservoirs. By October 1, 2000, the Corps shall develop a schedule to complete all disclosures, NEPA compliance, and successful Canadian coordination necessary to implement VARQ flood control at Libby.

VARQ reduces system flood control drafts at Libby and Hungry Horse reservoirs in years when flood control risks are moderate (average to below average water years) and adds about 10,000 cfs to summer flows at McNary Dam without increasing flood risks. Impacts to power, flood control, and environmental conditions in Canada have not been fully identified and coordinated. The VARQ concept is a change in system flood control developed by the Corps (1997 and 1999) in response to NMFS' 1995 Biological Opinion and requirements for Kootenai River sturgeon and bull trout imposed by the U.S. Fish and Wildlife Service (1996, 2000). Conformance with these biological opinions resulted in discharges from Libby Dam during the annual reservoir refill period far in excess of those envisioned in existing flood control operating plans. These fishery operations can reduce the likelihood and frequency of refill, adversely affecting the availability of augmentation water. NMFS 1995 Biological Opinion also required the Corps to carefully evaluate system flood control operations. The VARQ concept responds to all these Biological Opinion requirements.

In essence, VARQ shifts some system flood control requirements from Hungry Horse and Libby to Grand Coulee. Because Grand Coulee is closer to the major damage centers in the Portland, Oregon, and Vancouver, Washington, metropolitan area (the target of system flood control), it has a greater effect on peak flows than Hungry Horse and Libby. Thus, the amount of additional storage required at Grand Coulee to reduce flood risks to an acceptable level is less than the amount of storage foregone at Hungry Horse and Libby under VARQ. By moving system flood control storage evacuation to Grand Coulee, Hungry Horse can be operated to store up to 400 kaf more water in the spring, and Libby can store up to 1.5 Maf more under VARQ than under current constraints. Local flood control and other effects are small. These operations will increase flow levels in the lower Columbia River and the frequency of achievement of the flow objectives, in improved conditions for migration.

Whereas many interested parties are aware of this potential operation, implementing VARQ flood control may require additional coordination with Canada and environmental compliance.

9.6.1.2.4 BOR Non-FCRPS Project Operations to Support Mainstem Flow Objectives

Action: The BOR shall continue to annually provide 427 kaf from the upper Snake River, pursuant to state law, during the juvenile salmon outmigration period (April through August).

To provide this water, BOR has reacquired some 60,000 acre-feet of reservoir storage space in its upper Snake River basin reservoirs and has assigned about 100,000 acre-feet of previously unassigned space to flow augmentation. BOR has also leased 38,000 acre-feet of storage space in Palisades Reservoir as part of a 5-year agreement with the Shoshone Bannock Tribes of the Fort Hall Indian Reservation and has acquired 17,650 acre-feet of natural flow rights in Oregon for flow augmentation. BOR proposes to acquire any remaining water needed to meet the 427-kaf goal from willing lessors in Idaho's water banks. Using this strategy, BOR has successfully provided about 427 kaf annually from upper Snake River basin reservoirs and natural flow rights since 1993.

While the BOR has been able to meet its commitment to provide this amount since 1993, hydrologic conditions and legal and institutional impediments limit the surety that this amount could be provided in all years (NMFS 1999). BOR has committed to using available powerhead space[3] in several of its reservoirs in the event that it would be unable to provide 427 kaf without this extraordinary measure. Even with these measures, BOR estimates that during extended droughts it would be unable to deliver 427 kaf for salmon flow augmentation and BOR's access to Idaho's water banks expires at the end of 2000.

Action: The BOR shall operate Banks Lake at an elevation 5 feet from full during the month of July or August by reducing the volume of water pumped from Lake Roosevelt into Banks Lake by about 130 kaf during this time period.

Banks Lake is a 27-mile-long equalizing reservoir for the Grand Coulee pump-generating plant. It also provides water to irrigate 672,000 acres of Columbia Basin Project lands. Banks Lake has an active storage capacity of 715,000 acre-feet. BOR indicates the 130 kaf volume contained in the top 5 feet of Banks Lake storage (i.e., within its normal operating range) could be used to augment Columbia River flows during the summer migration period. This would be accomplished by reducing the volume of water pumped into Banks Lake from Lake Roosevelt and drafting it directly from Lake Roosevelt.

---

[3] At some projects, powerhead provides the necessary reservoir elevation for water diversions pursuant to state law. Idaho and stakeholders in BOR's projects have disputed the legality of using powerhead space for flow augmentation. NMFS and the BOR consider powerhead water to be legally available for flow augmentation and will continue to rely on it as necessary.

9.6.1.2.5 Non-Federal Project Operations Coordinated with FCRPS and BOR Projects to Support Mainstem Flow Objectives

Action: The Action Agencies shall facilitate and assist shaping and pass-through of upper Snake basin water at Idaho Power Company's (IPC) Hells Canyon Hydroelectric Complex (HCC) for flow augmentation to meet the flow objectives at Lower Granite Dam.

Presently the NMFS is in ongoing ESA Section 7 consultation with FERC and IPC on HCC operations. The technical management team may request alternate operations based on fish passage and flow conditions in-season.

Action: The BPA and Corps shall continue to request and negotiate agreements to annually provide 1 Maf of Treaty storage during January through April 15 and release the water during the migration season, and shall seek additional storage amounts.

Action: The BPA shall negotiate with BC Hydro and the other U.S. non-Treaty Storage Agreement signatories to mutually store water in NTS during the spring for subsequent release in July and August for flow enhancement, as long as operations forecasts indicate that water stored in the spring can be released in July and August.

Flow objectives are met infrequently during the summer months in the lower Columbia River. Storing water during the spring runoff for release during the summer months increases the frequency of meeting the summer flow objectives.

Action: The BPA shall negotiate with BC Hydro to release additional non-Treaty Storage water during July and August.

A promising prospect for achieving these objectives is installation of two additional turbines in the powerhouses at Mica and Revelstoke dams. This would allow flow to increase by an additional 20 kcfs during the months of July and August without the need to spill from these projects.

9.6.1.2.6 Measures to Evaluate and Adjust the Amount of Water Available to Support Flow Objectives

BOR Projects Basinwide. Operation of BOR's projects in the Columbia River basin contribute to streamflow depletions in the Columbia and Snake rivers during the juvenile salmon outmigration season. These depletions decrease the frequency of achieving flow objectives needed to protect migrating juveniles. The following measures specify actions within BOR's authority to reduce streamflow depletions at its projects.

Action: Before entering into any agreement to commit currently uncontracted water or storage space in any of its reservoirs covered by this Biological Opinion to any other use than salmon flow augmentation, BOR shall consult with NMFS under ESA section 7(a)(2). Such consultations shall identify the amount of discretionary storage or water being sought, the current probability of such storage or water being available for salmon flow augmentation, and any plan to replace the storage volume currently available to salmon flow augmentation that would be lost as a result of the proposed commitment. Also, BOR shall consult with NMFS prior to entering into any new contract or contract amendment to increase the authorized acreage served by any irrigation district receiving BOR-supplied water. The NMFS' criterion in conducting such reviews is to ensure that there be zero net impact from any such BOR commitment on the ability to meet the seasonal flow objectives established in this Biological Opinion. Replacement supplies should have at least an equal probability of being available for salmon flow augmentation as the storage space or water that is being committed.

Given that current rates of water deliveries adversely affect survival conditions in the migration corridor, further depletions should be avoided until recovery is achieved.

Action: The BOR shall pursue water conservation improvements at its projects and shall use all mechanisms available to it under state and Federal law to ensure that a reasonable portion of any water conserved will benefit listed species.

This action item is aimed at developing cooperative mechanisms to put more water in the mainstem Snake and Columbia rivers during the juvenile salmon migration season (April through August). Water conservation is one mechanism that can reduce total diversions and consumption without adversely affecting agricultural production. To be valuable to listed fish, water conservation must result in increased stream flow. Accomplishing this task will require the cooperation of water users and the exploration of opportunities under state law to protect such water from diminishment.

Action: Within two years from the date this opinion is signed, the BOR shall provide to NMFS a detailed progress report addressing the situation where BOR-supplied water within the Columbia River basin is being used without apparent BOR authorization to irrigate lands. In the report, BOR will indicate how it will proceed to identify and address instances of unauthorized use.

Federal agencies are required to consult only on actions that are "authorized, funded, or carried out by such agency[.]" 16 U.S.C. § 1536(a)(2). NMFS recognizes that unauthorized uses of BOR-supplied water are by definition not "authorized, funded or carried out" by BOR. As BOR works within the limits of its authority to address any identified situation of unauthorized use of BOR-supplied water, NMFS recognizes that in almost every instance, the BOR will need to take contract actions. Accordingly, in the second action item above of 9.6.1.2.6, NMFS has set out how to consult on these contract actions. This reporting requirement will assist all parties to understand the nature and extent of actual unauthorized use.

Action: For those BOR projects located in the Columbia River and its tributaries downstream from Chief Joseph Dam and those in Snake River basin tributaries downstream from Hells Canyon Dam (see table below), BOR shall, as appropriate, work with NMFS in a timely manner to complete supplemental, project-specific consultations. These supplemental consultations shall address effects on tributary habitat, tributary water quality, and direct effects on salmon survival (e.g. impingement, entrainment in diversions, false attraction to return flows, and others). These supplemental consultations shall address effects on mainstem flows only to the extent to which they reveal additional effects on the in-stream flow regime not considered in this Biological Opinion (e.g., flood control).

This Biological Opinion considered the likely effects of BOR's Columbia basin irrigation projects on flow conditions in the mainstem Snake and Columbia river migration corridor. Other effects, such as tributary habitat, fish passage and entrainment, and water quality, have not been evaluated in this Biological Opinion. In furtherance of the aggressive approach defined in this RPA, timely consideration of such effects and, if necessary, development and implementation of measures to avoid, minimize, or mitigate such effects, is needed. Supplemental consultations for several of these projects are currently underway (e.g. Yakima Project, Lewiston Orchards, Umatilla). These overarching needs are further defined in the project-specific measures identified below in Table 9.6-2.

Table 9.6-2. BOR Projects in the Columbia Basin Subject to Supplemental Consultations

Project	Location	Subbasin or Stream
Upper Columbia River (Upstream of Snake River Confluence)		
Chief Joseph Dam	North-central Washington, from Canadian border to Wenatchee	Okanogan and Columbia Rivers
Okanogan	North-central Washington, near Okanogan	Okanogan River
Yakima	Central Washington, near Yakima	Yakima River
Lower Columbia (Downstream of the Snake River Confluence)		
Umatilla	Northeast Oregon	Umatilla and Columbia Rivers
Arnold	Central Oregon, south of Bend	Deschutes River
Crescent Lake Dam	Central Oregon west of Bend	Deschutes River
Crooked River	Central Oregon, north of Bend	Crooked River
Deschutes	Central Oregon, north of Bend	Deschutes River
Wapinitia	North-central Oregon, south of The Dalles	Deschutes River
The Dalles	North-central Oregon, near The Dalles	Columbia River
Tualatin	Northwest Oregon, west of Portland	Tualatin River (Willamette River)
Snake River		
Lewiston Orchards	West-central Idaho, near Lewiston	Clearwater River

Upper Snake River Basin Projects. Projects in the Snake River basin located above Brownlee Reservoir are grouped as in the 1999 Supplemental FCRPS Biological Opinion. The assessment in this Biological Opinion is limited to considering the effects of the upper Snake project diversions and return flows (i.e., the aggregate effects of the "depletions") on the flow regimes in the Columbia and Snake rivers, including the mainstem flow objectives established in this Biological Opinion.

Action: The BOR shall seek through ongoing negotiations with stakeholders in Idaho to determine additional state law mechanisms to increase supplies of water available for flow augmentation from willing sellers and lessors.

Through ongoing negotiations with stakeholders in Idaho, the BOR is seeking to increase supplies of water available for flow augmentation by acquiring greater access to Idaho's water banks. The exact amounts that could be available from this source for flow augmentation vary annually with water supply, and the level of access that might be acquired through these negotiations is currently unknown.

Columbia Basin Project. Grand Coulee Dam, which is an integral component of the Columbia Basin Project, is also one of the specific FCRPS projects addressed in Section 9.6.1.2.3, on FCRPS Reservoir Operations. Because the Columbia Basin Project diverts water from and returns it to the mainstem Columbia River above McNary, its storage and diversion operations are not easily separated from the other operations at Grand Coulee.

Action: The BOR shall assess the likely environmental effects of operating Banks Lake up to 10 feet from full pool during the month of August. The assessment and NEPA compliance work shall be completed by June 2002 to determine future operations at this project by summer 2002.

An additional 130 kaf could be obtained from Banks Lake storage if the project were drafted 5 more feet, for a total draft of 10 feet, during the summer. This would provide a total flow augmentation volume from Banks Lake of about 260 kaf. However, because this total draft is beyond the normal project operating range, the BOR will need to conduct a formal study and NEPA compliance on this action before implementation.

Dworshak Hatchery and Reservoir Operations

Action: The Corps, in coordination with USFWS, shall design and implement appropriate repairs and modifications to provide water supply temperatures for the Dworshak National Fish Hatchery that are conducive to fish health and growth, while allowing variable discharges of cold water from Dworshak Reservoir to mitigate adverse temperature effects on salmon downstream in the lower Snake River.

The rationale for providing improvements to the hatchery water supply is to isolate the effect of Dworshak Reservoir operations on Snake River temperature control from the effect of hatchery operations. At present, Dworshak Reservoir cannot be operated for optimal temperature releases because of adverse effects on hatchery rearing performance. This problem would be resolved by making improvements in the hatchery water supply system to accommodate releases of cooler water from Dworshak to benefit salmonid migrants and water quality in the lower Snake River.

Action: The Action Agencies shall evaluate potential benefits to adult Snake River steelhead and fall chinook salmon passage by drafting Dworshak Reservoir to elevation 1500 feet in September. An evaluation of the temperature effects and adult migration behavior should accompany a draft of Dworshak Reservoir substantially below elevation 1520 feet.

The rationale for evaluating an additional 20-foot draft of Dworshak Reservoir in September is to determine whether cooling Snake River temperatures during September would provide an adult passage benefit. The potential benefits are 1) reduction in water temperature, 2) possible elimination of a thermal block that delays adult migration into and through the lower Snake River, and 3) improved gamete viability. An evaluation should be conducted to assess the effects of the September draft on lower Snake River temperatures and on the migratory behavior and passage timing of adult salmonids that are equipped with depth and temperature-sensitive tags. An evaluation of Dworshak refill probability indicates this study operation would have little impact on reservoir refill by the end of June in the following year, i.e., one additional refill miss within 3 to 4 feet of full pool in BPA's 50-year hydrosystem study.

Flood Control Assessment

Action: The Corps shall develop and conduct a detailed feasibility analysis of modifying current system flood control operations to benefit the Columbia River ecosystem, including salmon. The Corps shall consult with all interested state, Federal, Tribal, and Canadian agencies in developing its analysis. By December 31, 2000, the Corps shall provide a feasibility analysis study plan for review to NMFS and all interested agencies, including a peer-review panel (at least three independent reviewers, acceptable to NMFS, with expertise in water management, flood control, or Columbia basin anadromous salmonids). A final study plan shall be provided to NMFS and all interested agencies by July 1, 2001. The Corps shall provide a draft feasibility analysis to all interested agencies, NMFS and the peer-review panel by September 2005.

The primary objectives of this feasibility analysis shall include reducing the effects of flood control operations on the spring freshet, particularly during average to below average runoff years; minimizing flow fluctuations during fall chinook emergence and rearing; and achieving a high probability of reservoir refill, particularly at Dworshak, Grand Coulee, Hungry Horse, and Libby reservoirs, while maintaining acceptable levels of protection for developed areas within the active floodplain. This analysis shall consider all aspects of flood control, including: the flood control target flow(s); associated storage reservation diagrams; the method of calculating the initial control flow; and the timing and coordination of flood control management. The study shall incorporate the best currently available forecast technology for estimating runoff and peak flows. Innovative concepts, such as using an expert system to define operations in real-time, that would increase system flexibility or the ability to achieve the above stated objectives, should be incorporated to the extent practical. New storage reservation diagrams should include mechanisms for interpolation to facilitate higher storage contents going into the spring in some years. The Corps shall also identify those improvements necessary to facilitate higher flood control target flows and estimate the cost and time needed to implement such improvements.

This analysis shall include all Federal, non-Federal, and Canadian projects currently operated for system flood control. Because modifying flood control operations would affect an array of interests, the Corps should consult with all interested state, Federal, Tribal, and Canadian agencies in developing its analysis. The final feasibility report shall include a proposed action and respond to all concerns and comments on the draft.

System flood control strongly influences streamflow characteristics in the mainstem Snake and Columbia rivers. As described in Section 6 of this Biological Opinion, these hydrologic effects affect juvenile salmon survival. While current flood control operations routinely reduce even non-damaging floods, peak flows of historical magnitude (e.g. 1948 Vanport flood) would result in substantial damage. The intent of this study is to refine flood control operations such that flood control operations cause the least possible reduction in runoff volumes and the probability of reservoir refill while maintaining high levels of protection from damaging floods. Preliminary analysis of modifying system flood control showed that potentially much higher spring flows were possible (Corps 1997) in some years.

Much of the existing flood control operation plan dates to the 1960s and a systematic review of flood control operations has not occurred since 1991. That study, however, was based on the fundamental premise *"that the existing flood control capability ... would remain unchanged after any rule curve modifications were made."* (Corps 1991). Thus, *"it is conceivable that flood control criteria could be reduced substantially, and levees raised a corresponding amount to compensate."* A broader consideration of flood control options could identify operations that would benefit the fishery without increasing the likelihood of damaging floods.

New streamflow prediction techniques, including extended streamflow prediction (ESP) (NOAA River Forecast Center streamflow model) and remote sensing are much improved since 1969. Computer improvements facilitate consideration of a broader range of alternatives and the ability to manage flood risks more closely to a real-time basis. A thorough investigation of new forecasting technologies would enhance system response and afford greater precision in system flood control operations.

Furthermore, flood control concepts are changing. Historically, efforts were made to protect all developed lands from flooding by using levees, revetments, and upstream storage. These efforts have effectively disconnected rivers from their floodplains and have had both ecological and human consequences (Benner and Sedell 1997). Ecologically, diverse and integral habitats are lost when structures isolate a river from its floodplain (Ligon et al. 1995). Riparian corridor simplification is a significant cause of salmon declines (Ligon et al. 1995). Also, by cutting off upstream flood plains from the river, vast flood storage potential is lost, and floodplain development is encouraged. Thus, when large floods occur, the outcomes in terms of property damage can be more severe than would have occurred if lesser flood protection efforts had been taken and floodplain development discouraged. By examining flood damage areas and flood protection structures throughout the river corridor, the Corps may identify opportunities to bring more connectivity to some areas of active flood plain (e.g. undeveloped land and farmland) and more effective flood protection to others (e.g. communities).

Libby Operations

Action: By October 1, 2001, the Corps shall develop, and if feasible implement, a revised storage reservation diagram for Libby Reservoir that replaces the existing fall draft to fixed end-of-December elevations with variable drafts based on the El Niño Southern Oscillation Index (SOI) predictions or other forecast methodologies of runoff volume. The Corps will also complete successful coordination with Canada under the Columbia River Treaty.

Currently, a fall draft at this project is aimed at reaching a fixed end-of-December elevation to ensure that, given other project constraints, sufficient water can be evacuated to achieve desired levels by the end of April in all years. If lesser drafts were made, it could be difficult to achieve desired reservoir levels in the wetter years. Traditional snow-water surveys are not available until January, so Libby is drafted each year in the fall assuming a wet year condition. In low water years, this can result in drafts below the subsequent April 30 upper rule curve elevation (end of storage evacuation season), and result in the project being unable to refill by the end of June. Under current operating criteria, hydrosystem regulation studies (BPA 2000) show that Lake Koocanusa does not achieve the 75% probability of refill proposed by the Corps in the Biological Assessment (BPA et al. 1999). These excessive drafts can increase the streamflow attenuation necessary to achieve refill in the spring and reduce the probability of refill, placing additional risks on listed fish, particularly in the driest years when increasing discharge would be most valuable.

Recent advances in climatology have resulted in predictive tools that roughly estimate Pacific Northwest runoff volumes from meteorological conditions in the southern Pacific. The Corps has adopted an SOI-based runoff model as the best available forecast for Libby and Dworshak and uses these forecasts to define drafts from January through April for those projects. Also, the Corps is investigating operational changes that could alleviate the reason for avoiding all spills at Libby Dam, which is a contributing factor in the current fixed end-of-December reservoir draft. This RPA measure expands the use of the SOI-based runoff prediction into the fall and revises the storage reservation diagram to allow reduced drafts in average to dry years.

Kootenay Lake Operations

Action: The Corps shall explore the opportunity to change Kootenay Lake regulation to increase its benefit to salmon.

Increasing the operating range of the lake, particularly increasing the upper limit, would allow spring water storage and summer delivery that would benefit downstream salmon by augmenting summer flows. The USFWS has also requested such changes in operations to improve sturgeon spawning in the Kootenai River (letter of February 3, 1997, from Charles Dryer, USFWS, to Colonel Donal T. Wynn, Seattle District Corps).

9.6.1.2.7 Actions to Address Columbia Basin Project Effects Other than Flow Depletions and Storage Operations. Certain facilities and operations at the Columbia Basin Project present risks to listed salmon and steelhead other than those associated with mainstem flows. The BOR shall investigate the effects of these facilities and operations and where adverse effects on listed salmon or steelhead are found, develop measures to avoid or minimize such effects in consultation with NMFS.

Action: The BOR shall investigate the attraction of listed salmon and steelhead into wasteways and natural streams receiving waste water from the CBP. If listed fish are found to be attracted into these channels, the BOR shall identify structural or operational measures to avoid or minimize such use.

Action: By December 31, 2001, the BOR shall install screens meeting NMFS' screen criteria at the intakes to the Burbank No. 2 and Burbank No. 3 pump plants.

9.6.1.3 Juvenile Fish Transportation

9.6.1.3.1 Strategy. This RPA requires transportation of juvenile salmon and steelhead migrants in spring and summer. During the spring migration, transport is required at Lower Granite, Little Goose and Lower Monumental dams. During the summer migration, transport is required from the same three Snake River dams and also required from McNary Dam. Spill is to be provided in accordance with Section 9.6.1.4.4 to reduce the proportion of fish collected in spring and to provide for research in summer. But, except as specifically provided for research, all collected fish are to be transported.

The spring transport strategy in this RPA requires both transport and spill at collector projects to spread-the-risk by ensuring favorable project passage conditions for inriver migrants. There is no attempt to manage a specific proportion of the run left inriver. Estimates of the proportion of Snake River spring/summer chinook that are expected to be transported under this strategy range from 44% to 89% depending on flow/runoff conditions.

The summer transport strategy is to maximize collection and transportation due to concerns about low inriver survival levels. During the summer, flow is frequently below the biological flow objectives established by NMFS, and water temperature is frequently above the water quality standards established by EPA and the state water quality agencies. As a result, fish spill is curtailed, and all collected fish are transported during the summer to improve overall juvenile fish survival.

The actions in this section are presented as follows:

- Current and near-term actions
- Studies, including research, monitoring, and evaluation
- Future actions.

9.6.1.3.2 Current and Near-Term Actions

Action: The Corps shall continue to transport all non-research juvenile salmonids collected at the Snake River collector projects. The Corps and BPA shall continue to implement voluntary spill at all three Snake River collector projects when seasonal average flows are projected to meet or exceed 85 kcfs.

If future information shows that survival through inriver migration, including returning fish to the river, is beneficial, these data will be reviewed and discussed through the annual planning process. In particular, BPA and the Corps, working with NMFS through the annual planning process, need to consider the scientific basis for the 85-kcfs voluntary spill trigger. Any resulting changes in the annual transport operations will be memorialized through the consultation framework or a similar process.

Action: The Corps and BPA shall continue to bypass juvenile spring migrants collected at McNary Dam and shall provide the spring spill levels described for that project.

The rationale for deciding not to resume spring transport operations stems from concerns identified in the review of adult return information of fish PIT-tagged in the Snake River and subsequently transported from McNary (NMFS 1998 Supplemental Steelhead Biological Opinion, Appendix B, p. B-17). These data suggest that there may be an undetected problem with the juvenile collection facility that may not be limited to transported fish. Until this question can be resolved, voluntary spill up to the dissolved gas cap shall continue to be provided during the spring migration. Once an existing problem has been identified and corrected, the interim program will evaluate transporting a proportion of UCR steelhead from McNary. At that time, further adjustments to the collection of fish at Snake River projects may be considered through the annual planning process and, as appropriate, formally modified through consultation.

Action: The Corps and BPA shall operate the collector projects to maximize collection and transportation during the summer migration (i.e., no voluntary spill except as deemed necessary by NMFS for approved research).

Past research evaluating fall chinook transport from McNary indicated the highest benefits occur during the summer low flow/warm water temperature periods. The 1982 research (Park et al. 1983) evaluated transport by truck during the early, middle, and late phases of the summer out-migration.

The early control group (June 25 to July 2) was released when daily average river flows were dropping from 444 kcfs to 372 kcfs and water temperature averaged about 60°F. Based on survival to adulthood, there was no benefit to the early phase from transport (0.9:1).

The middle control group (July 6 to 22) was released when river flows ranged from 358 to 206 kcfs and water temperatures ranged from 61° F to 66° F. Based on survival data, there was a minor benefit to the middle phase (1.36:1).

The late control group (July 27 to Aug 5) was released when river flows were dropping from 218 kcfs to 158 kcfs and water temperatures were 67°F to 70° F. This group showed the highest transport benefit of 4.6:1. Available data, albeit limited, do not indicate a benefit from transport of summer migrants during early summer. A similar study was conducted in 1983 (Park et al. 1984), but marking did not begin until July 7 that year so the data are not comparable to the 1982 study. Results, however, showed a positive benefit from both barge and truck transport. Control groups in that study were released when river flows ranged from 169 to 232 kcfs.

Action: The Corps shall not initiate collection of subyearling fall chinook for transportation at McNary Dam until inriver migratory conditions are deteriorating (i.e., no longer spring-like).

In general, the switch from spring to summer operation will occur on or about June 20. Each year in the in-season management process, the technical management team has the discretion to make the switch to transportation at McNary earlier or later based on in-season monitoring of inriver conditions. When more favorable spring-like flow and temperatures either end before or extend after the spill planning dates, the actual date to end spill at collector projects, and to initiate transport from McNary, shall be modified, continuing to spread the risk of transportation versus inriver passage for spring migrants as long as spring-like river conditions persist.

Spring-like is defined as favorable flow and water temperature conditions; i.e., river flows at or above the spring flow target (220 to 260 kcfs) at McNary Dam and ambient water temperatures below 62°F.

Action: The Corps shall extend the period of barge transportation from the lower Snake River dams and McNary to further reduce reliance on trucking.

Barge transport of spring migrants from the lower Snake River dams was extended approximately 3 weeks in 1998 to partially address regional concerns regarding truck transportation. The Corps has proposed to extend the barging period an additional 5 weeks (to around the end of July). NMFS views the proposed extension as a first step; however, a further extension is desired. We recognize that, as a result of prioritizing available O&M funds, a further extension of barging will need to be phased in over a period of years.

9.6.1.3.3 Studies (Including Research, Monitoring, and Evaluations)

Action: By the end of 2000, the Corps shall develop, in coordination with NMFS and the other Federal, state, and Tribal salmon managers, a McNary Dam transportation evaluation study plan, specifically focusing on the response of Upper Columbia spring chinook and steelhead to transportation. Approved research should begin by 2001 if feasible.

Evaluation of spring transport from McNary shall be initiated in 2001, assuming that adult PIT-tag detectors will be installed at selected locations by spring 2002. Implementation of such research is a high priority and should serve to accelerate development and installation of adult

PIT-tag detection capability in mainstem adult fishways. At a minimum, objectives of the study shall include:

- Identification of population and/or genetic composition of test fish
- The absolute return rates of transport and inriver groups
- The ratios of transport to inriver return rates and their relationships to river conditions
- The effects of transportation from McNary on homing
- Relationships between ratios of transport and inriver return rates and measurements of juvenile survival ("D" values) below McNary Dam

Action: The Corps and BPA, in coordination with NMFS through the annual planning process, shall evaluate transport to inriver return ratios for wild Snake River yearling chinook salmon and steelhead. In addition, the Corps and BPA shall also evaluate effects of transportation on summer-migrating subyearling Snake River chinook salmon.

Currently, the only way to conduct this research on spring-migrating fish is to mark and release wild fish at Lower Granite Dam and re-collect some for transport at Little Goose Dam, allowing others to continue their migration inriver. This design should continue until wild Snake River anadromous salmonids are sufficiently abundant to conduct studies by PIT-tagging wild fish in natal areas above the lower Snake River dams. If the decision for the long-term operation of FCRPS projects on the lower Snake River includes continued reliance on transportation, the Corps and BPA shall continue transport survival studies for spring and summer migrants passing Lower Granite Dam in future years.

Future research to evaluate the smolt-to-adult survival of subyearling fall chinook transported from Lower Granite versus the survival of marked study fish left to migrate inriver will require adequate numbers of representative test fish (i.e., Lyons Ferry hatchery stock), and also may require special spill operations at 1 or more of the 4 collector dams.

Action: During all transport evaluations, the Corps and BPA, in coordination with NMFS through the annual planning process, shall include an evaluation of delayed mortality ("D") of transported versus inriver migrating juvenile anadromous salmonids.

Considerable uncertainty exists concerning the levels of differential post-Bonneville Dam mortality of transported and non-transported fish. Evaluations of post-transport and post-bypass delayed mortality is a high priority. The highest priority is determining how much transportation mitigates for the loss of juvenile anadromous salmonids during passage through the hydrosystem.

Action: The Corps and BPA shall evaluate the potential benefit of transporting wild yearling chinook separately from larger hatchery chinook and steelhead.

Recent studies have shown that the presence of large hatchery steelhead increases stress in yearling chinook salmon during collection and transport. This evaluation shall determine if the presence of larger hatchery chinook and steelhead during collection and transport reduces SARs of yearling chinook salmon.

Action: The Corps and BPA shall evaluate the effects of prior transport as smolts on the homing of adults.

Past research was not designed to directly evaluate the effects of transportation on the homing of returning adults. Ancillary data derived from earlier studies suggested that transportation-induced homing impairment was minimal. Studies designed to directly and precisely compare homing capabilities of transported and non-transported fish are needed. This research will require the installation of adult PIT-tag detectors at several dams on the Columbia and Snake rivers.

Action: The Corps shall evaluate the release of trucked fish from the new Bonneville Second Powerhouse juvenile bypass outfall.

This study depends upon favorable post-construction evaluation results of the new juvenile fish bypass facility. Early season migrants which are transported by truck are released from shoreline locations and should benefit from this action. Late season trucked summer migrants are presently released from a barge into more desirable currents (rather than from the shoreline). This practice avoids more than 20 miles of predator habitat. Extension of the barging period from upriver collector dams may reduce, but not eliminate, the need for these mid-river releases.

Action: Evaluate strategies to enhance post-release survival of transported fish, such as timing releases so that fish arrival at the estuary corresponds to minimal interactions with predators and maximal availability of forage.

No consideration has been given to the timing of fish arrival in the estuary when scheduling fish transport operations. In the past, the preference for timing the release of transported fish was after dark to reduce the potential for predation, but this does not occur on a regular basis.

9.6.1.3.4 Future Actions

Action: The BPA and Corps shall install necessary adult PIT-tag detectors at appropriate FCRPS projects before the expected return of adult salmon from the 2001 juvenile outmigration.

If technical problems preclude installation of these adult PIT-tag detectors within this time frame, the evaluation of spring migrant transportation from McNary should be delayed until the detection systems are assured to be installed.

Action: If results of Snake River studies demonstrate that the survival of juvenile salmon and steelhead collected and transported during any segment of the juvenile migration (i.e., before May 1) is no better than the survival of juvenile salmon that migrate inriver, the Corps and BPA, in coordination with NMFS through the annual planning process, shall identify and implement appropriate measures to optimize inriver passage at the collector dams during those periods.

Limited available data suggest that juveniles collected and transported early in the spring season do not survive as well as fish that are transported in May and thereafter. It may be that, because they are transported, those fish arrive in the estuary before they are physically prepared to enter saltwater, or alternatively, predator abundance may vary during the early ocean phase in different years. Additional data are needed to help reduce this uncertainty. Maximizing inriver passage of migrating juveniles during some periods will reduce the proportion of fish transported.

Action: The Corps shall identify and implement improvements to the transportation program.

Such improvements should include maintenance/upgrade of fish transport trailer chillers before the summer trucking season (as long as trucking continues), and daily transport of juvenile salmon exhibiting signs of *Columnaris* disease during the summer warm water season, preferably in 5- to 10-ppt saline with minimal handling if transported by truck.

Action: The Corps shall evaluate and implement structural and operational alternatives to improve juvenile transportation at the collector dams.

These alternatives could include improvements to the juvenile bypass systems, holding and loading facilities, and construction of smaller barges for use during the summer.

9.6.1.4 Juvenile Fish Passage

The actions described in this section represent the best starting point for planning future capital investment in measures to improve the survival of juvenile salmon migrating past the Corps mainstem FCRPS dams. The specific list of measures to be implemented, their priority, and the method of evaluation will be developed in the annual and 5-year plans described in Section 9.5. As determined through the annual planning process in Section 9.5, other combinations of measures may also be deemed sufficient to meet the juvenile and adult performance standards and thus be sufficient to avoid jeopardy.

Based on information in the biological effects analysis in Appendix B, Bonneville, The Dalles, and Lower Monumental dams have the lowest juvenile fish passage survival rates in the FCRPS. For this reason, improvements in juvenile dam passage survival at these mainstem dams should be an area of immediate focus.

Many of the measures described in this section are limited to prototype or facility development and evaluation, and include statements that the Action Agencies are expected to implement an action based on study results "as warranted." The intent in these cases is to proceed to implementation immediately upon completion of testing, unless the results present further problems that need to be addressed through further testing before implementation. The fish passage survival analysis in Section 9.7 assumes that fish passage facility improvements would be implemented, not just tested. As a result, progress in moving from research and development to implementation will be a necessary and integral part of the annual planning and review process, and undue delay may require a reinitiation of consultation.

9.6.1.4.1 Juvenile Fish Passage Strategy. A primary objective of the FCRPS Biological Opinion is to aggressively increase survival of juvenile outmigrants through the Federal hydrosystem. This objective should be accomplished consistent with two biological principles: 1) protecting biodiversity, and 2) favoring fish passage solutions that best fit the natural behavior patterns and river processes (ISAB, 1999). This applies to fish passage through the eight FCRPS hydroelectric projects, and their associated reservoirs. The purpose of this fish passage strategy statement is to provide general guidance on dam passage priorities for future annual implementation planning.

Spillway Passage. Spillway passage is the preferred passage method for juvenile salmonids that are not collected and transported. It should be the baseline against which other passage methods are measured. The body of research evidence indicates that juvenile survival is generally highest through this passage route and suggests it can reduce forebay delay. Therefore, measures that increase juvenile fish passage over FCRPS project spillways are the highest priority. This assumes that spillway passage is implemented in a biologically safe manner to maintain appropriate water quality, while assuring adequate juvenile egress conditions in the tailrace and minimizing effects on adult passage.

Surface Bypass Passage. Surface bypass is defined as a surface-oriented route that provides an appreciable attraction flow-field and discharges juvenile fish directly to the project tailrace. Continued development and testing of surface bypass prototypes at mainstem FCRPS projects should be a high priority. A surface bypass at one or more spill bays, or through a surface bypass adjacent to the spillway or powerhouse may provide complementary survival benefits for fish that do not pass through a conventional spillway tainter gate. Surface bypass passage is a promising concept that may, with further testing and development, satisfy the intent of increasing safe passage through a high-flow conveyance similar to the spillway. It also has a potential benefit of providing fish passage with incrementally lower spill discharges and lower production of total dissolved gases.

Surface Collection Passage. In contrast to surface bypass, surface collection is defined as a surface-oriented route that entails collection at one or more entrances, followed by lateral routing in a channel to a location where the bypass channel can be routed to the tailrace. Surface collectors are considered, in the Biological Opinion, to be installed across the entire (or portion of the) upstream face of the powerhouse at a given site. For fish that do not pass through either spillway or surface bypass routes, this option provides more natural passage conditions for those fish that approach the powerhouse. Similar to the surface bypass concept, surface collection is also a promising concept that may, with further testing and development, satisfy the intent of increasing safe passage through a high-flow conveyance. With successful development in the future (including reconciling concerns regarding high discharge outfalls), this option would be preferred to other powerhouse passage options (see below).

Powerhouse Intake Screen and Bypass Systems. Turbine intake screens and bypass systems provide the best protection for those fish that enter turbine intakes (as opposed to passing through other non-turbine routes). Increasing juvenile survival through collection and safe passage using this type of system continues to be a priority at many FCRPS hydro projects. This fish protection system will continue to be the primary powerhouse protection alternative at some projects until either surface bypass or surface collection is fully developed and constructed.

Turbine Passage. The least preferable route of passage for juvenile and adult fish is through turbines, where a generally higher mortality rate occurs due to direct mechanical injuries and adverse pressure changes incurred while passing through the turbine. Further, indirect mortality is likely a significant problem downstream of the powerhouse, where disoriented fish are vulnerable to predation. Efforts described above to reduce turbine passage notwithstanding, it is prudent to continue to research and, where appropriate, implement improved turbine designs that reduce direct and indirect mortality. Additional investigations are necessary to reduce the magnitude of direct and indirect turbine mortality, as well as continued evaluations of recent advances in turbine design such as minimum gap runners.

9.6.1.4.2 Overview of RPA Actions Project-by-Project. The following project-by-project overview is provided for ease of reference so that juvenile passage measures, which are detailed as actions in the following sections, can be viewed and understood from a broader context. This section also describes issues such as decision dates for alternative passage improvements, and other considerations that may influence implementation. Where a measure entails potential implementation at more than one FCRPS project, it is listed as a “system” measure.

Bonneville Dam. The dam passage survival rate at Bonneville Dam is currently one of the lowest of any Corps FCRPS project, and is therefore the highest priority relative to the need for improvements. Existing spill levels, configurations, and facilities at Bonneville Dam related to juvenile fish passage include the following operating criteria identified in the Fish Passage Plan:

- Twenty-four hour spill; nighttime spill at the TDG gas cap, daytime at 75 kcfs

- Standard-length screens at all 18 main units (at both powerhouses)
- First powerhouse monitoring facility/bypass outfall that releases fish into the immediate tailrace, and a new second powerhouse monitoring facility/bypass outfall that releases fish approximately 9,000 feet downstream of the powerhouse
- Ice and trash sluiceway at the first powerhouse
- 18-bay spillway, with deflectors on 12 bays

Bonneville First Powerhouse. The Corps shall evaluate surface collector and extended submerged intake screen prototypes in 2000, followed by a decision to proceed with development of one alternative (or a hybrid of each): proceed to design and construction of the most promising option; complete minimum gap turbine runner installation and evaluation; continue to develop debris-control measures; and continue to develop improvements to the existing juvenile fish bypass system (including dewatering screens and outfall relocation).

Bonneville Spillway. The Corps shall finish spillway deflector optimization development and implement deflector additions and improvements; develop optimum spill patterns and conduct juvenile survival studies; continue to evaluate adult spillway fallback and implement remedies as warranted; synthesize results to determine how to optimize spillway adult and juvenile project/spillway survival; and implement most promising measures.

Bonneville Second Powerhouse. The Corps shall develop surface bypass corner collector, implement pending high-flow outfall investigations for increasing the high flow impact velocity criterion, conduct outfall site selection evaluations, and design and construct corner collector system by 2003 (if exceeding velocity criterion does not increase juvenile mortality); continue intake screen guidance improvement investigations and implement as warranted; implement auxiliary water improvement measures; investigate and implement debris control measures; investigate less intrusive PIT-tag interrogation method for the new juvenile fish bypass system and implement as warranted.

<u>The Dalles Dam</u>. Spill levels, configurations, and facilities at The Dalles Dam related to juvenile fish passage include the following operating criteria identified in the Fish Passage Plan:

- Twenty-four hour spill at 40% of river flow
- Ice and trash sluiceway operated as a surface bypass
- Twenty-three bay spillway, with a shallow spilling basin and no deflectors

The Corps shall evaluate, identify, and implement the appropriate 24-hour spill levels (day and night considered separately) to optimize spring and summer juvenile survival; investigate surface bypass collection efficiency improvements (blocked trash racks) and sluiceway passage survival in 2001 and fully implement across the powerhouse as warranted; evaluate juvenile survival benefit of sluiceway outfall relocation; and implement composite outfall relocation and auxiliary water emergency measures. If the spillway juvenile mortality rate is excessive at 40% spill in 2000, the Corps shall investigate mechanistic causes of physical injury, including potential construction of spillway deflectors. The Corps shall defer intake screen and bypass system implementation decision until other measures are fully evaluated and consider the installation of "fish friendly" turbine designs (e.g., minimum gap turbine runners) as part of the turbine rehabilitation program.

John Day Dam. Spill levels, configurations and facilities at John Day Dam related to juvenile fish passage include the following operating criteria identified in the Fish Passage Plan:

- Twelve-hour spill (6:00 p.m. to 6:00 a.m.) at the TDG gas cap
- Standard-length screens at all 16 main units
- A new juvenile fish monitoring facility that releases fish approximately 1,000 feet downstream of the powerhouse
- Twenty-bay spillway, with new deflectors on 18 bays

The Corps shall continue 24-hour spill investigations to determine juvenile passage and survival benefits; construct end deflectors by 2002, and assess water quality and fish survival benefits of deflector optimization; conduct surface bypass removable spillway weir prototype evaluation in 2002 as a surrogate for skeleton bay surface collection; continue to develop extended intake screen system; conduct prototype tests in 2001; synthesize incremental juvenile survival benefits of all juvenile passage options in late 2002 and proceed with the most promising survival-improvement measures; investigate less intrusive PIT-tag interrogation method for juvenile sampling facilities and implement as warranted.

McNary Dam. Configurations and facilities at McNary Dam related to juvenile fish passage include the following operating criteria identified in the Fish Passage Plan:

- Twelve-hour spill from 6:00 p.m. to 6:00 a.m. at the TDG gas cap
- Extended-length screens in all 14 main units
- Juvenile fish monitoring facility/collection and bypass, with capability to either collect and transport fish via barge or truck or release fish to the river
- Twenty-two bay spillway, with deflectors on 18 bays

The Corps shall conduct spillway efficiency and effectiveness evaluations, spillway deflector optimization investigations, and surface bypass removable spillway weir prototype studies as appropriate (based on results at other locations); determine optimum spring migration juvenile survival configuration and operations; implement promising measures; upgrade extended intake screens and implement gatewell screen cleaning and other juvenile bypass system improvements; investigate and implement remedies to address adult egress from juvenile bypass system; investigate less intrusive pit-tag interrogation method for juvenile sampling facilities and implement as warranted.

Ice Harbor Dam. Configurations and facilities at Ice Harbor Dam related to juvenile fish passage include the following operating criteria identified in the Fish Passage Plan:

- Twenty-four hour spill (at the gas cap at night; daytime cap of 45 kcfs)
- Standard-length screens at all 6 main units
- Ten-bay spillway, with deflectors on 10 bays

The Corps shall implement adult fishway auxiliary water upgrades and measures to address adult egress from the juvenile bypass system; assess provision of less-intrusive PIT-tag interrogation method for the Ice Harbor juvenile bypass system; and consider the installation of "fish friendly" turbine design as part of the turbine rehabilitation program.

Lower Monumental Dam. Configurations and facilities at Lower Monumental Dam related to juvenile fish passage include the following operating criteria identified in this Biological Opinion or the Fish Passage Plan:

- Twenty-four hour spill at the gas cap
- Standard-length screens at all 6 main units
- Juvenile fish monitoring facility/collection and bypass, with capability to either collect and transport fish via barge or truck or release fish to the river
- Eight-bay spillway, with deflectors on 6 middle bays

The Corps shall continue 24-hour spill; investigate surface bypass RSW; investigate spillway deflector optimization (including addition of end bay deflectors); investigate juvenile bypass system separator replacement and other system improvements; relocate juvenile bypass outfall, design extended intake screen system; and implement most promising measures to increase juvenile survival.

Little Goose Dam. Configurations and facilities at Little Goose Dam related to juvenile fish passage include the following operating criteria identified in the Fish Passage Plan:

- Twelve-hour spill (6:00 p.m. to 6:00 a.m.) up to the gas cap
- Extended-length screens at all 6 main units
- Juvenile fish monitoring facility/collection and bypass, with capability to either collect and transport fish via barge or truck or release fish to the river
- Eight-bay spillway, with deflectors on 6 middle bays

The Corps shall investigate surface bypass removable spillway weir, investigate spillway deflector optimization (including addition of end bay deflectors), investigate replacing the juvenile bypass system separator and make other system improvements; upgrade extended intake screens; investigate 24-hour spill; implement those measures with greatest promise of increasing juvenile survival; determine need and frequency of powerhouse debris containment boom use to reduce predation losses; and implement debris removal criteria.

Lower Granite Dam. Configurations and facilities at Lower Granite Dam related to juvenile fish passage include the following operating criteria identified in the Fish Passage Plan:

- Twelve-hour spill from 6:00 p.m. to 6:00 a.m. up to the gas cap
- Extended-length screens at all 6 main units
- Juvenile fish monitoring facility/collection and bypass, with capability to either collect and transport fish via truck or barge or release fish to the river
- Prototype powerhouse surface collector
- Eight bay-spillway, with deflectors on eight bays

The Corps shall investigate surface bypass removable spillway weir in 2001; complete design of juvenile bypass system improvements to add open-channel flume, juvenile separation by size, and other system improvements; upgrade extended intake screens; investigate 24-hour spill; investigate spillway deflector optimization and implement as warranted; defer decision on permanent powerhouse surface bypass collector in abeyance until other measures are fully evaluated; implement measures with greatest promise of increasing juvenile surviva; and add additional transport barges as warranted.

9.6.1.4.3 Current and Near-Term Actions

Spill Program

Action: The Corps and BPA shall implement an annual spill program, consistent with the spill volumes and dissolved gas limits identified in Table 9.6-3, at all mainstem Snake and Columbia River FCRPS projects as part of the annual planning effort to achieve the juvenile salmon and steelhead performance standards.

The annual spill program will be based on the most recent monitoring and evaluation data concerning project passage, spill and system survival research. The specific annual spill levels and dates at each project will be determined preseason by the Action Agencies, in consultation with the technical management team and with the approval of NMFS. The planning dates for the annual spill program are April 3 to June 20 and June 21 to August 31 for the spring and summer migration periods, respectively, in the Snake River; and April 10 to June 30 and July 1 to August 31 for the spring and summer migration periods, respectively, in the lower Columbia River. Initial estimates of project spill levels, and the basis for each estimate, are shown in Table 9.6-3 below.

The specific spill volumes listed in Table 9.6-3 below must be viewed as approximate because the total dissolved gas levels measured at the monitoring site below each project, at a given spill level, can vary with such factors as river flow, forebay dissolved gas level, spill patterns, and water temperature changes. Spill levels at some projects may change as spill patterns are refined or if deflector optimization measures are implemented. Also, there are project-specific limitations on spill levels for reasons other than dissolved gas, including adult passage, navigation, and research activities. These limitations are typically of short duration but they can affect spill for fish passage to a limited degree.

Table 9.6-3. Estimated Spill Levels and Gas Caps for FCRPS Projects

Project	Estimated Spill Level[1]	Hours	Limiting Factor
Lower Granite	60 kcfs	6 pm - 6 am	gas cap
Little Goose	45 kcfs	6 pm - 6 am	gas cap
Lower Monumental	40 kcfs	24 hours	gas cap
Ice Harbor	100 kcfs (night) 45 kcfs (day)	24 hours	nighttime - gas cap daytime - adult passage
McNary	120-150 kcfs	6 pm - 6 am	gas cap
John Day	85-160 kcfs/60% [2] (night) 0-30% (day)	6 pm - 6 am 6 am - 6 pm	gas cap/percentage and ongoing studies on day spill
The Dalles	40% of instant flow	24 hours	tailrace flow pattern and survival concerns (ongoing studies)
Bonneville	90-150 kcfs (night) 75 or 90-120 kcfs (day)	24 hours	nighttime - gas cap daytime - adult fallback (ongoing study)

[1] Estimated spill levels shown in the table will increase for some projects as spillway deflector optimization measures are implemented.
[2] The total dissolved gas cap at John Day Dam is estimated at 85 to 160 kcfs and the spill cap for tailrace hydraulics is 60%. At project flows up to 300 kcfs, spill discharges will be 60% of instantaneous project flow. Above 300 kcfs project flow, spill discharges will be the gas cap (up to the hydraulic limit of the powerhouse).

9.6.1.4.4 Project-by-Project Spill Requirements

Lower Granite Dam. To achieve the desired fish passage efficiencies, the 1995 FCRPS Biological Opinion set the Lower Granite spill level at 80% of total instantaneous discharge for 12 hours per day. However, under most conditions, this level of spill could not be implemented because the gas cap was reached at spillway flows of 40 kcfs (NMFS 1998 Biological Opinion). More recent information suggests that the gas cap will be reached at about 60 kcfs; this level is the appropriate current spill limit. Based on radio-tracking studies with adult chinook, performed at Lower Granite Dam during 1996 and 1997, a spill level of 60 kcfs does not appear to adversely affect adult passage (T. Bjornn, fax to R. Kalamasz, S. Pettit, and J. Ceballos, dated April 4, 1998, T. Bjornn fax to J. Ceballos, dated January 20, 2000). It may be necessary to reduce spill to accommodate safety concerns when juveniles are being loaded directly onto barges for transportation downstream and the barges must be docked for extended periods. Spill operations must also consider research needs critical to the ongoing evaluation of the surface bypass prototype (e.g., project operations in 2000 have been modified to spill for 24-hours per day instead of only at night and powerhouse operations has been modified to provide the required hydraulic conditions in the immediate forebay).

The BPA has specified 11.5 kcfs as a minimum powerhouse flow for system reliability. Because this minimum is dependent on the status of generation at other projects, it may not be necessary at all times.

Little Goose Dam. The 1995 FCRPS Biological Opinion set the Little Goose Dam spill level at 80% of total instantaneous discharge 12 hours per day (NMFS 1998 Biological Opinion). As at Lower Granite Dam, the Action Agencies could not usually implement this level because the gas cap was reached at spillway flows of approximately 35 kcfs. More recent information suggests that the gas cap will be reached at about 45 kcfs; this level is the appropriate current limit at Little Goose Dam. Based on radio-tracking studies with adult chinook performed during 1997, a spill level of 60 kcfs did not appear to adversely affect adult passage (C. Perry, Idaho Cooperative Fish and Wildlife Research Unit [ICFWRU] fax to J. Ceballos, NMFS, dated April 9, 1998).

The BPA has specified 11.5 kcfs as a minimum powerhouse flow for system reliability. Because this minimum is dependent on the status of generation at other projects, it may not be necessary at all times.

Lower Monumental Dam. The 1995 FCRPS Biological Opinion set the Lower Monumental Dam spill level at 81% of total instantaneous discharge for 12 hours per day (NMFS 1998 Biological Opinion). Again, this level of spill was not provided voluntarily because the gas cap was reached at spillway flows of approximately 40 kcfs. The estimate of spill at the gas cap has not changed. However, spill levels to the gas cap will now be provided for 24 hours per day. Based on radio-tracking studies with adult chinook performed during 1997, a spill level of 45 kcfs did not appear to adversely affect adult passage (C. Perry, ICFWRU, fax to J. Ceballos, NMFS, dated April 9, 1998, T. Bjornn, ICFWRU, fax to J. Ceballos, dated January 20, 2000). Because the gas cap is currently reached at approximately 40 kcfs, no reduction in spill is necessary for adult passage.

The BPA has specified 11.5 kcfs as a minimum powerhouse flow for system reliability. Because this minimum is dependent on the status of generation at other projects, it may not be necessary at all times.

Ice Harbor Dam. The 1995 FCRPS Biological Opinion prescribed spill levels at Ice Harbor Dam of 27% in the spring and 70% in the summer, each for 24-hours per day. The 27% spring objective was often reached, even though the gas cap limited voluntary spill to flows of 25 kcfs. The summer target of 70% was also reached at the lower flow levels (1998 NMFS Biological Opinion). Due to the installation of spillway flow deflectors, more recent information suggests that the gas cap will be reached at 100 kcfs. Based on research performed during the early 1980s, adult passage would become a concern at daytime (0500 to 2000) spill in excess of 45 kcfs. Recent information from radio-tracking studies performed from 1996 to 1998 suggest that spill levels from 55 to 70 kcfs did not appear to adversely affect adult passage (C. Perry, ICFWRU, fax to J. Ceballos, NMFS, dated April 9, 1998, T. Bjornn fax to J. Ceballos, dated January 20, 2000). The 45 kcfs adult passage daytime cap may need to be reconsidered once the final study results are available. However, no change is proposed, and the daytime limit remains 45 kcfs.

The BPA has specified 7.5 to 9.5 kcfs as minimum powerhouse flows for system reliability. Because this minimum is dependent on the status of generation at other projects, it may not be necessary at all times.

McNary Dam. The 1995 FCRPS Biological Opinion set the McNary Dam spill level at 50% of total instantaneous discharge for 12 hours per day (NMFS 1998 Biological Opinion). Due to limited powerhouse capacity and because the gas cap was reached at spillway flows of 120 kcfs, these spill levels were reached under most conditions. More recent information suggests that the gas cap will be reached at about 135 kcfs. This level of spill is the approximate interim limit, pending deflector construction at the four end-bays.

BPA has specified a minimum powerhouse flow of 50 kcfs to maintain power transmission system stability.

John Day Dam. The 1998 FCRPS Supplemental Biological Opinion set the John Day Dam spill level at 60% of total instantaneous discharge up to the gas cap during the nighttime hours. At project flows up to 300 kcfs, spill discharges will be 60% of instantaneous project flow during 12 hours per day. Above 300 kcfs, spill discharges will be the gas cap (up to the hydraulic limit of the powerhouse). With the completion of spillway deflectors and new spill patterns, gas cap spill flow has ranged up to170 kcfs. Spill limits of 25% minimum and 60% maximum are imposed to assure adequate juvenile egress conditions from the spillway at low spill flows and from the juvenile bypass system during high spill flows. General physical model studies have indicated that spill percentages below 25% create poor egress conditions (eddies and slack water) in the spillway tailrace, and spill levels above 60% tend to create a large eddy in the tailrace below the powerhouse that can actually cause flow from the bypass to move upstream.

BPA has specified a minimum powerhouse flow of 50 kcfs to maintain power transmission system stability.

The Dalles Dam. The 1995 FCRPS Biological Opinion prescribed a spill level at The Dalles Dam of 64% for 24 hours (NMFS 1998 Biological Opinion). Spill survival studies conducted by NMFS in 1997, 1998 and 1999 indicated that the 64% spill level can result in relatively low spillway survival compared to fish released below the project. These studies also indicated that a 30% spill level spillway survival was always as good or higher than the 64% level. Companion studies using radio-tagged fish and hydroacoustic monitoring indicated that reducing the spill percentage from 64% to 30% caused more fish to pass through the powerhouse sluiceway and turbines. Turbine survival has not been measured at this project but is assumed to be similar to that observed at other projects. (Details of these studies and references can be found in the Dam Passage White Paper, NMFS 2000a.)

Based on the available information, the ISAB recommended an evaluation of 24-hour spill levels at The Dalles in the 30% to 50% range (ISAB 2000). NMFS recommends an evaluation of 24-hour spill at the 40% level and expects to improve juvenile fish survival with this interim spill operation (see Spill Research, monitoring, and evaluation section below). Additionally, because reduced juvenile survival at higher spill levels may have been related to the daylight adult spill pattern, there is potential in the future for higher than 40% nighttime spill with a juvenile passage pattern after The Dalles survival test is concluded and the results are evaluated.

The BPA has specified a minimum powerhouse flow of 50 kcfs to maintain power transmission system stability.

Bonneville Dam. The 1998 FCRPS Supplement established a nighttime spill level at the dissolved gas cap, generally between 90 and 150 kcfs for the duration listed in the current Corps' Fish Passage Plan. The minimum spill level shall be no less than 50% of total river flow to provide good tailrace egress of juvenile migrants. Daytime spill levels are limited to 75 kcfs at Bonneville Dam due to concerns for adult salmonid fallback through the spillway. Recent evidence from adult radio-tracking studies conducted in 1996, 1997, and 1998 indicate that increases in adult fallback associated with increased daytime spill flows from 75 to120 kcfs range are relatively small. Juvenile passage benefits from the increased spill level would likely outweigh small adult losses that may be associated with the higher spill level. Further, spillway deflector optimization improvements may result in more uniform spill gate openings, which could reduce adult fallback rates. NMFS believes this issue warrants further investigation. Planned studies are described below.

The BPA has specified a minimum powerhouse flow of 30 kcfs.

System Actions to Improve Spill Capability

Action: To improve the future flexibility of the transmission system, BPA-Transmission Business Line (TBL) shall initiate planning and design necessary to construct a Schultz-Hanford 500-kV line or an equivalent project, with a planned schedule for implementation by 2004 or 2005.

This line would make additional daytime spill possible in the lower Columbia to help meet performance standards by restoring approximately 200-300 MW of California transfer capability. Because construction of this new line will require Congressional and NEPA review, BPA-TBL should begin this planning effort in 2000.

Action: BPA-TBL shall continue efforts to evaluate, plan, design and construct a joint transmission project to upgrade the West of Hatwai cutplane and improve the transfer limitations from Montana.

Although the specific type of project to be implemented has not been identified at this time, this project is expected to be completed in the 2003 to 2004 time frame. This upgrade would make additional daytime spill possible at the Snake River dams to help meet performance standards by restoring approximately 500 MW of Montana transfer capability. Since this project will also require NEPA review, BPA-TBL should begin this joint planning effort in 2000.

Action: BPA-TBL shall continue to evaluate strategically located generation additions and other transmission system improvements and report progress to NMFS annually. BPA-TBL shall also limit future reservations for transmission capacity, as needed to enable additional spill to meet performance standards, while minimizing effects on transmission rights holders.

If additional spill is found to be appropriate at FCRPS projects (more than the capacity that the Schultz-Hanford project provides), to enable this additional spill, further transmission system reinforcements may be required to restore any additional lost capacity. BPA-TBL has made only a cursory examination of these potential transmission system reinforcements. The most promising candidates are major 500-kV lines in the I-5 corridor; however, such new lines would be very costly and challenging to site. If work on these projects started in 2002 (pending favorable results in ongoing spill studies), completion of these reinforcements would be expected in the 2007 to 2010 timeframe. In addition, several new gas-fired combustion turbines south of the John Day cutplane (with a total capacity of about 1250 MW of base load generation) are being licensed and could be operational by summer 2002. If additional spill is found to be appropriate, and before long-term fixes can be implemented, BPA will limit future reservations for transmission capacity, as appropriate, to enable spill while minimizing effects on existing transmission rights holders.

Turbine Unit Operations

Action: The Corps and BPA, in coordination with the Fish Passage Operations and Maintenance Coordination Team (FPOM), shall operate all turbine units at FCRPS dams for optimum fish passage survival. Methods to achieve this objective shall include:

The Corps and BPA shall operate turbines within 1% of peak efficiency during the juvenile and adult migration seasons (March 15 through October 31 in the Columbia River and March 15 through November 30 in the Snake River) as indicated by the load shaping guidelines contained in the Corps' annual Fish Passage Plan (FPP). These guidelines will be updated through the FPP review process prior to February 1 each year. Operating turbines at peak efficiency is believed to provide the highest survival of anadromous species during passage through a turbine (Bell et al. 1981; Eicher 1987).

The Corps and BPA shall continue efforts to index test all families of turbine units specific to each project in the FCRPS to ensure that peak efficiency tables listed in the Fish Passage Plan reflect current operating conditions. This work shall be completed by late 2002. This will include index testing, and development and implementation of operational cam curves. These curves shall be developed and updated as necessary to reflect current fish passage conditions (screens, surface collectors, unit modifications, etc.). This work shall be coordinated through FPOM.

Action: The Action Agencies, in coordination with the Regional Forum, shall determine the appropriate operating range of turbines equipped with minimum gap runners (MGR) to increase survival of juvenile migrants passing through these new turbine designs.

The Action Agencies shall evaluate the potential for exceeding the upper limit of the 1% efficiency band to improve fish survival related to passage through turbines with MGR technology. The evaluation shall include an examination of indirect consequences (in terms of fish survival) of exceeding the 1% peak efficiency guidelines (including screen effects, gatewell hydraulics, draft tube and tailrace conditions, etc.). Report results of this evaluation to NMFS by October 2002.

9.6.1.4.5 Studies (Including Research, Monitoring, and Evaluations)

Bonneville Dam

Action: The Corps and BPA shall evaluate adult fallback and juvenile fish passage under daytime spill to the gas cap at Bonneville Dam in 2002-2003, after deflector optimization improvements allow for increased spill above current levels. Research results will be considered, in consultation with NMFS through the annual planning process, to determine implementation of additional changes in spill to further improve fish survival.

Research goals shall include rate of adult fallback and juvenile passage change between 75 kcfs and new gas cap spill levels attainable through deflector optimization. The future daytime spill level will depend on the results of this study. The study design for future spill evaluations, and the resulting changes in the annual spill operation, should be coordinated through the NMFS Regional Forum process.

Further modifications to spill operations suggested by the studies at this project for 2002 and beyond may be limited pending transmission system improvements expected to come on-line by 2005 or by potential modifications before then to spill operations at The Dalles and John Day dams. Other actions may improve the flexibility and reliability of the transmission system by an earlier date.

Action: The Corps shall complete the ongoing prototype powerhouse system surface collection evaluations at Bonneville First Powerhouse in 2000. Compare against screened bypass, and if warranted, design and construct permanent facilities after full consideration and resolution of biological and engineering uncertainties, especially high-flow outfall investigations.

Existing Bonneville First Powerhouse juvenile passage facilities guide a relatively low percentage of fish away from turbines, and guided fish are bypassed to an outfall site with predator aggregations. The full potential of a surface collection and high-flow bypass outfall system needs to be identified, then weighed against other alternatives.

Action: The Corps shall complete Bonneville First Powerhouse prototype evaluations of extended submerged intake and gatewell vertical barrier screens, including an assessment of fry passage.

The Corps shall continue design development of improved screens, a downstream migrant collection channel, and connection to the new juvenile bypass monitoring facilities and outfalls.

Action: The Corps shall complete the design of debris removal facilities for the Bonneville First Powerhouse forebay.

If the decision is made to install a new extended-length screen and bypass system at this powerhouse in 2001, the Corps shall install debris-removal facilities as warranted. Special consideration should be given to potential predation and juvenile fish entrainment problems associated with debris booms.

Action: The Corps shall continue the investigation of minimum gap runners at the Bonneville First Powerhouse.

The Corps shall continue investigation of the new minimum gap runners at Bonneville Dam First Powerhouse to ensure that the new runner environment provides improved survival for juvenile migrants that pass through turbines. The Corps shall submit a report to NMFS stating the findings of these investigations by January 2001.

Action: The Corps shall complete Bonneville Second Powerhouse post-construction evaluation of the new juvenile fish bypass outfall, and address design and operational refinements as warranted.

Issues such as smolt survival, fry impingement and loss, avian predation at the outfall, and potential design deficiencies will need to be identified and corrected.

Action: The Corps shall continue design development and construction of a Bonneville Second Powerhouse permanent corner collector at the existing sluice chute, pending results of high-flow outfall investigations. The Corps shall construct new facilities if, and as soon as, evaluations confirm the optimum design configuration and survival benefits.

Prototype testing in 1998 showed that a large percentage of juveniles entering the forebay were collected by the sluice chute. The decision to proceed with this measure is contingent on identifying whether an optimum bypass outfall location can be selected that will minimize mechanical and predation losses in the tailrace.

Action: The Corps shall continue Bonneville Second Powerhouse investigations of measures to improve intake screen fish guidance efficiency and safe passage through the gatewell environment.

The Bonneville Second Powerhouse bypass system has a state-of-the-art fish conveyance system coupled with relatively low fish guidance efficiency. Improving guidance of this system is an obvious next step to improving powerhouse passage, pending decisions on the optimal mix of actions at the second powerhouse for contributing to the performance standard.

<u>The Dalles Dam</u>

Action: The Corps and BPA shall continue spill and passage survival studies at The Dalles Dam in 2001. Research results will be considered, in consultation with NMFS through the annual planning process, to assess the need for additional changes in spill to further improve fish survival by 2002 if possible, but no later than 2005.

The goal of these studies is to evaluate spillway survival using a spill level that balances the risks associated with high spill levels and increased turbine passage. These studies should also include evaluation of passage survival and rates through the other routes of passage at this project. Future studies may be required to investigate the causes of spillway mortality.

Future changes in spill levels at The Dalles will depend on the results of the ongoing survival and spill passage studies. The study design for any future studies, and the resulting changes in the annual spill operation, will be coordinated through the annual planning process.

Further modifications to spill operations suggested by the studies at this project for 2002 and beyond may be limited pending transmission system improvements expected to come on line by 2005 or, before then, on potential modifications to spill operations at Bonneville and John Day dams. Other actions may improve the flexibility and reliability of the transmission system by an earlier date.

Action: The Corps shall continue design development and 2001 prototype testing of upper turbine intake occlusion devices at The Dalles, with a goal of increased non-turbine passage rates through either the sluiceway or the spillway. The Corps shall install occlusion devices across the entire powerhouse, as warranted.

Occlusion of upper intakes is a promising method of reducing turbine entrainment and associated mortality.

Action: The Corps shall continue biological and engineering investigations and design of a composite ice and trash sluiceway outfall relocation and adult ladder auxiliary water system at The Dalles Dam and construct such devices as warranted.

The existing ice and trash sluiceway is a highly efficient surface collector. However, recent PIT-tag survival data suggest that survival is unacceptably low. Relocation of the outfall to improve passage survival also provides the opportunity to develop a combined system whereby excess water can be used to augment the auxiliary water supply for the east adult fishway.

John Day Dam

Action: The Corps and BPA shall continue investigation of 24-hour spill at John Day Dam in 2001. Research results will be considered, in consultation with NMFS through the annual planning process, to determine implementation of daytime spill to further improve juvenile fish survival as needed for its contribution to the performance standard.

High spillway effectiveness and high daytime passage were noted during 24-hour spill in 1997 and 1999. The 1999 studies indicate a significant reduction in forebay residence time for chinook and smaller (primarily wild) steelhead. These observations and the study limitations imposed by ambient flow conditions in 1999 warrant further investigation during the spring and summer seasons in 2000 and 2001.

The framework for the ongoing study is as follows:

1. The study goals identify juvenile salmonid response to daytime spill in terms of spillway passage, forebay residence time and overall passage survival.

2. The scope of the study will include both spring and summer spill.

3. Adult passage considerations and potential adult fallback will be considered in the study design.

4. The study plan will be reviewed through the annual planning process.

Further modifications to spill operations suggested by the studies at this project for 2002 and beyond will be coordinated through the annual planning process and may be limited pending transmission system improvements expected to come on line by 2005. Other actions may improve the flexibility and reliability of the transmission system by an earlier date.

Action: The Corps shall continue design development of a prototype RSW and extended deflector for testing at John Day in 2002. The Corps should synthesize evaluation results, determine the fish survival benefits of one or more RSWs or a skeleton bay surface bypass, and install the units as warranted.

It has been shown that surface-oriented entrances, such as those provided by a prototype RSW, will pass a high percentage of juveniles, potentially more than if the same flow is passed through the deeper conventional spill gates.

Action: The Corps shall continue John Day prototype development and investigations of extended submerged intake screens, gatewell vertical barrier screens, and, if necessary, orifices to optimize guidance and safe passage through the system, including a gatewell debris cleaning plan. Design and construct as warranted.

Prototype investigations have indicated that extended screens have the potential to guide up to 28% more juvenile salmon from the turbine intakes at this project when compared to standard-length screens. Unfortunately, gatewell hydraulics were found to injure an unacceptable number of the guided fish. Model and prototype investigations are necessary to resolve the injury problem and provide safe passage conditions observed at other projects with extended-length screens.

McNary Dam

Action: The Corps shall continue evaluations to assess the need for improvements of the existing intake screens, gatewell vertical barrier screen cleaning system, and bypass facilities (including debris containment and removal systems, separation, sampling, loading, and outfall facilities) at McNary to determine where improvements are necessary to reduce problems experienced during the 1996 flood, increase fish survival, and resolve holding and loading facility problems, including raceway jumping by juvenile salmon and steelhead.

The McNary Dam juvenile fish intake screening and bypass system experienced the greatest adverse effects associated with 1996 flooding, and is the passage facility most in need of upgrades. Implement improvements as warranted.

Action: The Corps shall investigate a surface bypass RSW at McNary Dam, based on prototype results at other locations, and install the unit in multiple spillway bays, as warranted.

The potential for improved spillway passage through use of RSWs has to be investigated in the context of current spillway passage percentages for spring migrants at McNary Dam, where there is currently no spring transportation program and no voluntary fish spill during the 12 daytime hours.

Lower Monumental Dam

Action: The Corps shall design and construct a new juvenile bypass outfall at Lower Monumental Dam.

The existing outfall site is poor because the tailrace current frequently flows upstream toward the powerhouse, and the outfall facilities recently were damaged by a transport barge. The Corps shall design the new outfall to return both PIT-tagged fish and primary bypass flow to the river.

Action: The Corps shall initiate design development and testing of extended submerged intake screens and vertical barrier screens at Lower Monumental Dam and construct units as warranted.

Lower Monumental Dam presently has standard screens. Improved fish guidance efficiency would improve survival of fish entrained at powerhouse turbine intakes by diverting a higher proportion away from turbine passage where they are subjected to direct mechanical and/or indirect mortality.

Little Goose Dam

Action: The Corps shall conduct post-construction evaluation of the new debris containment boom at Little Goose to monitor populations and behavior of aquatic predators during periods when debris accumulates at the log boom.

The Corps should develop criteria for initiation of debris removal at the new log boom before the 2002 passage season and assess log boom predator aggregation in both wet and dry years. The Corps shall alter criteria as warranted.

Lower Granite Dam

Action: The Corps shall continue design development, fabrication/deployment, and testing of a prototype RSW at Lower Granite in 2001, in conjunction with the existing prototype powerhouse occlusion devices, including the forebay behavioral guidance structure (BGS) and upper intake occlusion device. As warranted by prototype test results, install one or more permanent RSWs and occlusion devices at appropriate lower Snake hydro projects, in coordination with the annual planning process.

Use of one or more RSWs at lower Snake hydro projects will potentially increase safe spillway passage during periods of low-to-moderate spill.

Action: The Corps shall complete design for new juvenile bypass facilities at Lower Granite Dam, including enlarged orifices and bypass gallery, open-channel flow bypass, improved separator for juvenile separation by size, and improved fish distribution flumes and barge-loading facilities and shall proceed to construction as warranted.

Lower Granite is the first mainstem dam on the Snake River encountered by migrating juvenile salmon and steelhead. This location offers the greatest potential for collecting the largest number of smolts for transportation. Unlike the other dams, there is presently no way to separate juvenile fish by size. Such size separation is believed to reduce stress and enhance long-term survival. Juvenile collection/bypass facilities at all of the other collector projects have been upgraded with state-of-the-art improvements over the last decade. These improvements are necessary, while additional information on the benefits of transportation is collected.

9.6.1.4.6 System or General Studies (including Research, Monitoring, and Evaluations)

Action: The Action Agencies, in coordination with NMFS through the annual planning process, shall investigate the spillway passage survival of juvenile salmonids at appropriate FCRPS dams. These investigations shall assess the effect of spill patterns and per-bay spill volumes on fish survival, across a range of flow conditions. The Action Agencies shall develop a phased approach (including costs and schedules) and set priorities, in consultation with NMFS in the annual planning process, to continue spillway passage survival studies in 2001 and future years.

Spillway passage has become an increasingly important route of passage for juvenile salmonids at FCRPS dams. These studies will ensure that each spillway is operated in a manner that results in the lowest possible direct and indirect mortality.

Action: The Action Agencies, in coordination with NMFS through the annual planning process, shall evaluate the effect of spill duration and volume on spillway effectiveness (percent of total project passage via spill), spill efficiency (fish per unit flow), forebay residence time, and total project passage survival of juvenile steelhead and salmon passing FCRPS dams. Studies shall include both collector and non-collector projects. Adult passage considerations and potential adult fallback shall also be considered in study designs. Little Goose and Lower Granite dams have a high priority for daytime spill studies. An overall phased study approach should be developed by January 2001.

Whereas the current nighttime spill regime is based on NMFS' understanding of hours of peak daily juvenile fish passage, it is clear that fish move throughout the day and that, as a result, longer spill hours may improve juvenile fish survival past the dams by increasing the proportion of fish passing in spill. There may also be operational changes associated with spill patterns or hourly project operations that influence the proportion of fish passed through spill.

It may also be possible to reduce delay when fish first encounter the dam and, thereby, limit exposure to predation in project forebays. Conversely, longer spill hours could have negligible-to-measurable adverse biological effects, such as delay, fallback of adults, or increased exposure to dissolved gas supersaturation. The intent of the efficiency and effectiveness information is to ensure that the use of current and future spill volumes is optimized as a means of achieving the biological performance standards. Any resulting changes in the annual spill operation will be coordinated through the annual planning process.

Another reason to increase NMFS' knowledge of spill effectiveness is to allow more accurate estimates of smolt-to-adult returns (SAR) of PIT-tagged fish released in and above the hydrosystem. Currently, it is difficult to estimate how many tagged juveniles pass through the spillway and turbines because PIT-tags are only detected at bypass systems. SARs can be determined for bypassed and non-bypassed fish, but the non-bypassed component cannot be accurately split into spill and turbine estimates. Gathering more information about spill effectiveness would allow for greater accuracy in estimating the non-bypassed proportion.

The research actions called for above are proposed to further evaluate the fish spill program at selected projects. In addition, NMFS believes the results of these evaluations will assist in making appropriate future modifications in the spill program to improve both fish survival and water quality.

To the extent that greater spill duration and/or volumes are required for the purposes of spill evaluation at some projects, efforts will be made to minimize or offset additional effects to the power system.

Action: The Corps shall continue high-flow outfall investigations to determine whether it is appropriate to modify bypass outfall criteria in the context of high-discharge bypass discharges.

Development of high-flow outfalls for surface collector/bypass systems is contingent on verification of negligible mechanical and predation losses as flow plunges into the tailrace at high velocities. This research is relevant at numerous sites.

Action: The Corps shall continue to develop and evaluate improved fish-tracking technologies, computational fluid dynamics (numerical modeling), and the ability to integrate these as a potentially improved means of determining fish responses to forebay hydraulic conditions.

More precise understanding of fish behavioral responses to forebay hydraulic and other conditions is required to optimize future fish collection and bypass system designs. Integrated use of improved fish tracking and numerical modeling offers the potential for research advances that will lead to survival enhancement measures.

Action: The Corps shall continue to investigate a means of increasing entry rates of fish approaching surface bypass/collector entrances.

Deep, wide surface collector entrances, similar to the successful Wells Dam surface collector system, have been studied at Corps prototype sites, but performance has been marginal. Therefore, a study is needed to evaluate fish behavior and flow-fields of large surface-oriented entrances that are believed to be highly efficient and effective, such as The Dalles ice and trash sluiceway.

Action: The Corps and BPA shall assess less-intrusive PIT-tag interrogation methods at FCRPS juvenile bypass systems with interrogation sites, including McNary, John Day, and Bonneville dams. The Corps and BPA shall also assess providing similar detection capability for the Ice Harbor juvenile bypass system.

The Corps and BPA should assess the use of full bypass flow PIT-tag detection, without the need to dewater and route fish through separators and sample flumes, with the benefit of reducing the potential for adverse survival effects of passage through these bypass systems.

Action: The Corps and BPA, in coordination with the Fish Facility Design Review Work Group and the Fish Passage Improvement Through Turbines Technical Work Group, shall continue the program to improve turbine survival of juvenile and adult salmonids. This program shall include the following activities:

The Action Agencies shall investigate hydraulic and behavioral aspects of turbine passage by juvenile steelhead and salmon through turbines to develop biologically based turbine design and operating criteria. The Corps shall submit a report to NMFS stating the findings of the first phase of the Turbine Passage Survival Program by October 2001. Annual progress reports will be provided after this date.

The Action Agencies shall examine the effects of draft tubes and powerhouse tailraces on the survival of fish passing through turbines. The evaluation should include biological and hydraulic evaluations and, if warranted, implementation of measures to reduce the effects of turbine backroll on juvenile salmonid survival, as well as the potential for reducing physical and hydraulic predator habitat in the tailrace environment. Action should also be taken to close draft tube gate closure slots at dams where these exist.

The Action Agencies shall remove all unnecessary obstructions in the higher velocity areas of the intake to draft tube sections of the turbine units. These include miscellaneous hardware attachment points, handles, bolt heads, etc. Methods to streamline escape ladders, flow splitters, and other necessary obstructions should be evaluated and implemented, if feasible.

The Action Agencies shall consider all state-of-the-art turbine design technology to decrease fish injury and mortality before the implementation of any future turbine rehabilitation program (including any major repair programs, the ongoing rehabilitation program at The Dalles Dam, and the future program at Ice Harbor Dam). The Action Agencies shall coordinate within the annual planning process before making decisions that would preclude the use of fish-friendly technologies and to minimize any adverse effects of project downtime.

The Action Agencies shall determine the number of adults passed through turbines, then, if warranted, investigate the survival of adult salmonid passage through turbines (including steelhead kelts). This program will include baseline passage evaluation and survival estimates and an investigation of hydraulic and behavioral aspects of turbine passage. This information will be used for the purpose of developing biologically based turbine design and operating criteria.

Action: The Corps shall continue to evaluate the need for improvements of the existing intake screens, gatewell vertical barrier screens' cleaning system, and bypass facilities (including debris containment and removal systems, separation, sampling, loading, and outfall facilities) at the four lower Snake River hydropower projects.

The objective of these investigations is to upgrade intake screen, bypass, and loading facilities to modify and/or incorporate new components, especially in cases where problems have been identified since original design and construction. This includes investigation and implementation of measures to reduce raceway jumping.

Action: The Corps shall complete investigations of improved wet separator designs at Ice Harbor Dam by late 2001. The Corps shall design and construct a new wet separator at McNary, Lower Monumental, and Little Goose dams as warranted.

The Corps shall conduct post-construction evaluations of improved juvenile fish separation performance.

Action: The Corps shall complete the extended submerged intake screen systemwide letter report and implement recommended improvements.

The Corps shall complete an investigation of fish performance and engineering issues pertaining to the need for improved porosity-control panel and panel connection design and install improved panels in all extended submerged intake screens. In particular, the Corps shall develop improved vertical barrier screen gatewell cleaning and inspection measures for McNary and John Day dams and implement them as warranted. Also, the Corps shall develop improved debris handling measures in the forebays and screen/bypass systems to limit juvenile injury and mortality. The Corps shall implement other measures related to extended-length screen improvements, as warranted.

9.6.1.4.7 Configuration Alternatives and Decision Dates

Bonneville Dam

Action: By January 2002, the Action Agencies shall develop an analysis that compares the relative passage survival benefits of an extended-length intake screen bypass system to those of a surface-collection bypass system at Bonneville First Powerhouse and, through the annual planning process, determine which of these configurations to implement.

Two configuration alternatives are under evaluation for an improved bypass system at Bonneville First Powerhouse. One alternative completely upgrades the existing conventional bypass system by replacing the existing standard-length intake screens with extended-length screens, upgrading the collection gallery, and relocating the outfall. The other alternative employs the developing surface attraction and collection technology in front of the powerhouse and passes juveniles in a collection channel to a new outfall site downstream. Intake screens and surface collection may be found to work best in tandem, suggesting a hybrid of the two systems may be a third alternative configuration. The decision on which alternative to implement may be made as early as January 2001, but no later than January 2002.

John Day Dam

Action: By January 2003, the Action Agencies shall develop an analysis that compares the relative passage survival benefits of replacing existing standard-length intake screens with extended-length screens at the powerhouse to surface collection at one or more skeleton bays or spillway bays. Through the annual planning process, the Action Agencies will then determine which of these two configuration alternatives to implement.

Two different configuration alternatives are currently under evaluation at John Day Dam. Extended-length screens have been under development and evaluation for several years. Evaluation to date has indicated that the screens increase FGE, but not without undue mortality in the gatewells. The cause of the mortality is under investigation, and a new design is under development. Surface collection technology has yet to be evaluated at John Day. An RSW is under development for prototype evaluation in 2002. This requires that the Action Agencies make a determination by 2003, through the annual planning process, about which of these alternatives to implement at John Day.

9.6.1.5 Reservoir Passage

In general, juvenile mortality in reservoir typically is associated with predation. While predation may be the primary cause of mortality, many factors contribute to vulnerability to predation, including water temperature, delay of passage or migration, dissolved gas supersaturation, fish condition, disease, turbidity, lack of cover, etc. Various actions are ongoing that directly reduce predation of juvenile outmigrants (e.g., Northern Pikeminnow Management Program) or may indirectly affect potential predation (water management, including releases of cool water, 24-hour spill, spill patterns, avian lines, water cannons, etc.). The Action Agencies shall also develop other approaches that may contribute to reducing reservoir mortality.

9.6.1.5.1 Predator Control Strategy. The riverine ecosystems of the lower Snake and lower Columbia rivers have been altered dramatically by the development of the FCRPS. This development, and associated fish management practices, has created an environment that has benefitted a variety of species that prey on juvenile and adult salmonids. Studies cited in the Predation White Paper (NMFS 2000c) indicate that relatively large numbers of juvenile salmonid migrants are eaten by a variety of piscivorus fish, birds, and marine mammals. The northern pikeminnow alone is responsible for the loss of approximately 8% of the juvenile salmonid migrants in the system, and gulls were estimated to take 2% of all migrants passing one Columbia River dam. Marine mammal damage has been observed on up to 19% of the adult spring/summer chinook passing Lower Granite Dam. NMFS recognizes that death, injury and health problems resulting from dam and reservoir passage and the presence of non-indigenous predator species are issues that will persist regardless of how predation is managed. It also recognizes that native predators are a part of the river ecosystem. Nevertheless, NMFS believes that some degree of predator control is necessary and that the following measures will help achieve the survival performance goals identified in this Biological Opinion, particularly related to the 10% reduction in reservoir mortality estimates.

9.6.1.5.2 Current and Near-Term Actions

Action: The Action Agencies shall continue to implement and study methods to reduce the loss of juvenile salmonids to predacious fishes in the lower Columbia and lower Snake rivers. This effort will include continuation and improvement of the ongoing Northern Pikeminnow Management Program and evaluation of methods to control predation by non-indigenous predacious fishes, including smallmouth bass, walleye, and channel catfish.

Northern pikeminnow, smallmouth bass, channel catfish, and walleye are important predators of juvenile salmon (Poe et al. 1991; Tabor et al. 1993). Various studies conducted in the 1980s indicated that northern pikeminnow predation in John Day Reservoir alone consumed between 1.4 and 3.3 million juvenile salmonids each year. Predator control efforts to date have focused on removing northern pikeminnow from the Snake and Columbia rivers and evaluating the behavior and distribution of predators in the near-dam and reservoir reaches. Additional emphasis should be placed on other predatory species in areas where those species cause significant loss of juvenile salmonids (see Section 9.6.1.5.3, below).

The effects of predator fish removal, habitat modifications, and management operations should be evaluated periodically as long as the programs continue. Evaluation would include effect on juvenile salmon survival, changes in target predator species population structures, and possible compensation by other predatory species.

Action: The Corps, in coordination with the NMFS Regional Forum process, shall implement and maintain effective means of discouraging avian predation (e.g., water spray, avian predator lines) at all forebay, tailrace, and bypass outfall locations where avian predator activity has been observed at FCRPS dams. These controls shall remain in effect from April through August, unless otherwise coordinated through the Forum Process. This effort will also include removal of the old net frames attached to the two submerged outfall bypasses at Bonneville Dam. The Corps shall work with NMFS FPOM, USDA Wildlife Service, and USFWS on recommendations for any additional measures and implementation schedules and report progress in the annual facility operating reports to NMFS. Following consultation with NMFS, corrective measures shall be implemented as soon as possible.

Bird predation marks are among the most common injuries observed on juvenile steelhead at smolt monitoring sites. During 1995 and 1996, 15% and 10%, respectively, of all the hatchery steelhead examined at John Day Dam exhibited bird predation marks (Martinson et al. 1997). These observations may indicate a high rate of predation on juvenile steelhead that could be reduced with appropriate measures. The net frames at Bonneville Dam are no longer used for research and have become favored perching areas for fish-eating cormorants and gulls. The Corps shall coordinate scoping and implementation of predator control measures with USFWS to ensure that the measures do not endanger bald eagles, osprey, and other bird species that are afforded Federal protection.

Any avian control measure involving capture or killing of migratory birds will require a permit issued by USFWS under the procedures and standards set out in the Migratory Bird Treaty Act and in USFWS's implementing regulations.

9.6.1.5.3 Studies (Including Research, Monitoring, and Evaluation)

Action: The Action Agencies, in coordination with the Caspian Tern Working Group, shall continue to conduct studies (including migrational behavior) to evaluate avian predation of juvenile salmonids in the FCRPS reservoirs above Bonneville Dam, and if warranted and after consultation with NMFS and the USFWS, develop and implement methods of control that may include reducing the populations of these predators.

Gulls, terns, pelicans, common mergansers, and other birds consume juvenile salmonids in the Columbia and Snake rivers (Meacham and Clark 1979 in Bevan et al. 1994; Ruggerone 1986 in Bevan et al. 1994; Bevan et al. 1994; Wood 1987). The combined effect of this predation on listed stocks is unknown, but the increasing colonies of Caspian terns, California and ring-billed gulls, and white pelicans could have a substantial effect on limited fish populations. A study of gull predation in the upper Columbia River in 1986 indicated that 2% of the juvenile salmonids passing Wanapum Dam were consumed. Additional information on consumption rates, migration patterns, and the ultimate effect on fish populations is needed before sound management decisions can be made. This effort must be coordinated with ongoing avian control activities in the Columbia River estuary and with the USDA Wildlife Service and USFWS.

Action: The Action Agencies shall quantify the extent of predation by white pelicans on juvenile salmon in the McNary pool. A study plan shall be submitted to NMFS by June 30, 2001, detailing the study objectives, methods, and schedule. Based on study findings, and in consultation with USFWS and NMFS, the Action Agencies shall develop recommendations and, if appropriate, an implementation plan.

Up to six dozen white pelicans have been observed along the Oregon shore a short distance below the McNary Dam juvenile facility during the spring migration. Additional data are needed to determine the extent of pelican predation on salmonids.

Action: The Action Agencies shall recover PIT-tag information from predacious bird colonies and evaluate trends, including hatchery-to-hatchery and hatchery-to-wild depredation ratios.

Evaluation of this information, when combined with bird and fish behavioral information, will help managers develop a better understanding of issues such as prey selection, stock-specific vulnerability, and potential long-term predation effects on specific listed stocks, including effectiveness of management actions to reduce predation by birds.

Action: The Action Agencies shall develop a pilot study to assess the feasibility of enhancing the function of ecological communities to reduce predation losses and increase survival in reservoirs and the estuary.

The pilot study should include a combination of hydrosystem operations, enhancement of mainstem and estuarine habitat, and directed fishery management options. Information for the near-term studies would serve as the basis for a longer-term effort to enhance habitat and community function within the mainstem corridor. Issues to evaluate include natural and manmade habitat alterations, reservoir level fluctuations during predator spawning seasons, sport fish management options, and sediment and nutrient transport.

Action: The Action Agencies, in coordination with NMFS, shall investigate marine mammal predation in the tailrace of Bonneville Dam. A study plan shall be submitted to NMFS by June 30, 2001, detailing the study objectives, methods, and schedule.

From 1990 through 1993, the annual incidence of marine mammal tooth and claw abrasions on fish examined at the Lower Granite adult trapping facility ranged between 14 and 19% for spring-summer chinook, and between 5 and 14% for steelhead. The proportion of adults examined that had open wounds ranged from 5 to 6% for chinook and 1 to 6% for steelhead (Harmon, 1994). The prevalence of these abrasions was generally higher during the earliest portion of the run, with reported incidence of 30% on the chinook in 1993 (Harmon, 1995). Based on the severity of the observed signs, NMFS speculates that many fish injured by marine mammals die before reaching this project. Marine mammal predation occurs in the near-ocean, estuary, and lower Columbia River up to Bonneville Dam. On many occasions, California sea lions have been observed feeding on adult salmon (primarily spring chinook) near the fishway entrances below Bonneville Dam. While predation by marine mammals in the lower river is not a result of the FCRPS, site-specific predation immediately below FCRPS dams (i.e., Bonneville) is, in part, a result of the presence and operation of the dam. Evaluation of this predator activity should include development of remedial methods that may include relocation or lethal removal. This effort must be coordinated with ongoing marine mammal control activities in the Columbia River estuary and near-ocean.

9.6.1.6 Adult Passage and Research

The actions described in this section represent the best starting point for planning future capital investment in measures to improve the survival of adult salmon migrating past the Corps mainstem FCRPS dams. The specific list of measures to be implemented, their priority, and the method of evaluation will be developed in the annual and 5-year plans described in Section 9.5. As determined through the annual planning process in Section 9.5, other combinations of measures may also be deemed sufficient to meet the juvenile and adult performance standards and, thus, be sufficient to avoid jeopardy.

In many cases, the measures described are limited to prototype or facility development and evaluation and include statements that the Action Agencies are expected to implement the results "as warranted." The intent of the measures in these cases is to proceed to implementation upon completion of testing, unless the results of the evaluation present further problems that have to be addressed through further testing.

9.6.1.6.1 Adult Fish Passage Strategy. A primary objective of this RPA is to maximize direct survival of upstream migrating adult fish at the Federal hydrosystem dams with passage facilities and to minimize indirect (pre-spawning) mortality in intervening reservoirs and upstream of the hydrosystem. To achieve this objective the RPA expands investigations of adult passage problems in order to identify direct and indirect mortality-related problems and implement needed improvements. The following research and configuration action items are meant to accomplish six objectives:

- Reduce site-specific and cumulative delay (including fallback over spillways, fallback through turbines and intake screen/bypass systems, and fallback/fallout from fishways).

- Identify correctable project-related direct mortality factors.
- Enhance headburn investigations.
- Protect downstream migrating adult steelhead post-spawners (kelts).
- Improve auxiliary water system diffusers to minimize risk of potential failure (and risks to adult migrants.
- Identify factors related to pre-spawning mortality of fish having passed through the FCRPS hydrosystem.

9.6.1.6.2 Studies (including Research, Monitoring, and Evaluations)

Action: The Action Agencies shall conduct a comprehensive evaluation to assess survival of adult salmonids migrating upstream and factors contributing to unaccounted losses.

Broad objectives for such studies may include the following:

- Determine conversion rates between dams.
- Partition inter-dam losses by factor.
- Assess causal mechanisms associated with losses.
- Assess reproductive success, including causal mechanisms associated with reduced reproductive success, if any.
- Identify measures, as appropriate, to address factors affecting passage, survival, and reproductive success.

More specific investigations may include the following:

- Fallback (operational related versus other factors)
- Passage delay (in relation to project and reservoir operations, including turbines, spill, and peaking)
- Injury (resulting from passage, marine mammals)
- Head burns

- Homing/straying
- Mainstem spawning
- Tributary turnoff and spawning
- Effect of dissolved gas supersaturation
- Effect of temperature (including use of cool water micro-habitat)
- Energy expenditure
- Susceptibility to disease
- Unaccounted incidental mortality associated with harvest
- Cumulative effects (synergism)

Action: The Corps and BPA shall conduct a comprehensive evaluation to investigate the causes of headburn in adult salmonids and shall implement corrective measures, as warranted.

An example of corrective measures would be investigating the potential benefit of replacing existing spill gate closure (sill) seals, in conjunction with improved connector designs, which are benign to large fish that fall back through the spillway. It is possible that this could reduce the incidence of headburn-type injury.

Action: The Corps shall initiate an adult steelhead downstream migrant (kelt) assessment program to determine the magnitude of passage, the contribution to population diversity and growth, and potential actions to provide safe passage.

Evaluations should be conducted to review available literature and develop pilot testing regarding reconditioning of kelts. The Corps shall assess and conduct a short-term holding evaluation at a project site where kelt are more abundant, and initiate a kelt transportation pilot study as a possible means of reducing dam passage mortality. The Corps shall evaluate kelt passage associated with the RSW at Lower Granite Dam (described in Section 9.6.1.4), which will be prototype-tested in 2001 in the context of juvenile fish passage. The Corps shall synthesize these work elements and report the magnitude of kelt passage, effects of passage on survival, and potential actions to improve survival, if deemed appropriate, to the NMFS Regional Forum by 2003.

Action: The Corps shall use information from previous and ongoing investigations regarding the problem of adult steelhead holding and jumping in the fish ladders at John Day Dam, develop a proposed course of action, and implement as warranted.

This problem has been investigated in a fragmented manner for years. A more detailed collation of cumulative work to date is required, combined with an assessment of alternatives.

Action: The Corps shall investigate and enumerate fallback of upstream migrant salmonids through turbine intakes at all lower Snake and lower Columbia River dams. The Corps shall implement corrective measures to reduce turbine mortality, as warranted.

These measures may include installation of extended-length screens (where feasible), extending the period during which the intake screens and juvenile bypass system are in operation, and modifications to operations. Study plans, recommendations, and a schedule for accomplishing this action will be developed through the annual planning process.

Action: The Corps shall investigate means of providing egress to adult fish that have fallen back into juvenile collection galleries and primary dewatering facilities at Ice Harbor and McNary dams. The Corps shall either install structural, or implement operational, remedies that will minimize delay and injury of fish that fall back, as warranted.

Every year, many adult steelhead and salmon fall back through turbine intakes and accumulate in juvenile bypass systems, where many are delayed for protracted periods. Timely egress alternatives for these fish must be identified.

Action: The Corps shall investigate measures to reduce adult steelhead and salmon fallback and mortality through the Bonneville Dam spillway. A final report shall be submitted to NMFS stating the findings of these investigations and recommending corrective measures. Potential recommendations shall be included in the annual planning process, as appropriate.

Adult fallback through the Bonneville spillway has been a long-standing concern. Further investigation is needed to determine factors affecting fallback and potential measures to reduce it.

Action: The Corps shall examine existing fish-ladder water temperature and adult radio-telemetry data to determine whether observed temperature differences in fishways are adversely affecting fish passage time and holding behavior. If non-uniform temperatures are found to cause delay, means for supplying cooler water to identified areas of warmer temperatures should be developed and implemented in coordination with the annual planning process.

Data collected by the Corps show that water temperatures at various sections of the John Day fishways differ from 1 to 4 degrees Celsius (2° to 7° F) at times. Effects of such differences on fish passage are unknown.

Action: The Corps and BPA shall conduct a comprehensive depth and temperature investigation to characterize direct mortality sources at an FCRPS project considered to have high unaccountable adult losses (from either counts and/or previous adult evaluations).

Previous radiotelemetry investigations have been two-dimensional and have attempted to characterize passage routes and timing of successfully passing fish. This study will also attempt to focus on those fish that do not successfully pass and determine whether a consistent source of mortality can be identified and corrected.

Action: The Corps shall investigate adult fish delay and fallback at ladder junction pools and implement remedies to reduce this problem, as warranted.

A large percentage of fish fall back from fishway junction pools at each FCRPS and other hydro projects studied to date. Cumulative delay and influence on pre-spawning mortality could be substantial. Modified hydraulic conditions and other possible remedies, coupled with behavior responses in these areas, may reduce this delay.

Action: The Corps shall evaluate adult count station facilities and rehabilitate where necessary at all projects to either a) minimize delay of adults, or b) minimize counting difficulties that reduce count accuracy.

Some FCRPS hydro project fishway counting stations need design improvement to reduce delay. Cumulative delay, and influence on pre-spawning mortality, could be substantial. Rehabilitating counting stations could also improve the accuracy of adult fish counts.

Action: The Corps shall develop and implement a program to better assess and enumerate indirect prespawning mortality of adult upstream migrating fish. Such mortality may be due to, or exacerbated by, passage through the FCRPS hydro projects.

The program should also enhance efforts to enumerate unaccountable losses associated with tributary turnoff, harvest, or other factors in FCRPS mainstem reservoirs and upstream of FCRPS projects. The program should also include pilot studies to assess the effects of upstream migration of adults through the hydrosystem (including the thermal environment through which they must migrate) on their overall fitness and spawning success, including energy budgets, ability to complete spawning behavior, and successful production of quality gametes. Currently, little work has been completed to assess the magnitude and breadth of pre-spawning mortality of adult migrants, especially upstream of the FCRPS hydrosystem. These investigations are expected to identify measures at FCRPS hydro projects, and possibly in tributaries, that will lead to reductions in pre-spawning mortality throughout the Columbia River basin. As warranted, the Corps shall initiate further actions to reduce pre-spawning mortality.

Action: The Corps shall ensure that alterations to fish ladders and adult passage facilities to accommodate Pacific lamprey passage do not adversely affect salmonid passage timing and success.

Followup evaluations are needed as a precaution.

9.6.1.6.3 Adult Fishway Operating Criteria. The Corps' annual fish passage plan (FPP) stipulates operating criteria for FCRPS hydro project adult fishways. Where this criterion is not satisfied, incremental adverse effects to adult migrants (such as delay) may occur. Actions to enhance compliance with fishway criteria include auxiliary water system assessments and upgrades. Other actions address the issue of inadequate fishway entrance weir submergence during low tailwater elevations.

Action: The Corps shall develop improved operations for adult fishway main entrances at FCRPS dams so that the best possible attraction conditions are provided for adult migrants, both at the four Columbia River hydro projects and the four lower Snake hydro projects (where reservoir elevations are held near MOP). The Corps shall report the findings of these flow-balancing investigations in a report to NMFS by the end of 2001 and shall continue to work through FPOM to evaluate and implement, as warranted, structural changes to satisfy FPP fishway entrance criteria.

Current FPP fishway entrance criteria cannot be satisfied at some entrances at many FCRPS hydro project fishways during low tailwater periods. Concurrently, some entrances pass appreciably more fish than other entrances at the same project. The Corps should, on an interim basis, conduct evaluations and implement flow-balancing operations of fishway entrances to assure that entrance discharges are equivalent to what would be provided if criteria were being satisfied. The Corps should also continue to investigate various operations (such as closing floating orifice gates or other operational alternatives) to improve adult entrance and passage conditions.

Action: The Corps shall evaluate and modify, if necessary, the Bonneville Dam First Powerhouse main fishway entrances to ensure compliance with the 8-foot minimum gate depth criterion at all tailwater elevations. Alternatively, the Corps shall develop an acceptable rationale for not doing so. The Corps shall report findings to NMFS by late 2001.

At low tailwater elevations, the entrances for this fishway cannot satisfy FPP fishway operating criteria. Ensuring satisfactory adult passage could require correction of this problem.

9.6.1.6.4 Reliability Enhancement. It is imperative that FCRPS hydro project fishways operate in the optimum manner during fish passage periods to minimize the risk of injury and mortality. Actions to increase reliability include fishway assessments to identify aging facilities (and components) in need of replacement or redesign, debris handling needs, and emergency backup auxiliary water capabilities (related to fishway entrance attraction water supply).

Action: The Corps shall develop and maintain an auxiliary water-supply, emergency-parts inventory for all adult fishways where determined, in coordination with NMFS, to be necessary.

Emergency supplies are needed to maintain fishways within optimum criteria for passage in the event of turbine, pump, electrical, debris management, or water-control system component failures.

Action: The Corps shall continue design development, and subsequently construct an emergency auxiliary water supply system at The Dalles Dam east ladder.

The Dalles adult fishways pass the second-highest number of adult fish of any FCRPS hydro project. With aging auxiliary water turbines, generators, and transformers, there is an increasing risk of faulty adult fishway performance during primary passage periods. Emergency backup auxiliary water is vital to attract fish into the fishways, if a primary fishwater turbine failure occurs.

Action: The Corps shall continue to investigate alternatives to dewater adult auxiliary water system floor diffusers for inspection at The Dalles adult fishway powerhouse collection channel. The Corps shall implement design and construction of needed changes, as warranted.

Due to leaking fishway entrance gates, there is an inability to dewater the powerhouse adult collection channel to inspect aging facilities such as add-in diffusers. Several years ago, a large number of adult salmon passed through diffusers and were killed. This action will minimize the chance of the recurrence of this problem.

Action: The Corps shall investigate methods to provide additional emergency auxiliary water to The Dalles Dam north fishway, during periods when the normal auxiliary water supply is interrupted.

If the existing Northern Wasco County PUD turbine at the north shore fishway has a prolonged outage, gravity auxiliary water would have to be provided for fishway attraction flow. The current rock conveyance channel is deteriorated and unstable. This additional water could also be used to supply the second fishway entrance if adult passage studies indicate the entrance is needed.

Action: The Corps shall complete the rehabilitation of the aging McNary Dam south ladder auxiliary water supply pumps.

A McNary fishway assessment conducted in 1995 identified the need to rebuild aging auxiliary water pumps before they deteriorated further.

Action: The Corps shall develop and implement an automated monitoring and alarm system at appropriate FCRPS projects, as determined in the NMFS Regional Forum, to remotely monitor changes in head differential at auxiliary water supply system diffusers.

Implementation of this action would help avoid undetectable diffuser failures and potentially significant adult fish losses. In the interim, the Corps shall work through the FPOM coordination team to develop early detection measures and include these in the annual Fish Passage Plan before the 2001 fish passage season.

9.6.1.6.5 Fishway System Assessments. Additional fishway assessments are needed to address, in a more comprehensive manner, fishway systems at some FCRPS hydro projects that have aging facilities or ongoing, unresolved problems. These assessments will lead to a well-defined list of corrective measures.

Action: The Corps shall initiate an investigation and prepare a report on the Bonneville First Powerhouse Bradford Island and Cascade Island adult fishway auxiliary water system by the end of 2001. In the report, the Corps shall identify measures that will improve or replace aging components, thereby enhancing current and long-term performance and reliability.

The need for design changes and improvements shall be evaluated, particularly with respect to elevated dissolved gas levels in the auxiliary water supply systems. Report recommendations should be implemented, as warranted.

Action: The Corps shall continue its investigation of the Bonneville Second Powerhouse adult fishway auxiliary water system and shall identify measures to satisfactorily address emergency backup auxiliary water needs. The Corps shall also design and install an improved diffuser differential monitoring and automated-response system, which will reduce the potential for future diffuser failures. The Corps shall identify and implement measures that will result in enhanced long-term performance and reliability.

Bonneville Second Powerhouse adult auxiliary water facilities failed in 1997 during the peak of the adult fall chinook and steelhead migrations. This action is attended to ensure that this does not occur again.

Action: The Corps shall initiate an engineering study to evaluate existing limitations relating to its inability to satisfy FPP operating criteria at the John Day Dam north shore ladder.

The study scope should also assess backup AWS needs, reliability or enhancement design improvements, and upgrade options for the AWS system. The Corps shall implement corrective measures as warranted.

Action: The Corps shall complete adult fishway auxiliary water supply evaluations at each lower Snake River hydro project and implement corrective measures as warranted.

The objective of this measure is to ensure compliance with fishway entrance criteria, optimize emergency auxiliary water backup provisions, and assure long-term reliability.

9.6.1.7 Water Quality

9.6.1.7.1 Water Quality Strategy. The effect of water quality on ESA-listed anadromous fish in the basin supports the merit of an integrated and coordinated approach for addressing both the ESA and CWA. Accordingly, EPA, NMFS, USFWS, and the Federal Action Agencies (i.e., Corps, BOR, and BPA) are undertaking efforts to conserve listed species under the ESA and create a nexus for water quality improvements consistent with the CWA.

The ESA and the CWA are compatible and complementary statutes offering opportunities, through integration, to conserve listed species and improve overall system water quality. Both laws stress the importance of maintaining ecosystem integrity. Recognizing that system improvements for fish and wildlife can also benefit water quality, EPA, NMFS, USFWS, and the Federal Action Agencies intend to integrate fish and wildlife and water quality efforts in the form of actions to support the objectives and responsibilities of the ESA, CWA, and other fish and wildlife program goals such as the NWPPC's fish and wildlife program under the Northwest Electric Power Planning and Conservation Act.

Currently, voluntary spill for fish passage occurs at dams up to the dissolved gas supersaturation level of 120% in the project tailrace, or 115% TDGS in the project forebays, as allowed by special conditions to state and Tribal water quality standards. However, spill for fish passage that results in exceedances of the 110% gas standard is considered an interim strategy in the sense that the long-term goal is to try to keep TDG levels within Federally-approved state and Tribal water quality standards.

Accordingly, the 1995 FCRPS Biological Opinion mandated initiation of the Dissolved Gas Abatement Study (DGAS). This multi-year comprehensive study by the Corps of Engineers investigated and extended understanding of gas absorption and reduction associated with spill at Columbia and Snake river hydro projects. It also investigated short- and long-term operational and structural gas abatement alternatives, which resulted in installation of spillway flow deflectors at both John Day and Ice Harbor spillways. These improvements increased project survival at both sites, and improved water quality during both voluntary and involuntary spill periods. The DGAS also developed numerical models to fully investigate the hydrosystem response to structural and/or operational changes. One outcome of DGAS was that no structural action was identified that would reduce total dissolved gas levels to 110% without threat of adverse effects to passing fish.

To assess the feasibility of reducing TDG to the 110% standard while still meeting the survival objectives of listed salmon, EPA, NMFS, USFWS and the Federal Action Agencies commit to continued efforts to identify water quality improvement actions (see Appendix D). These efforts will lead to decisions on whether structural or operational changes exist which will allow FCRPS projects to achieve both fish passage and water quality objectives, or to support changes in non-Federal projects in the Columbia River basin that have a cumulative effect of reducing TDG levels systemwide. Information developed from these studies may also provide a basis for future decisions concerning beneficial use and water quality criteria revisions. Such decisions will result from a coordinated effort between EPA and NMFS, and discussions with states, Tribes, and other interested parties. The EPA, NMFS, USFWS, and the Federal Action Agencies will continue to work toward implementing a combination of actions that benefit both fish survival and water quality.

Part of the decision-making process to evaluate the structural and operational changes necessary to meet the 110% goal will be based on a review of the existing data collected since the release of the NMFS 1995 Biological Opinion (see Section 6.2.5.1.1 for a summary of the 2000 Biological Opinion Update of Spill and Risk Management). Gas bubble trauma in juvenile salmonids is observed at all gas supersaturation levels, but the overall incidence and severity resulting from fish passage spill at FCRPS projects is low.

The strategy outlined in Section 9.5.2.4 on water quality is to identify ongoing activities and planned improvements in fish survival that also serve to improve water quality by reducing TDG and water temperature. Long-term structural, operational, and procedural measures for water quality improvements are addressed more fully in Appendix D.

The water quality plan includes the following basinwide goals for total dissolved gas and temperature. NMFS, EPA, and the Action Agencies commit to work toward these goals. They recognize, however, that reaching the goals may take more time than the duration of this Biological Opinion and that exceedances may nevertheless occur.

Dissolved Gas Goal. The long-term dissolved gas goal is to reach the 110% total dissolved gas (TDG) standard in all critical habitat in the Columbia and Snake River basins while taking actions to recover listed species in the basins. For anadromous fish, achieving the goal would mean fish passage survival levels are consistent with the performance standards for the mainstem projects.

This goal is intended to guide operating and capital improvement decisions relating to TDG created during periods of spill. A systemwide approach is needed to address gas generated at mainstem projects where fish are present, and at upstream facilities (i.e., outside the current range of listed salmon) in both the U.S. and Canada, the five Public Utility District dams on the Columbia River between the Snake River and Chief Joseph Dam, and the Hells Canyon complex on the Snake River. There are some exceptions noted in the ability to meet the state and Tribal TDG standard.

Without physical modifications to the dams beyond those that are presently under way, the long-term TDG goal cannot be attained in the near term between April and August at and between the eight mainstem FCRPS dams. This is a result of the need to rely on spill to safely pass juvenile salmon around those dams. A similar issue exists with Dworshak Dam, where in some circumstances spill is necessary to contribute to the attainment of spring and summer flow objectives for salmon migration and water temperature standards in the Clearwater and lower Snake rivers. Therefore in the near term, it will be necessary to conduct spill operations that cause exceedances of the 110% TDG gas standard. The Corps is responsible for ensuring that the spill program, and the Snake River flood control shift from Dworshak, are conducted in a manner consistent with applicable state and Tribal water quality standards, including compliance with any related procedural requirements. This includes obtaining any necessary exemptions, special conditions, waivers, modifications, site-specific criteria, or standards changes. In any event, the spill operations shall comply with the special TDG conditions set forth below.

To ensure progress toward the long-term goal, the Corps, BOR, and BPA will also work with NMFS, USFWS, EPA, the Columbia River Tribes, and the states of Washington, Oregon, Idaho, and Montana through an adaptive management process as a part of the Water Quality Plan to accomplish the following:

- Make operational and capital investment decisions at the Federal projects to reduce levels of gas generated by spill and to reduce the reliance on spill as a primary means of juvenile fish passage.

- Fund, implement, and report on adequate physical and biological TDG monitoring to assess compliance with state and Tribal water quality standards and other special conditions that may apply.

- Fund and implement modeling to better assess and act on TDG water quality issues.

The feasibility of meeting the long-term goal will be revisited annually during the water quality improvement planning process.

Special TDG Conditions for Juvenile Fish Passage. At the eight Columbia/Snake River mainstem hydro projects, spill will be reduced as necessary when the average TDG concentration of the 12 highest hourly measurements per calendar day exceeds 115% of saturation at the forebay monitor of any Snake or lower Columbia river dam or at the Camas/Washougal station below Bonneville Dam. Spill will also be reduced when the 12-hour average TDG levels exceed 120% of saturation at the tailrace monitor at any Snake or lower Columbia River dams or Dworshak Dam. Spill will also be reduced when instantaneous TDG levels exceed 125% of saturation for any 2 hours during the 12 highest hourly measurements per calendar day at any Snake, Clearwater, or lower Columbia River monitor.

> *[**Note seeking comment**: Since 1995, NMFS has annually applied to Washington, Oregon, Idaho, and the Nez Perce Tribe for waivers from the 110% standard to allow for juvenile fish passage and flow augmentation spill as described above. All have granted waivers (or temporary standard changes) consistent with the interim exception at some times and under certain circumstances. NMFS appreciates this support in meeting the survival requirements of listed salmon. NMFS also appreciates the continued willingness to work with NMFS and the other Federal agencies. However, operation of FCRPS projects consistent with water quality standards is the responsibility of the Action Agencies, not NMFS. State water quality agencies and EPA have repeatedly and consistently made the point that annual waivers are not an appropriate means of addressing these issues.*
>
> *Through the opportunity to review and comment on this Biological Opinion, NMFS and the Action Agencies are seeking recommendations from the States and Tribes on how best to go about the approval processes described above.]*

<u>Water Temperature Goal</u>. The long-term goal for water temperature is standard attainment in all critical habitat in the Columbia and Snake River basins. In the mainstem Columbia/Snake River, attainment of the temperature standard is very complex, due to a number of interrelated factors that affect water temperatures at certain times of the year and to the limited ability to alter water temperature in the mainstem. In the tributaries, attainment of the temperature standard is also complex, due to many of these same factors and the long time needed to realize the temperature benefits of remedial actions (such as riparian restoration). Therefore, in the near term, working with the state and/or Tribe with relevant regulatory authority, the interim goal is to take actions to move toward attaining the standard. Actions to be taken where TMDLs are not yet in place will be consistent with the annual collaborative process described in the following paragraph. Once TMDLs are in place, actions will be consistent with these TMDLs for each relevant water quality limited body.

To ensure progress toward the long-term goal, the Corps, BOR, and BPA will also work with NMFS, USFWS, EPA, the Columbia River Tribes, and the states of Washington, Oregon, Idaho, and Montana through an adaptive management process as a part of the water quality plan to achieve the following:

- Make operational and capital investment decisions at the FCRPS projects to move toward attainment of thermal water quality standards.

- Seek consensus on offsite mitigation measures that would contribute to attainment of water temperature standards.

- Fund, implement, and report on adequate physical and biological temperature monitoring to assess compliance with state and Tribal water quality standards and other special conditions that may apply.

- Cooperate with others to fund implementation and modeling to better assess and act on thermal water quality problems and opportunities.

- Develop emergency measures that may be needed to address immediate and acute water temperature problems affecting listed salmon.

The feasibility of meeting the long-term goal will be revisited annually during the water quality improvement planning process.

9.6.1.7.2 Water Quality Plan Implementation and Water Quality Improvment Team. Over the longer term, with a focus on water quality, EPA, NMFS, USFWS, and the Federal Action Agencies will participate in developing and implementing a water quality plan for the Columbia River mainstem (Appendix D) that supports TDG and temperature water quality improvements to the Columbia River basin, mainly in the portions of the Columbia, Snake, and Clearwater rivers where FCRPS dams exist. The water quality plan will be consistent with the Columbia/Snake river mainstem Total Maximum Daily Load (TMDL) that is currently being developed by EPA, states, and Tribes. EPA, NMFS, and the Federal Action Agencies expect to integrate implementation of the water quality plan with ongoing TMDL development activities on the mainstem and in the subbasins to improve the ability to achieve water quality standards.

To successfully implement the water quality plan for the FCRPS, a new organizational structure composed of Federal, state, and Tribal representatives is necessary to integrate the efforts of all interested stakeholders and provide a connection between existing broad-scale coordination efforts that are ongoing in the basin. To provide a sound link between the CWA and ESA requirements, a water quality improvement team (WQIT) will need to be formed. The water quality plan will be implemented as a responsibility of the WQIT as part of the regional forum.

The intent will be to link and integrate actions undertaken in the annual planning process and the Columbia River Basin Forum, through input and updates on water quality plan implementation. This would include consideration of the traditional TMDL development and implementation processes to improve water quality on the mainstem Columbia River. The WQIT would have both TDG and temperature technical subcommittees to ensure appropriate subject matter expertise in the planning and implementation processes.

9.6.1.7.3 Current and Near-Term Actions and Studies

Dissolved Gas Measures

Action: The Action Agencies shall monitor the effects of total dissolved gas supersaturation. This annual program shall include physical and biological monitoring and shall be developed and implemented in consultation with the WQIT and the Mid-Columbia Public Utility Districts' monitoring programs.

At a minimum, the physical monitoring components of this plan shall include placement of physical dissolved gas monitors in the tailraces and forebays of all lower Snake and lower Columbia River dams, and daily recording of dissolved gas data on the CROHMS database. This program shall also include a quality assurance (QA) and quality control (QC) component, including redundant and backup monitors at as many locations as necessary, as well as weekly calibration of dissolved gas monitoring equipment, an error checking, correcting and recording function for CROHMS data, and daily data reporting. The QA/QC components shall be reviewed annually and modified as improved information and techniques become available. The annual review shall be conducted by the Action Agencies in coordination with the WQIT.

At a minimum, the biological monitoring components will include smolt monitoring at selected smolt monitoring locations, adult monitoring at Bonneville and Lower Granite dams, and daily data collection and reporting.

Action: The Action Agencies shall complete development of a dissolved gas model to be used as a river operations management tool by spring 2001. Once a model is developed, the applications and results shall be coordinated through the WQIT. The Action Agencies shall coordinate the systemwide management applications of gas abatement model studies with the annual planning process, the Transboundary Gas Group, the Mid-Columbia Public Utilities, and other interested parties.

Dissolved gas supersaturation, caused by large volumes of water spilling over dams, can result in the injury or mortality of juvenile salmonids. Since the 1960s, increased hydraulic capacity at powerhouses of mainstem projects, increased water storage, and structural modification to spillways have substantially reduced this problem. However, high levels of dissolved gas have been measured under some river conditions even in recent years, such as during periods of involuntary spill. Development of a systemwide dissolved gas model would assist with in-season management of involuntary spill.

Action: The Corps shall continue the spillway deflector optimization program at each FCRPS project and implement it, as warranted. The Corps and BPA shall conduct physical and biological evaluations to assure optimum gas abatement and fish passage conditions.

The spillway deflector optimization program shall have the following objectives:

- Increase juvenile fish passage survival at FCRPS projects by increasing the allowable spill discharge up to the TDG special condition gas cap level during voluntary spill periods (as defined by the NMFS annual spill program in Section 9.6.1.4.4).

- Decrease total dissolved gas levels during both voluntary and involuntary spill periods.

- Considering both juvenile and adult fish passage criteria, develop spill patterns that improve juvenile survival, reduce delay of juvenile salmon in forebays, optimize juvenile egress from tailraces, and provide good adult passage conditions downstream of fish ladder entrances.

Action: The Corps shall include evaluations of divider walls at each FCRPS project in the spillway deflector optimization program. Design development and construction of divider walls would begin only after coordination within the annual planning process, and only if warranted.

Design development of divider walls is an option under consideration to potentially reduce entrainment of powerhouse flow into spillway flow. The degree to which powerhouse flow in the tailrace mixes laterally with spillway flow is an unresolved issue. Specifically, the extent to which powerhouse flow total dissolved gas levels are increased or decreased in the tailrace may be affected by mixing with water that has passed through the spillway. Additional investigation is required to increase understanding of this issue. Optimum deflector design development shall include a full investigation of powerhouse flow entrainment with spillway flow and total dissolved gas uptake downstream of each project. Construction at an FCRPS project shall be included in the deflector optimization program, if warranted, for the purpose of attaining water quality and fish survival benefits.

Action: The Corps shall continue to develop and construct spillway deflectors at Chief Joseph Dam by 2004 to minimize total dissolved gas levels associated with spill.

To the extent feasible, the Corps, Bureau, and BPA shall treat Grand Coulee and Chief Joseph dams as a composite project to reduce the incidence of spill at Grand Coulee, while spilling proportionately more at Chief Joseph. Chief Joseph deflectors should be designed for historic spill levels, coupled with the additional need to accommodate incremental spill from Grand Coulee.

Action: The Corps shall investigate total dissolved gas abatement options at Libby Dam, including the installation of spillway deflectors and/or additional turbine units. The Corps shall construct gas abatement improvements at Libby on the Kootenai River, as warranted, to reduce total dissolved gas levels below the project.

Through the use of numerical TDG modeling, the Corps should assess projected gas abatement benefits at Libby Dam on a site-specific and systemwide basis.

Action: The Corps shall continue to investigate removable spillway weirs (RSWs), in conjunction with extended spillway deflectors, as a means of optimizing safe spillway passage of adult steelhead kelts and juvenile migrants.

While these prototype RSW evaluations continue, they have the potential to both incrementally reduce spill discharge and total dissolved gas levels downstream. Thus, development of RSWs (and other surface bypass concepts) have the potential to integrate implementation of actions to meet both ESA and CWA requirements. (See also Section 9.6.1.5, Juvenile Fish Passage Studies.)

Action: The Corps shall investigate total dissolved gas abatement options at Dworshak Dam, and implement as warranted, in coordination with the annual planning process.

Implementation of total dissolved gas abatement measures at Dworshak have the potential to improve water quality during periods when project discharges exceed current turbine capacity.

Action: The Corps shall design the spillway Number 1 (end bay) deflector at John Day, and implement as warranted, in coordination with the annual planning process.

Absence of a spillway deflector at spill bay Number 1 results in fixed monitor station TDG readings that are unrepresentative relative to the entire spillway tailrace.

Water Temperature Measures. The Action Agencies, in coordination with EPA, NMFS, and USFWS, intend to abate or offset temperature effects associated with FCRPS operations, and assess the feasibility of reducing temperature in ways beneficial to fish, based on the actions identified below.

Summer operations for temperature control in the Snake River are included in Section 9.6.1.2.3 under Dworshak Dam operations.

Modifications to allow Dworshak National Fish Hatchery water supply rearing operations to be independent of Dworshak Reservoir temperature control releases in the summer are included in Section 9.6.1.2.6 under Measures to Evaluate and Adjust the Amount of Water Available to Support Flow Objectives.

Evaluations of fish ladder water temperature and adult passage data are included in the adult passage studies discussion in Section 9.7.1.2.

Action: The Corps shall work through the regional forum process to identify and implement measures to address juvenile fish mortality associated with high summer temperatures at McNary Dam. As a starting point, assemble and analyze the temperature data that have been recorded in the McNary forebay, collection channel, and juvenile facilities. Relationships between juvenile mortality, temperatures, river flow rates, and unit operations shall be examined in detail. The Corps shall investigate the feasibility of developing a hydro-thermal computational fluid dynamics model of the McNary forebay to evaluate the potential to determine optimal powerhouse operations or structural modifications for minimizing thermal stress of juvenile salmon collected in the summer, and to conduct a modeling program if warranted.

Thermal profile data have been routinely collected at McNary Dam for over a decade. These data formed the basis for special project operations, such as north powerhouse loading operations during the summer warm-water temperature period. The 1995 NMFS Biological Opinion required the Action Agencies to take measures to reduce the potential for reoccurrence of the 1994 thermal-related mortality observed at McNary Dam. Coutant (1999) suggested the cause of the observed acute mortalities was a cumulative thermal dose of exposure to high temperature water received over a period of several days (NMFS 2000 White Paper; passage of juvenile and adult salmonids past Columbia and Snake River dams).

Action: By December 31, 2000, the Action Agencies shall develop and submit for NMFS' and EPA's approval, a plan to model the water temperature effects of alternative Snake River operations.

The modeling plan should focus on water temperatures in the Snake River, from Hells Canyon Dam on the Snake River and from Dworshak Dam on the North Fork of the Clearwater River to Bonneville Dam on the Columbia River. Predictive nodes should be located at the near-dam forebays and tailraces of each project. Both one-dimensional and multi-dimensional models (due to reservoir stratification) may be needed to fully define expected temperature conditions within the reach. The models should be developed to function both as a pre-season planning tool and to provide predicted outcomes of immediate operations in real time to assist the in-season water management decision process.

Action: In consultation with EPA, NMFS, and state and Tribal water quality agencies, the Action Agencies shall develop a temperature data collection strategy necessary for developing and operating the models and documenting the effects of project operation.

Existing water temperature and meteorological data are inadequate for this purpose. Existing data and statistical tools will be used to identify locations where additional or improved data collection, in terms of precision, accuracy and frequency, would be most beneficial.

9.6.1.8 Strategy to Improve Fish Facility Operations and Maintenance

The strategy to improve fish facility operations and maintenance addresses the need for adequate O&M budget and funding commitments by the Corps and BPA, coupled with the resource capability to undertake and implement needed O&M actions. The overall goal is to ensure that new and existing fish passage facilities perform at their designed level to increase both juvenile and adult fish survival. An improved O&M program should accomplish the following:

- Meet the increasing O&M needs of aging fish facilities.
- Incorporate new O&M requirements as new fish passage facilities are installed.
- Accommodate expanding annual budget requirements associated with operational changes and research needs.
- Implement preventive maintenance programs for fish passage facilities to assure long-term reliability.

9.6.1.8.1 Fish Passage Plan Development and Implementation. The Corps shall continue to annually update the FPP in coordination with NMFS and through the process established by FPOM. Comments developed by NMFS on the draft FPP shall be reconciled by the Corps in writing to NMFS' satisfaction or implemented before release of the final FPP. The Corps should continue to provide weekly and annual reports regarding implementation of the FPP to NMFS.

All planned special facility operation activities that cause any facility to be out of compliance with the operations and criteria described in the main text of the FPP (and expected to result in the take of listed salmon stocks) must be adequately coordinated with NMFS at least 1 month before the anticipated action date. Simply identifying special project operations in the FPP does not necessarily mean that the action has undergone the requirements of ESA Section 7 consultation. The effects of special operations on listed fish are usually not adequately specified in the FPP, and NMFS requires further essential information, including a brief summary of the action, location, anticipated date and time, analysis of potential effect on listed salmon stocks, and potential alternative actions.

The Corps shall make hourly turbine unit and spill bay operation data available on its Web site during the juvenile migration season. These data are necessary for NMFS to monitor compliance with operating criteria in the annual FPP (e.g., unit operating priorities and spill patterns), as well as agreed-upon special project operations for research or maintenance.

9.6.1.8.2 Actions to Improve Operation and Maintenance of Passage Facilities

Action: The Corps, in coordination with the Regional Forum, shall maintain juvenile and adult fish facilities within identified criteria and operate FCRPS projects within operational guidelines contained in the Corps' Fish Passage Plan. The Corps will coordinate with NMFS on the development of these criteria and operational guidelines before the start of each fish passage season (generally February 1).

Insufficient ladder entrance water depth and insufficient entrance attraction velocity are factors that negatively affect adult fish passage (Bell 1991). Maintaining fishways within optimum criteria for passage is likely to reduce dam passage delays for migrating salmon. Monitoring adult fishways frequently, and improving the maintenance and repair of fishway components such as pumps, gear boxes, diffuser valves, and entrance gate controls, is expected to improve system operational reliability.

Fishway inspections for all fish passage facilities shall occur at least three times per day during the fish passage season. Any identified maintenance needs and repairs shall be completed as quickly as possible. Juvenile bypass collection channel orifices in operating units shall be cleaned three times per day during the high debris periods (April through June). During emergency auxiliary water supply outages, floating orifices in adult fishways shall be closed before the main entrances are.

Upgrading existing adult fish passage facilities will also aid the monitoring effort and contribute to maintenance of optimum criteria. The upgrade shall include:

- Automation of control systems
- Placement of staff gauges (for determining water elevations) in areas that are accessible for both cleaning and reading
- Providing velocity meters in areas of known low velocity in the collection channels

Action: The Corps shall develop and implement preventative maintenance programs for fish passage facilities that assure long-term reliability, thereby minimizing repair costs.

Action: The Corps shall address debris-handling needs and continue to assess more efficient and effective debris-handling techniques to assure that the performance of both new and old fish passage facilities will not be compromised.

This effort should include the investigation of debris shear booms at all FCRPS Corps projects that pass listed fish. Design and construction of appropriate facilities should be undertaken as warranted. Shear booms keep as much debris as possible from accumulating at the upstream powerhouse face, where the debris increases fish injury and mortality and requires more labor-intensive handling and removal. These investigations will include assessment of predator cover and potential guidance of juvenile salmonids away from fish passage facilities as a result of the boom structure.

9.6.1.8.3 Actions to Improve Operation and Maintenance Planning and Budgeting

Action: The Corps and BPA, through the annual planning process, shall develop and fund annual and 5-year O&M plans and budgets that enhance the capability to implement current and projected O&M actions at FCRPS projects for listed salmonid stocks.

In recent years the Corps' O&M program budget for operations and maintenance of fish passage facilities at FCRPS projects has remained static and has not met increased needs. As a result, there is a growing backlog of needed maintenance actions. Enhanced preventative maintenance programs are needed to avoid costly and untimely repairs and improve facility reliability. New fish passage facilities are being installed, which will create new operations and maintenance needs. Other operational needs, such as increased juvenile fish barging, also raise annual O&M budget requirements. To address these needs the O&M annual budget will be based on the annual and 5-year plans to be developed by FPOM under SCT. The annual and 5-year plans will be based on the following:

- Development of a fish facilities preventative maintenance program
- Current requirements for updating aging facilities
- Requirements of new facilities scheduled to come on line each year
- Debris-handling needs and techniques
- Current operations and any anticipated changes.

The Corps' resource capability to undertake and implement O&M actions should also be considered.

9.6.1.9 Advance Planning for Possible Additional Actions

Action: Consistent with direction from Congress and their authorities, and in coordination with NWPPC, the Action Agencies shall develop and submit for independent review an economic and cultural mitigation plan. The plan shall address information needs associated with a potential request for authority to implement breaching the four lower Snake River dams, including roads, rail, utilities, pumps, diversions, embankments, and bridges. The plan shall specifically include strategies and options to mitigate disproportionate impacts to communities, industries, and Indian Tribes. These studies and evaluations related to breach shall be completed before the mid-point assessment in 2005.

Action: The Corps shall promptly complete the Lower Snake River Feasibility Study and shall by 2002 seek appropriations to complete preliminary engineering and design work by 2005 for potential removal of the four lower Snake River dams.

Although breaching is not essential to implementation of the initial actions called for in the RPA, which constitute a non-breach approach, the RPA requires that the Action Agencies prepare for the possibility that breaching could become a necessary contingency. These actions will reduce the time needed to seek congressional authorization for breach, and thus reduce the time needed for possible implementation, thereby avoiding risks of delay should breach later become a preferred approach.

9.6.2 Habitat Actions

Because listed fish in the Columbia are in such precarious condition, the habitat strategy is intended to accelerate efforts to help fish in priority areas in the short-term, while laying a foundation for long-term strategies through subbasin and watershed assessment and planning. This habitat strategy is premised on a close linkage between Federal and non-Federal habitat programs to establish clear priorities and compatible assessments, planning and coordination mechanisms.

In the short term, Federal agencies commit in the All-H Paper to focus immediate attention on priority subbasins – subbasins with potential for significant improvement in anadromous fish productive capacity as a result of habitat restoration. The All-H Paper identifies these short-term actions, timelines, and responsible Federal agencies. This Opinion identifies the Action Agencies' contribution to the All-H program. In this Opinion, where costs are stated, they are estimates meant to help define the scale and pace of the action, not specific amounts the Action Agencies must actually spend to comply with this Opinion.

Over the long term, the habitat strategy has three overarching objectives: 1) protect existing high-quality habitat, 2) restore degraded habitats on a priority basis and connect them to other functioning habitats, and 3) prevent further degradation of tributary and estuary habitats and water quality.

When related to the basic habitat needs of listed anadromous fish, habitat efforts have the following objectives:

- Water quantity: increase tributary water flow to improve fish spawning, rearing and migration.

- Water quality: comply with water quality standards, first in spawning and rearing areas, and then in migratory corridors.

- Passage and diversion improvements: address instream obstructions and diversions that interfere with or harm listed species.

- Watershed health: manage both riparian and upland habitat, consistent with the needs of the species.

- Mainstem habitat: improve mainstem habitat on an experimental basis and evaluate the results.

- Estuary improvement: improve and restore habitat conditions in the Columbia River estuary.

***Action*:** The BOR (or such other agency as the Secretary of the Interior or Congress shall designate) shall initiate programs in three priority subbasins per year over a 5-year period, in coordination with NMFS, USFWS, the states and others, with an objective to protect productive habitat and address flow, passage, screening problems, and improving degraded habitat in each subbasin over a 10-year period. Under the Northwest Power Planning Council Program, BPA addresses passage, screening, and flow problems, where they are not the responsibility of others. BPA expects to expand on these measures in coordination with the Council process to complement Bureau actions described in this Action.

The Federal agencies have identified priority subbasins where addressing flow, passage and screening problems could produce short-term benefits. In these subbasins, analysis suggests that focusing resources on protecting productive habitat and addressing water, passage and diversions would maximize short-term gains. This action initiates immediate work in three such subbasins per year, fifteen subbasins at the end of 5 years. The BOR is the lead for these initiatives. However, because the BOR currently lacks funding authority for much of this work, it will begin the work for which it does have authority and seek to obtain the additional authorization and appropriations to implement this action fully. In addition, recognizing the critical importance of initiating this work quickly, BPA will expand on measures under the Council program to complement the Bureau's action. Finally, for some ESUs such as CR chum salmon, habitat restoration is also a high priority in the short term.

***Action*:** In priority subbasins, BPA shall provide funds to and protect existing productive habitat that is at risk of being degraded.

Undertaking difficult and expensive efforts to restore degraded habitat while losing existing productive habitat would be a poor bargain. Accordingly, this opinion puts high priority on protecting habitat that is currently productive, especially if at risk of being degraded. BPA should protect these habitats through conservation easements, acquisitions or other means, working with non-profit land conservation organizations and others.

Action: BPA shall, in coordination with NMFS, experiment with innovative ways to increase tributary flows by, for example, establishing a water brokerage to demonstrate innovative solutions for tributary flow problems. BPA will begin these experiments as soon as possible and submit a report evaluating their efficacy at the end of 5 years. Estimated BPA expenditure: $2.5 million first year, $5 million second year, $5-10 million per year thereafter, as justified by prospective transactions.

Tributary flow problems are widespread. Whether and how solutions can be implemented through existing laws and administrative processes is largely an institutional question. To test new approaches to this problem, BPA will organize experiments such as organizing a non-profit water brokerage to demonstrate transactional strategies for securing tributary flow—and where feasible, addressing water quality—in streams with significant non-Federal diversions. The project would develop a competitive process to supply water to increase flows and water quality at the least financial and administrative cost. The brokerage would also develop a plan for a pollution bank through which water quality credits could be exchanged, and evaluate whether such projects could in another 10 years complete enough water quality and quantity improvements to fully protect the non-Federal land portion of critical habitat for species of concern. The initial effort will be for 5 years. An objective third-party evaluator will evaluate the program after 5 years, and a decision will be made whether to continue any of them.

Action: BPA shall, working with agricultural incentive programs such as CREP, negotiate and fund long-term protection for 100 miles of riparian buffers per year.

Under certain farm incentive programs, farmers and ranchers may enter into 10-to-15 year contracts to plant riparian buffers or restore wetlands on streams that provide habitat for listed salmonids. Experience with similar programs suggests that these buffers can be made permanent, or at least long-term, by adding an increment to the contract price. Securing such protection adds value in terms of riparian corridor restoration and, where recognized by state law, instream flow restoration.

Action: The Action Agencies shall provide the FCRPS share of staff and administrative support for a Federal Habitat Team to coordinate Federal agency support for non-Federal habitat protection and restoration.

To ensure that Federal support for non-Federal habitat initiatives is effective, clear, regular and predictable, lines of coordination among Federal agencies and between Federal and non-Federal entities will be needed. In the All-H Paper, the Federal agencies propose to ensure this coordination through a Federal Habitat Team. Federal land management agencies are expected to fund and implement coordination related to Federal lands. BPA will fund coordination expenses associated with non-Federal habitat programs, which is the primary purpose of the Federal Habitat Team.

Action: BPA shall work through the Northwest Power Planning Council to ensure development and updating of subbasin assessments by early 2001, and completion of subbasin plans. BPA shall match state and local funding for coordinated development of watershed assessments and plans, 2001 through 2006.

In the long term, habitat recovery and watershed restoration for non-Federal public, Tribal, and private lands requires state and local stewardship. An overall framework for this stewardship can be created through subbasin and watershed habitat plans and related recovery plans that establish goals, objectives and priority actions across ownerships and programs. BPA is funding the bulk of the Northwest Power Planning Council's subbasin and watershed assessments and plans. Under current schedules, the Council's subbasin assessments will be completed around the end of 2000, with further planning and watershed assessments to follow. As these steps are completed, priorities, targets and schedules will emerge, and priorities can be adjusted.

Action: BPA, working with the BOR, Corps, EPA and the U. S. Geological Survey Corps, shall develop a program to 1) identify mainstem habitat sampling reaches, survey conditions, describe cause-and-effect relationships and identify research needs; 2) develop improvement plans for all mainstem reaches; and 3) initiate improvements in three mainstem reaches. Report results annually.

Cost: $25 million over 5 years.

Large-scale water development over the last 65 years has inundated and degraded mainstem habitat on a significant scale. Populations such as fall chinook that were once highly productive spawned in the mainstem and in the lower reaches of major tributaries. Studies in other river systems in the Northwest indicate that mainstem habitat improvements can result in greater population and habitat diversity, complexity and productivity. However, no systematic assessment of habitat modifications from dam construction has been done, nor have potential restoration sites and specific benefits to salmon and steelhead been identified. BPA, working with the Corps, will take immediate steps to begin to address these uncertainties by collecting baseline data, improving mainstem reaches in ways that mimic the range and diversity of historic habitat conditions as much as possible, and monitor and evaluate the results. Results will be reported annually. After 5 years, NMFS and the Action Agencies, in consultation with the Northwest Power Planning Council and others, will determine whether to make changes in this program.

Action: During 2001, the Corps and BPA, working with the Lower Columbia River Estuary Program (LCREP) shall, in a manner acceptable to NMFS, fund an inventory of estuary habitat; model physical and biological features of the historical lower river and estuary; and develop criteria for estuary habitat restoration.

The states of Oregon and Washington, under the CWA, have developed a management plan through the LCREP, to help rebuild the estuary. The plan is an appropriate starting point for the estuary's contribution to salmon recovery. As a preliminary step in building on the plan, an inventory and an analytical model should be developed. With this information, criteria for estuary habitat restoration can be identified to guide restoration efforts pending further refinements in the LCREP plan.

***Action*:** BPA and the Corps shall provide financial and technical support to LCREP to more specifically address the habitat needs of salmon and steelhead in the LCREP plan.

The Corps and BPA will provide financial and technical support to LCREP to clarify and elaborate those elements of the LCREP plan that relate to salmon and steelhead habitat protection, acquisition and restoration. This work should help establish clear goals for salmon conservation in the estuary, identify habitats whose characteristics and diversity support salmon productivity, identify potential performance measures, identify flow requirements to support estuarine habitat requirements for salmon, and develop a program of research, monitoring, and evaluation.

Action: Over a 10-year period beginning in 2001, BPA and the Corps shall provide two-thirds of the financial requirements of a program, administered through the LCREP's non-profit entity, to acquire, protect and restore high quality habitats identified in the LCREP plan (Plan Action 2) over a 10-year period. The Federal share of the program shall aim at an initial goal of 10,000 acres of tidal wetlands and other key habitats to rebuild productivity in the lower 46 river miles. The Corps and BPA shall also provide planning and engineering expertise to implement the non-Federal share of on-the-ground habitat improvement efforts identified in Plan Action 2.

Much of the estuary's historic shallow-water habitat has been lost to due to the effect of local, navigational and hydropower development. The LCREP plan proposes a 10-year program of habitat acquisition and restoration to anchor high-quality habitat on both sides of the river to support salmon rebuilding. A high priority should be put on tidal wetlands and other key habitats to rebuild productivity in the lower 46 river miles. Federal agencies will provide technical and financial support for this program, and to implement on-the-ground activities identified in planning. As more information is gained from inventory and analytical work, the 10,000-acre figure will be modified to ensure that all habitats important to the survival and recovery of anadromous fish are included in this recovery effort. Examples of acceptable estuary habitat improvement work include acquiring rights to diked lands, breaching levees, improving wetlands and aquatic plant communities, enhancing moist soil and wooded wetland via better management of river flows, reestablishing flow patterns that have been altered by causeways, supplementing nutrient base by importing nutrient-rich sediments and large woody debris into the estuary, modifying abundance and distribution of predators by altering their habitat, creating wetland habitats in sand flats between the north and south channels, creating shallow channels in inter-tidal areas, and enhancing connections between lakes, sloughs, side channels and the main channel. The Corps and BPA will place a high priority on improving the access to and quality of chum habitat, especially in the Grays River system. The Corps and BPA will place a high priority on improving the access to and quality of chum habitat, especially in the Gray's River system. The Corps currently is planning efforts to restore habitat in connection with its proposed navigation channel deepening project, and the work outlined in this term and condition is in addition to the mitigation/restoration work identified in any NMFS channel-deepening Biological Opinion.

Action: Between 2001 and 2010, BPA and the Corps shall provide two-thirds of the financial requirements to expand the LCREP monitoring and research program to address the objectives of this Biological Opinion to effectively protect and restore the estuary ecosystem for listed populations and evaluate the efficacy of management actions to rebuild the productivity of the system over the long term. (Plan Action 28).

Action: During 2000, BPA, working with NMFS, shall continue to develop a conceptual model focusing on critical linkages between estuarine conditions and salmon population structure and resilience to assess estuarine influence on salmon populations in the Columbia River. The model will highlight linkages that are probably impacted by upper river hydropower and water management and identify information gaps that need to be addressed in developing recommendations for FCRPS management and operations.

Cost: $150,000.

9.6.3 Overview of Harvest Measures

9.6.3.1 Overview

This section outlines harvest measures to improve prospects for survival of listed fish and fulfill the FCRPS' obligation to mitigate for hydrosystem impacts. Many listed ESUs are not affected by harvest in today's fisheries. For those that are, impacts are limited to incidental impacts in fisheries targeting healthy and abundant stocks, particularly hatchery stocks. For the ESUs still affected by harvest, impacts have been greatly reduced in recent years in response to the listings and declining abundance. The potential benefits of additional reductions in harvest impacts for those ESUs still affected by fishing are limited, even if fishing directed at non-listed stocks was eliminated altogether. The general approach for near-term harvest management defined in the All-H Paper – the context for this Biological Opinion – is to cap ocean and inriver harvest rates at or below recently-set rates to allow time for other recovery measures to take effect. To the extent that harvest impacts are reduced further relative to these harvest rate caps, the survival benefits can be quantified relatively easily.

Ensuring that the existing harvest constraints extend into the future — and in a few cases reducing harvests even further — will be critical to the success of recovery efforts. Indeed, existing harvest rate caps and associated survival benefits (outlined in further detail in the All-H Paper) have been presumed in the scientific risk assessments that inform this Biological Opinion throughout. It is both reasonable and prudent, therefore, to expect the Action Agencies to help implement measures designed to ensure that these harvest constraints and/or reductions — and the survival benefits they secure — continue. This is particularly true for the immediate future, before other measures to increase survival have taken full effect.

The objectives of this section are to describe how the FCRPS can meaningfully contribute to ensuring that harvest constraints continue into the future and, for ESUs still affected significantly by harvest and requiring further reductions, to enable such reductions. The section identifies specific actions that will lead to greater fishery selectivity. This will reduce fishery impacts on listed fish and enable the harvest of non-listed fish. Harvest constraints and associated survival benefits can then be better secured into the future to contribute, along with measures applied in other life stages, to survival and recovery goals.

9.6.3.2 Measures to Assist in the Further Reform of Harvest

Harvest reform is defined broadly; it includes implementing various kinds of selective fishery management strategies, developing and applying alternative fishing methods and gear types, and creating or expanding fishing opportunities in known-stock terminal areas. To realize the full potential of harvest reforms requires augmenting and/or modifying existing programs and tools for managing fisheries, including systems for monitoring and evaluating stock and fishery-specific impacts. Because most or all hatchery fish will have to be marked, catch sampling and stock identification programs will have to be modified and bolstered. Existing management and assessment models will also have to be refined and/or replaced.

9.6.3.2.1 Measures to Address Effects of Selective Fishing on Fishery Management Systems (e.g., Fishery Management and Stock Assessment Models)

Action: The Action Agencies shall work closely with NMFS, USFWS, Tribal and state fishery management agencies, and the relevant Pacific Salmon Technical Committees and provide funding to address analytical problems and revise or replace current management models as necessary to accommodate selective fisheries.

Existing harvest management strategies and models evolved in the context of non-selective fisheries. The models can play a crucial role in the management of ocean and freshwater fisheries and in stock assessment programs. Many of these models are based on data stemming from the coastwide coded-wire tag (CWT) program, such as the coastwide chinook model the United States and Canada maintain in connection with the Pacific Salmon Treaty. This model, as well as others, was not designed to accommodate selective fisheries. They evolved in the context of non-random fishery removals, which radically changed with the advent of selective fishing. It is nevertheless critical to sustain and enhance the stock and fishery-specific information provided by these programs, not only to maintain fishery management and stock assessment capabilities, but also to comply with legal commitments such as those in the Pacific Salmon Treaty and related agreements.

Action: The Action Agencies shall work closely with NMFS, USFWS, and Tribal and state fishery management agencies and provide funding to ensure that impacts on catch sampling programs, data recovery systems, and data bases stemming from mark-selective fisheries are addressed.

Changes in fishery monitoring and data systems will be necessary to provide the degree of resolution required to enable fishing in the continuing context of listed fish. For example, electronic tag detectors will probably be needed to sample fishery catches and hatchery escapements to maintain critical stock-specific and fishery-specific information provided by the CWT system. For years, the adipose fin clip was used solely to identify fish that carry a CWT. Now, fish with an adipose clip may or may not carry a CWT, and fish that have a CWT may or may not have a fin clip. Some databases will have to be modified and reformatted to accommodate changes in the types of data collected and the way it is collected.

Action: The Action Agencies shall work closely with NMFS, USFWS, and Tribal and state fishery management agencies and provide funding to better estimate incidental mortalities in selective fisheries.

Even selective fisheries will cause some level of incidental mortality on listed fish. For years, incidental mortalities have been estimated from sparse data. For example, a single estimate of hook-and-release mortalities formerly was used to cover ocean fisheries coastwide, regardless of species or type of hook and line used. Estimates have been improved, but they could be improved further. For many fisheries, the weak link in the estimates lies in tabulating the encounter rate in particular fisheries. In the context of listed fish, where even low impacts can affect the prospects for survival and recovery, accurate and precise estimates of incidental mortalities are important. Studies can be conducted in specific fisheries to better estimate these mortalities as a function, for example, of the type of gear used, how it is fished, water temperatures, the extent of recaptures, and other variables.

9.6.3.2.2 Measures to Develop or Expand the Use of Selective Fishing Methods and Gear

Action: The Action Agencies shall work closely with NMFS, USFWS, and Tribal and state fishery management agencies and provide funding to ensure the development, testing, and/or deploying of selective fishing methods and gear that reduce incidental impacts on listed fish and/or enable the harvest of non-listed fish in ways that are benign to listed fish.

Fishing methods that use live capture gear can be developed and/or expanded to enable fisheries to operate where listed fish are present, provided that the fish can be visually identified by the fishermen, and that the incidental handling mortality falls within acceptable limits. The potential benefits can be substantial. Steelhead fisheries that are allowed to retain only marked hatchery fish have lasted for years, with much lower impact on natural fish than other fisheries. Fishing mortality on natural fish has been reduced from 30% to 60% down to 2% to 5% in some cases.

Similar live-catch fishing strategies may also be effective for commercial fisheries by enabling sorting between species — fall chinook and steelhead, for example — or between marked hatchery and unmarked natural fish. Other strategies are designed to avoid catching listed species in the first place; these can result in significant benefits by reducing the catch of listed species in a fishery targeting strong runs. An example is the gill net exchange program recently negotiated between the Action Agencies, Tribes, and Federal agencies. This program will be at least partially implemented in the fall 2000 fishery. The benefits of this program can be assessed and, if appropriate, expanded in the future. Similarly, Canadian fishers and managers have tested a number of innovative techniques to minimize the catch of weak natural runs, such as using weed lines on gillnets in the Skeena River commercial fishery to minimize impacts on depressed runs of steelhead.

Because such methods will be effective only if accepted by fishers, this program should provide funding for and solicit proposals from the fishing community to test selective fishing methods and/or gear. Experiments and demonstration projects with live-capture fishing gear and methods such as traps, seines, tangle nets, revival tanks, and other live-catch methods should be implemented rapidly. The strategies that work should be deployed as broadly and quickly as possible. Methods and strategies to reduce incidental fishing mortalities in all fisheries, regardless of whether they use conventional or live-capture gear types, should be identified and implemented.

9.6.3.3 Measures to Provide Alternative Fishing Locations

Action: The Action Agencies shall work closely with NMFS, USFWS, and Tribal and state fishery management agencies and provide funding to identify, develop, and create alternative terminal fishing opportunities.

Fishery opportunities can be expanded and/or improved in known-stock terminal areas where abundant fish can be harvested with minimal impacts on listed fish. These areas could be especially helpful in reducing pressures on fish in existing mixed stock areas, particularly for Tribal fisheries that are already oriented toward terminal fishing. Examples include the Tribal program in the Umatilla River and Oregon's select area fishery in Youngs Bay.

9.6.3.4 Developing Plans and Strategies for Reducing Impacts on Listed Fish while Retaining or Enhancing Fishery Values or Mitigating Impacts on Fisheries

Action: The Action Agencies shall work closely with NMFS, USFWS, and Tribal and state fishery management agencies and provide funding to develop and implement effective fishery effort reduction programs and other innovative strategies to reduce fishery impacts on listed fish and/or enhance fishery values.

These strategies may include, but are not limited to, buying out and retiring commercial fishing licenses and permits (when the result is linked to reductions in harvest of listed species); purchasing of harvest conservation easements to reduce impacts on listed fish in commercial fisheries; and identifying economic development strategies to enhance fishery values with smaller catches. Innovative strategies might include, for example, price supports or other economic incentives to enhance fishery values, when such tools reduce fishery impacts on listed fish and/or the retention of economic benefits of the fishery.

9.6.3.5 Developing Plans and Strategies for Crediting Reductions in Impacts on Listed Fish

Action: The Action Agencies shall work closely with NMFS, USFWS, and Tribal and state fishery management agencies to develop methods for crediting survival benefits toward FCRPS offsite mitigation. These should identify, for example, how much the incidental impact on listed fish has been or could be reduced and the extent to which the reductions should be dedicated to increasing escapements versus allowing higher catches of non-listed fish. Besides identifying and quantifying (to the extent possible) survival benefits, the method should evaluate the extent to which the FCRPS makes the measures possible by contributing the necessary funding for their development and deployment. Methods must be included for monitoring and evaluating survival benefits over time.

The methods used to credit the FCRPS with survival benefits most likely will vary depending on the specific measures. How those benefits are used may also vary with circumstances. For example, greater selectivity in a given fishery can potentially be used for either or both of two objectives: 1) achieving a higher catch of non-listed abundant stocks while staying within a harvest rate cap on listed fish; or 2) further reducing the rate of incidental harvest impacts on listed fish, given a particular level of catch. In some cases, depending on the status of the listed fish, all survival benefits flowing from greater harvest selectivity should accrue solely to escapements. In other cases, however, a portion of the benefits of greater selectivity could accrue to the fishery as a higher total catch. Action Agencies and the harvest managers may agree to a formula which accommodates both objectives – increases in escapement and increases in total catch – thereby better aligning the interests of the FCRPS with those of the harvest sector. The proportion dedicated to reducing impacts on listed fish will translate easily into a survival benefit, some or all of which could be assigned to the FCRPS offsite mitigation performance standard.

9.6.3.6 Developing Implementation Plans for Harvest Reforms, Alternative Fishing Locations, and Other Harvest Measures

Action: The Action Agencies shall work closely with NMFS, USFWS, and Tribal and state fishery management agencies and coordinate with other regional forums (e.g., the

Council's fish and wildlife program) to negotiate and implement annual and 5-year plans. These plans shall identify and prioritize measures and associated funding to implement the various harvest reforms and other measures outlined here that are intended to benefit listed fish and/or enhance fishery values.

The annual and 5-year plans should address the specific measures identified throughout this section, as well as additional strategic investments that may be identified later as effective at reducing impacts on listed fish and/or enhancing fishery values. In all cases, implementation plans should specifically provide for monitoring and evaluating the effects of the implemented measures.

9.6.4 Offsite Mitigation - Hatcheries

Salmon and steelhead hatcheries constructed as mitigation for the development of the FCRPS have successfully produced fish to replace some of the lost fishing opportunities caused by ongoing operations of the hydrosystem. However, these same hatchery programs have also contributed to the decline of natural-origin fish populations now listed as threatened or endangered under ESA. Hatcheries need restructuring to minimize or eliminate their adverse effects. The hatcheries could then continue to provide mitigation consistent with ESA requirements. Additionally, recovery and survival of listed ESUs affected by hatchery practices could be enhanced.

BPA currently funds conservation hatchery programs as part of the NWPPC's Regional Fish & Wildlife Program for five of the populations listed in Table 9.2-22 (spring/summer chinook in the Lemhi River, Yankee Fork Salmon River, Grande Ronde River, Johnson Creek, Tucannon River, and the Redfish Lake sockeye captive broodstock program). These programs are based upon recently developed hatchery supplementation techniques that differ substantially from traditional mitigation hatchery programs in that they use locally adapted broodstock, natural rearing techniques, and acclimation sites for release of smolts to ensure development of wild-like salmonid progeny that emulate the survival, physiology, and behaviors of natural-origin fish.

BPA is also funding, through the Council's program, several implementation, planning and research projects that are continuing to generate valuable information on the effects of hatchery supplementation programs on wild stocks and on methods to improve the quality and survival of hatchery supplementation. These projects include the Idaho supplementation studies, NATURES supplementation research, the Yakima experimental supplementation hatchery at Cle Elum, and systemwide research on captive broodstock programs for Pacific salmon. The overall aim of hatchery supplementation programs is to supplement or buffer these natural populations in the short term until changes can occur to other factors affecting survival of these populations, such as harvest, habitat, or hydro.

Artificial propagation programs are also used as an experimental means to avoid population extinction by bolstering the abundance and distribution of fish. Such conservation hatchery programs, generally scheduled to last two to four generations, appear promising for increasing numbers of adult fish in the short term, thus avoiding immediate extinction. However, such programs have not yet ensured long-term enhancement of self-sustaining populations in their natural habitats, as required by the ESA.

Reliance on artificial propagation of salmon and steelhead both to meet original FCRPS mitigation responsibilities and as a conservation measure to avoid extinction requires continued research to improve mitigation and conservation. The effects of hatchery-origin fish on the survival and productivity of naturally produced populations are critical research areas.

9.6.4.1 Actions to Reform Existing FCRPS Mitigation Hatcheries

Where costs are stated, they are estimates meant to help define the scale and pace of the action, not amounts the Action Agencies must actually spend to comply with this Biological Opinion.

Action: The Corps shall fund the capital costs of reforms needed for Lower Snake River Compensation Plan anadromous fish hatchery programs based on the requirements detailed in the pertinent hatchery biological opinions and the NWPPC's Artificial Production Review. BPA shall fund the power allocated share of the operations and maintenance costs of the reforms and shall reimburse the Federal Treasury for the power allocated share of the capital costs.

Costs for this estimated at $6 million annually for each of the first 5 years and assuming an FY 2001 base budget of $14.7 million. A one-time capital expense of $9 million is also estimated to be required.

Action: The BOR shall implement the reforms needed for the Grand Coulee mitigation anadromous fish hatchery programs, based on the requirements detailed in the pertinent hatchery biological opinions and the NWPPC's Artificial Production Review. BPA shall fund the power allocated share of the operations and maintenance costs of the reforms and shall reimburse the Federal Treasury for the power allocated share of the capital costs.

This action is estimated to cost $1.3 million annually for each of the first 5 years.

Action: The Corps shall implement the reforms needed for the Willamette basin anadromous fish hatchery programs, based on the requirements detailed in the pertinent hatchery biological opinions and NWPPC's Artificial Production Review. BPA shall fund the power allocated share of the operations and maintenance costs of the reforms and shall reimburse the Federal Treasury for the power allocated share of the capital costs.

This action is estimated to cost $1.5 million annually for each of the first 5 years.

Action: The Corps shall implement the reforms needed for the Corps' Columbia basin anadromous fish hatchery programs, based on the requirements detailed in the pertinent hatchery biological opinions and NWPPC's Artificial Production Review. BPA shall fund the power allocated share of the operations and maintenance costs of the reforms and shall reimburse the Federal Treasury for the power allocated share of the capital costs.

Costs for this action have not yet been estimated.

NOTE: BPA does not repay the capital or O&M costs of the Mitchell Act hatcheries. Absent legislation, BPA cannot assume a direct funding responsibility where BPA does not already have repayment responsibility. To do so would augment NMFS' appropriations. Unless Congress reallocates the Mitchell Act hatchery costs to the FCRPS, BPA cannot repay them.

Hatchery reforms required in these actions primarily include the following:

- Develop new local broodstocks and eliminate inappropriate broodstocks.
- Adopt proper mating protocols.
- Implement improved rearing protocols.
- Manage the number of hatchery fish allowed to spawn naturally.
- Construct acclimation facilities to improve survival and homing.
- Construct broodstock collection facilities.
- Mark hatchery fish to distinguish them from natural-origin fish.
- Draft hatchery and genetic management plans (HGMPs) to comprehensively guide future operations.
- Conduct monitoring and evaluation.

Specific hatchery reform actions are based on recent biological opinions addressing hatchery operations and on NWPPC's Artificial Production Review.

See comment above.

9.6.4.2 Actions to Create an Artificial Propagation Safety-Net Program

Action: BPA shall promptly fund the conduct of benefit/risk assessments and development of HGMPs for 12 seriously depressed salmon and steelhead populations.

Several important populations of listed salmon and steelhead in the Snake River basin have dropped to critical levels, and their decline appears to be continuing. Before habitat and propagation improvements occur, these populations could become extinct.

This action requires immediate investigation of artificial propagation techniques to increase population numbers for an interim period until necessary habitat improvements become effective. These interventions are not expected to be long-term solutions to declining fish numbers, but safety nets to keep populations above critical levels.

Conduct of benefit/risk assessments and development of HGMPs should proceed immediately on the following populations:

Steelhead: Lemhi, Yankee Fork Salmon, East Fork Salmon, and Lower Salmon River, as well as two (yet-to-be-identified) B-run steelhead populations.

Spring/summer chinook: Lemhi and Yankee Fork Salmon rivers, Valley Creek, Grande Ronde River, Johnson Creek, and Tucannon River.

Action: BPA shall budget for safety-net interventions when assessments and HGMPs indicate that such interventions are vital to the survival and recovery of the listed population.

This action requires applying immediate artificial propagation techniques to increase population numbers for an interim period until necessary habitat improvements become effective. These interventions are not expected to be long-term solutions to declining fish numbers, but safety nets to keep populations above critical levels.

An HGMP must precede intervention on any population and a thorough risk/benefit assessment must be done to confirm the need for intervention and to provide a detailed implementation plan. The critical nature of this interim, safety-net strategy may require BPA to seek a NEPA exemption from CEQ for any intervention except construction of permanent hatchery rearing facilities at other than an existing hatchery site.

Action: BPA shall budget for the contingency of additional risk/benefit assessments and HGMPs for any salmon or steelhead population that NMFS identifies during the term of this Opinion as critically depressed and essential to recovery of a listed ESU. Based on results of assessment and plans, funding and implementation of the safety-net conservation program shall proceed promptly.

Additional interventions on listed populations may be required in the near future. Interventions to maintain population diversity until habitat improvements are manifested will depend on 1) population status, 2) results of ongoing supplementation experiments, and 3) the extent of population diversity required for an ESU. Because such interventions are not the desired approach to recovery, but may become a necessary safety-net action, they will be withheld as long as prudent. When an emergency need is recognized, however, funding must be available immediately. An example of this is the Gorley Springs chum salmon spawning channel on the Grays River, Washington. The spawning channel was destroyed by floods in winter 1999. Habitat modifications will not be completed until fall 2001.

9.6.4.3 Actions to Implement Recommendations in the NWPPC's Artificial Production Review

Action: BPA shall fund the implementation of recommendations as part of the NWPPC's Artificial Production Review, including reporting of hatchery performance based on the monitoring and evaluation programs within the HGMPs.

The NWPPC's Artificial Production Review contained recommendations to improve the benefits and minimize the risks of hatchery mitigation programs for listed populations. Many of these recommendations were captured in earlier action measures.

Regular performance reviews, examining both the benefits and the risks of production programs, will enhance the ongoing reform of hatchery programs. The NWPPC will host these reviews. Hatchery performance will be evaluated relative to the purposes and objectives in the respective HGMPs and will be based on the performance information obtained from monitoring and evaluation plans in the HGMPs.

Action: The Action Agencies will work with other entities sharing responsibility for mitigation hatcheries to conduct critical research on 1) the effects of state-of-the-art supplementation and captive broodstock programs on the survival and productivity of listed populations, and 2) improving the quality of artificially propagated fish critical to the conservation of listed populations.

Reliance on artificial propagation to mitigate effects of the FCRPS and conserve listed populations requires greater understanding of the benefits and risks of these programs. BPA is funding a considerable amount of research to improve hatchery operations. Additional research should be promptly implemented addressing the following needs:

- Estimate the relative fitness of naturally spawning hatchery-origin and natural-origin fish and its genetic, ecological, behavioral, and physiological components, including spawn timing, spawner phenotype, mating behavior and success, and survival by life stage.

- Investigate behavioral and ecological interactions between hatchery-origin and natural-origin fish in natural spawning, rearing, migration corridor, and estuarine habitats.

- Determine the effects of conventional hatchery culture, “natural”hatchery culture methods, captive rearing, and captive broodstock methods for survival, health, nad physiological characteristics, behavior, genetic variation, and fitness of cultured fish in the wild.

- Determine the fine-scale genetic structure of salmon populations. What features of this structure are at risk from hatchery activities? How important is local adaptation for salmon populations?

- Evaluate the relative importance of inbreeding depression and outbreeding depression in salmon. How prevalent are these phenomena in natural populations? In hatchery populations?

9.6.5 Research, Monitoring, and Evaluation Plan

In the context of this Biological Opinion, research, monitoring, and evaluation can be divided into the following five categories:

- Performance monitoring

- Individual action evaluations

- Integrated evaluation of the cumulative effects of all individual actions

- Determining background environmental conditions

- Determining mechanisms of population regulation

The FCRPS cannot be isolated from all of the other factors that affect salmonid populations. The actions in other management arenas (other life stages and Hs) may strongly interact with actions in the hydrosystem corridor, ultimately affecting actions taken in the FCRPS. A research, monitoring, and evaluation program should encompass the entire salmonid life cycle and the varying management provinces through which fish pass.

Of particular emphasis during the near term and a central element of research included in the annual plan are discrete hypothesis testing and uncertainty resolution of those critical uncertainties that form the underpinning to assess the status of the ESUs and the appropriate measures needed for their survival and recovery. Understanding the extent and reproductive success of natural spawning of hatchery fish and the delayed mortality of fish passing dams either by transportation, or inriver is a critical need. Information on these uncertainties is needed for meaningful conclusions on the other categories of M&E described above. Progress on resolving these uncertainties is a primary consideration in the Biological Opinion, annual and 5-year planning, and for the 5-, 8-, and 10-year checkins.

For a research, monitoring, and evaluation program to be most useful, it must be developed and implemented within a time-frame that allows establishment, or confirmation, of existing baseline data and simultaneous monitoring activities and management action. After management actions are in place, years of data collection and analysis are required to determine salmonid population trends using customary methods (e.g., recruits per spawner, spawning escapement). Although such data are the foundation of current assessments of salmon populations in the Columbia River basin, long-term analyses will hinder defining the ongoing, near-term, and future actions needed to stem steep declines in some salmonid stocks. It is, therefore, critical to arrive at a mechanistic understanding of salmonid population standards. Therefore, in addition to current juvenile survival monitoring, the following must have high priority for monitoring and evaluation:

- Developing short-term measures of stock performance that can serve as proxies for standard metrics such as recruits per spawner

- Developing short-term measures of stock performance that focus on the life history stages identified as critically important to population growth in the cumulative risk initiative analysis: egg-to-smolt, estuarine, early ocean growth, and survival

These short-term measures will determine salmon population growth and, as such, will be explicit links between population processes and the condition of salmonid habitat.

The following sections describe elements of a research, monitoring, and evaluation program that the Action Agencies shall implement under this reasonable and prudent alternative. Detailed requirements are stated for the hydrosystem corridor, estuary, and nearshore ocean life-history stages (FCRPS flow management is assumed to affect the latter). General principles are described for research, monitoring, and evaluation of the effectiveness of hatchery, tributary habitat, hydrosystem, estuary, early ocean, and harvest actions. Additional detail regarding monitoring and evaluation requirements for management actions in the areas of habitat, hatcheries, and harvest is provided in Sections 9.6.2, 9.6.3, and 9.6.4.

The research, monitoring, and evaluation actions specified in this section are intended to address the FCRPS share of these responsibilities. It is acknowledged that other federal and non-federal entities have responsibilities to perform monitoring and evaluation of their actions. It is anticipated that the cost and implementation of the research, monitoring, and evaluation in thse circumstances shall be shared among these entities, commensurate with their responsibilities and shall be coordinated through applicable regional processes. Implementation of all research, monitoring, and evaluation that is the responsibility of the Action Agencies shall be developed in the 1- and 5-year planning processes.

9.6.5.1 Overall Assessment Goals

The most appropriate quantitative measure of population health is the average annual rate of population growth (lambda). Lambda describes the trajectory of the population size through time. It is derived from a stochastic (randomly varying) analysis of population dynamics, incorporating both the mean population growth rate and its variance. Using lambda as the ultimate measure of population health is advisable for several reasons:

- Use of a population growth rate allows a more rapid assessment of the effectiveness of an action (or a suite of actions) than targeting the population size at recovery.

- A population with a lambda greater than 1.0 is on the road to recovery, even if the population size is currently small.

- Lambda can be improved by actions that address the variability in population growth rate.

- All management actions that serve to improve population health, even if indirectly, can be assessed via lambda.

- Given a recovery target of lambda, it is simple to determine the change in population growth trajectory required to meet the target and the probability of detecting the effect of actions in a set time frame.

No other single population metric is as general, as biologically supported, or as easily integrated into a formal quantitative monitoring and evaluation plan. We advocate the use of a lambda ranging from 1.05 to 1.10 calculated over no less than 20 years as the standard measure of a healthy, recovering salmonid population. Lambda should not be used as the only non-jeopardy or delisting criterion, but a lambda appreciably greater than 1.0 for longer than an entire ocean condition cycle is a strong indicator of a robust salmonid population.

Research, monitoring, and evaluation efforts must focus on the following four areas:

- Population status

- Habitat (including estuarine/early ocean, mainstem, and tributaries)

- Indirect and direct effects of hydroelectric project and reservoir passage

- Hatcheries

- Harvest

Research, monitoring, and evaluation programs for each of these management provinces are briefly described in the following sections.

9.6.5.2 Population Identification and Establishment of Recovery Goals

Action: The Action Agencies and NMFS shall work within regional prioritization and congressional appropriations processes to establish and provide the appropriate level of FCRPS funding for tasks relating to the establishment of recovery goals for listed salmon ESUs in the Columbia River basin. These tasks will include defining populations based on biological criteria and evaluating population viability in accordance with NMFS' viable salmonid population approach, and shall be completed by 2003.

Establishing recovery goals for listed ESUs is an action fundamental to the recovery process. Defining biologically based populations is necessary before those goals can be established. Assessing population status (or viability) will be important to gauge needed changes and progress toward those goals. This effort will include information including genetic differentiation (allele frequencies), environmental and habitat characteristics, life history and morphological traits, demographic information, estimates of straying or migration and geographic distribution. The Action Agencies will ensure that all these data are obtained for upper and mid-Columbia ESUs and Snake River ESUs, and that geographic distribution and straying and migration rate information is obtained for Columbia River chum.

These efforts will take place within the context of the Technical Recovery Teams. The Snake River Technical Recovery Team is anticipated to convene between October 2000 and January 2001. The Upper and Middle Columbia River Technical Recovery Team(s) will convene at a later date. Once TRTs are convened, tasks are anticipated to be completed within 18 months. The specific timeline for the relevant tasks is provided in Table 9.6-4.

Data collection to be conducted during the sub-basin assessment process is expected to facilitate this action.

Table 9.6-4. Timeline of Tasks for Establishment of Recovery Goals

Task	Product(s)	Completion Date
1. Identify populations	population list	Month 3-4
2. Characterize populations (historical and current)	list of populations with characteristics (a-d).	
a. Abundance/productivity		Month 4-6
b. Diversity		Month 4-6
c. Spatial structure		Month 4-6
d. Habitat capacity		Month 9-10
1. Estimate viability of populations	list of populations with viability status (a-c) and criteria for achieving (if not presently viable)	
a. Abundance/productivity		Month 11-12
b. Diversity		Month 11-12
c. Spatial structure		Month 11-12
1. Provide scenarios that achieve ESU-level viability	For each population, describe characteristics (a-c above) necessary for ESU viability (multiple scenarios)	Month 12-18
2. Identify factors for decline	identify critical life stages	Month 14-15
	identify potential factors affecting mortality at different stages	Month 15-18

9.6.5.3 Mainstem and Tributary Habitat

The objectives for mainstem and tributary habitat research, monitoring, and evaluation programs are most appropriately set at the subbasin or smaller scale. The objectives should address the habitat factors identified by assessments and those being addressed by management or project actions of greatest significance to salmonid productivity in that region. The subbasin assessment template that CBFWA is currently developing should provide the background context that will enable specific monitoring objectives to be identified for each region.

Action:

- The Action Agencies shall evaluate the implementation of site-specific management actions. (Were they completed as designed?)

- The Action Agencies shall evaluate the effectiveness of site-specific management actions, such as the effect of riparian fencing on reestablishment of riparian vegetation.

- The Action Agencies shall evaluate the effectiveness of multiple management actions on upland, floodplain, riparian and instream habitat characteristics. For example, how do such management actions affect water quantity and quality factors such as flow, temperature, dissolved oxygen, and nutrients when applied across a watershed?

- The Action Agencies shall estimate the response of the salmonid population to alterations in mainstem and tributary habitat condition. For example, how do habitat changes caused by management measures at a watershed level affect abundance and survival?

The information provided by research, monitoring, and evaluation programs designed to meet these objectives will define performance standards for specific types of management actions, habitat changes through time, and changes in salmonid population performance related to habitat. Analytical techniques that integrate the information collected for each of the three monitoring and evaluation objectives should be specified as part of the program's design, ensuring consistent and compatible data across the region.

General classes of habitat improvement actions are readily identifiable. Monitoring and evaluation studies should be initiated in the first 2 years to take advantage of selected opportunities to gain information on the effectiveness of these types of actions in terms of physical standards and juvenile survival criteria or standards (e.g., egg-to-parr survival, egg-to-smolt survival). Study design and selection should take into account the relative change in survival expected in a particular setting, the existence of baseline information, and the ability to detect improvements over the range of life history patterns (e.g., upstream and downstream rearing areas).

Action: The Action Agencies and NMFS shall work within regional prioritization and congressional appropriations processes to establish and provide the appropriate level of FCRPS funding for a study of the feasibility (including both biological benefits and ecological risks) of habitat modification to improve spawning conditions for chum (and chinook) salmon in the Ives Island area is conducted.

The objectives of the study will be to determine whether it would be beneficial to increase the frequency of access to spawning habitat or the areal extent of spawning habitat by means other than flow augmentation. The feasibility study will evaluate actions to alter the hydraulic control points that limit flow in the Ives Island area to provide the same areal extent and quality of spawning habitat (including characteristics such as upwelling through the gravels, currently present at the site) at lower levels of Bonneville discharge; reconstruct spawning channels to increase the extent of habitat available at a given level of Bonneville discharge; and maintain hydraulic connections between tributary habitats and the mainstem Columbia River to allow entry for adults and emergence channels for juveniles. The feasibility study will also consider institutional issues of property ownership and land-use designations; the likelihood that modified habitat would withstand high flows (e.g., under mainstem and local tributary flood conditions); maintenance, rehabilitation, and removal costs; and potential adverse effects on existing fish and wildlife habitat.

9.6.5.4 Hatcheries

Action: The Action Agencies and NMFS shall work within regional prioritization and congressional appropriations processes to establish and provide the appropriate level of FCRPS funding for a hatchery research, monitoring, and evaluation program consisting of studies to determine whether 1) hatchery reforms are reducing the risk of extinction for Columbia River basin salmonids, and 2) conservation hatcheries are contributing to recovery.

Reforms should conform generally to the recommendations made in NMFS' interim artificial propagation policy (NOAA 1993) and conceptual framework for conservation hatcheries (Flagg and Nash 1999).

Initially, the objectives for hatchery monitoring and evaluation will include identifying and evaluating current hatchery production goals and scales, and ensuring that the goals and scales are appropriate to the ecological and genetic effects of hatchery production in the local system. This assessment has several components, including the following actions:

- Determine the natural productivity of the area affected by the hatchery program.

- Estimate if possible the carrying capacities of rearing habitat and the migration corridor.

- Determine numbers of naturally spawning first-generation hatchery fish (i.e., hatchery escapement).

- Determine the relative reproductive success of naturally spawning hatchery fish compared to those of wild origin.

- Monitor the size, age, health, smolt quality (growth), and release locations, timing, and life stages of hatchery fish.

- Assess if possible the frequency and magnitude of ecological interactions between hatchery and wild fish.

Given these elements of the biological context in which each hatchery program exists, it would be possible to design the proper reform protocol. The goal of hatchery reforms is to reduce or eliminate adverse genetic and ecological effects of hatchery production on natural populations. Thus, the concomitant research, monitoring, and evaluation program would assess the following aspects of natural populations:

- Reduced genetic variation

- Potential transfer of genetic traits from hatchery to wild stock

- Reduced genetic population structure

- Increased ecological interaction with hatchery fish (competition, predation, disease)

- Masked population status by the presence of naturally reproducing hatchery fish

It is important to note that it will be possible to evaluate the effects of mixed stock populations only when hatchery marking practices become comprehensive.

Ultimately, the monitoring and evaluation program must be able to identify hatchery and natural population interactions and isolate their effect on the growth rate of the natural populations. To do so, the evaluation program must consider the cumulative effects of hatchery production across the appropriate subbasin, as well as throughout the entire life cycle of the fish. This would require that a relationship be developed between the lambda of the natural population and the total production of hatchery fish, which would depend on such factors as survival and productivity during freshwater rearing and seaward migration, residence, and return. Only then will we have the statistical power to detect incremental risk of extinction, or rates of recovery.

Therefore, for hatchery operation, performance standards must address at a minimum genetic integrity, abundance, and productivity (recruits per spawner) of both hatchery and wild fish. The information provided by these metrics defines the standards to minimize genetic and ecological risks to listed fish. Strategies for minimizing genetic and ecological risks are identified in Flagg and Nash 1999. Many of these postulated reforms will require applied research and field testing. Hatchery monitoring and evaluation objectives will operate primarily on a subbasin or smaller scale. The monitoring and evaluation must be tailored to each species produced and address practices that affect the scale of effects (i.e., release practices, logistics of broodstock recovery, and straying of hatchery fish).

9.6.5.5 Estuarine and Early Ocean Habitat

An important, but often overlooked, aspect of the biology of Columbia River basin salmonids is the effect of the FCRPS on their beneficial use of estuarine and ocean (plume and nearshore) environments. Regional analyses have identified these environments as critical to population growth potential, thus as appropriate for mitigation actions. Salmonid biological requirements in these environments are not well known, however. Research, monitoring, and evaluation programs must therefore focus on basic natural history characteristics and on evaluating strategies to enhance important habitat characteristics. Of primary importance are:

- The contribution of juvenile survival during the estuary/early ocean phase to overall ocean survival
- Cause-and-effect links between estuary/early ocean resources and juvenile survival
- Cause-and-effect links between estuary/ocean resources and adult survival
- The spatial distribution of each stock in the estuary/ocean and temporal contribution to survival
- The influence of natural variation versus that of humanly caused changes in environmental conditions affecting juvenile and adult survival in the estuary/ocean phase

As this information is collected, it will be possible to evaluate the effects of alternative management actions in these environments. Several key determinants of estuarine and early ocean survival have been identified. Monitoring efforts should focus on these as well as collection of basic natural history data. The following data collection efforts are needed:

- Enhance and benchmark plume modeling; establish a long-term plume monitoring station.
- Partition the role of the estuary habitat from that of the nearshore ocean in juvenile survival.
- Identify and differentiate physical/chemical versus biological factors that cause mortality.

- Evaluate the influence of altering volume and timing of the historical hydrograph, hydrosystem operations, and the physical condition (bathymetry and structure) of the lower Columbia River and the estuary, as well as the effect on juveniles of the size, shape, and beneficial use of the Columbia River plume in the nearshore ocean environment.

- Determine the extent of indirect humanly caused mortality in these environments, for example, how tern and cormorant populations are affected by hatchery and hydrosystem operations.

These research, monitoring, and evaluation needs are currently being addressed by the following ongoing activities.

Action: The Action Agencies shall develop and implement a long-term research, monitoring, and evaluation plan for the lower Columbia River (below Bonneville Dam) and the estuary, plume, and ocean.

The purposes of the long-term research, monitoring, and evaluation program shall be 1) to develop appropriate indicators of physical and biological change that connect FCRPS flow management operations to the estuarine conditions of salinity, temperature, and suspended particulate matter, and 2) to determine the manner in which juvenile salmon use lower river mainstem, side channel, and estuarine habitats. It will be important to coordinate the long-term research, monitoring, and evaluation plan with the state natural resources agencies, the Lower Columbia River Estuary Program, the Columbia River Estuary Study Task Force, the Tribes, the public, and the Corps' feasibility analysis of altering flood control rule curves and operations to address mainstem flow objectives. Of special importance is the extent to which restoring shallow water estuary habitat might mitigate the additional flood risk resulting from altered rule curves.

Action: The Action Agencies and NMFS shall work within regional prioritization and congressional appropriations processes to establish and provide the appropriate level of FCRPS funding for studies to develop a physical model of the lower Columbia River and plume that can be used to characterize potential changes to estuarine habitat associated with changes in hydrosystem flows, and the effects of altered flows where they meet the California Current to form the Columbia River plume.

Physical characteristics of the estuary such as river flow, hydrograph, velocity, bathymetry, salinity intrusion, and circulation patterns define estuarine conditions. Therefore, it is important to characterize the physical aspects of the estuary and to compare existing and future physical attributes with historic conditions to assess the potential effect of hydrosystem flow regimes on estuarine habitat. Physical changes to the estuary will affect the ecology of the estuary and potentially how salmonids use the estuary for migration, growth, and development. The plume habitat as an extension of the estuary, or as a unique habitat important to Columbia River salmon, will be similarly affected by actions of the FCRPS. Characterization of these effects to assess the importance of historical and current conditions will help facilitate the recovery of all salmon stocks.

Action: The Action Agencies shall investigate and partition the causes of mortality below Bonneville Dam after juvenile salmonid passage through the FCRPS.

A long-term research, monitoring, and evaluation plan should be developed to measure mortality that may occur after smolts have passed through Bonneville Dam, including 1) post-Bonneville mortality that may be associated with passage of smolts through the Federal hydrosystem, and 2) the extent of delayed mortality, which is uncertain and central to decisions about hydrosystem configuration and the role of juvenile salmonid transportation. These evaluations should attempt to determine how much of the post-Bonneville mortality is natural and how much is related to other factors, such as hydrosystem passage and fitness.

Action: The Action Agencies and NMFS shall work within regional prioritization and congressional appropriations processes to establish and provide the appropriate level of FCRPS funding for studies to develop an understanding of juvenile and adult salmon use of the Columbia River estuary.

Estuary use potentially has a major effect on salmonid survival to adulthood. The estuarine ecology of salmon in general and the use of Columbia River estuarine habitat in particular are poorly understood. Juvenile distributions in relation to habitat type, food habits, prey preferences, and the growth and physiological condition of juveniles entering and leaving the estuary are important aspects of salmonid ecology in the estuary. Information is needed on these aspects of all salmonid life histories to develop an understanding of salmonid estuary use and any influences of the hydrosystem on flows, turbidity, and nutrient delivery that in turn might affect salmonid ecology in the estuary.

Action: The Action Agencies and NMFS shall work within regional prioritization and congressional appropriations processes to establish and provide the appropriate level of FCRPS funding for studies to develop an understanding of juvenile and adult salmon use of the Columbia River plume.

Plume dynamics and interaction with the California Current can potentially have a major effect on salmonid survival to adulthood. The plume ecology of salmon and use of the plume habitat are poorly understood. It is important to assess juvenile distribution as regards food availability, predators, and performance (fitness, growth, health) in relation to plume dynamics. Information on all salmonid life histories is needed to develop an understanding of salmonid use of the plume and any influences of the hydrosystem on turbidity, nutrient delivery, and habitat attributes that might affect salmonid ecology and survival in the plume.

Evaluating juvenile and adult use of the estuarine and nearshore environments will require monitoring techniques still in the early phases of development. In particular, the use of acoustic (sonic) tags with fixed, towed, or buoyed detector arrays is recommended, as is the continued development of existing technologies such as PIT-tag detector flowthrough trawl surveys. The immediate value of a concerted sampling effort in the estuary and nearshore regions will be development of cause-and-effect relationships between FCRPS flow management and physical conditions (e.g. bathymetry, suspended particulate matter, temperature) that affect the availability of suitable habitat for juvenile salmonids. NMFS will use this information to recommend future changes in flow management operations to improve juvenile survival.

Action: The Action Agencies and NMFS shall work within regional prioritization and congressional appropriations processes to establish and provide the appropriate level of FCRPS funding for a program to monitor trends and variations in habitat conditions and the use of habitat by juvenile salmon in the lower Columbia River and estuary. Emphasis should be placed on use of shallow water habitats in the tidal freshwater and oligohaline reaches of the estuary.

Salmon prey resources (biomass of benthic, epibenthic, and land-derived food resources and their spatial distribution) are linked to the physical features of the lower Columbia River and estuary. Monitoring juvenile use of estuarine habitats and the condition of these habitats through time (season and year) and under various hydrologic conditions (flow years) is needed to build a knowledge base for assessing future changes resulting from hydrosystem operations.

Action: The Action Agencies and NMFS shall work within regional prioritization and congressional appropriations processes to establish and provide the appropriate level of FCRPS funding for studies to develop restoration criteria based on juvenile salmonid preferences for shallow water habitat types, and a process for selecting and evaluating potential restoration projects based on these criteria. The Action Agencies shall implement restoration projects to restore estuarine processes that have been disrupted by flow regime alterations due to hydrosystem development.

Estuarine habitat restoration may be an important tool for restoring salmonid habitats and estuarine ecological processes, and addressing diverse salmonid life stages that may be affected by hydrosystem operations and sediment retention. High-priority habitat restoration projects should be defined and possibly implemented.

Action: To ensure that critical salmonid habitat is restored and protected, the Action Agencies and NMFS shall work within regional prioritization and congressional appropriations processes to establish and provide the appropriate level of FCRPS funding for the integration of the monitoring studies and modeling analyses to evaluate ongoing anthropogenic and natural modifications to the lower Columbia River and estuary.

Integration of all the estuarine action items discussed above is needed to monitor progress toward salmonid habitat goals, assess long-term effects of changes in hydrosystem operations on estuarine habitat and salmonid use, and monitor benefits of habitat restoration activities.

9.6.5.6 Hydroelectric Project and Reservoir Passage

A research, monitoring, and evaluation program designed to detect the indirect and direct effects of the hydrosystem is fundamentally different from those associated with hatchery and habitat actions. Rather than recovery-goal-directed actions, operation of the FCRPS is an ongoing action. Whereas it is important to develop and implement experimental operational or system configuration actions within the FCRPS, long-term monitoring and evaluation of background conditions is also essential in light of the demonstrated and hypothesized effects on salmonids. Therefore, the primary goal of the hydrosystem monitoring and evaluation program is to determine survival rates of migrating juvenile and adult salmonids and to identify factors that contribute to mortality, both direct and indirect.

9.6.5.6.1 Juvenile Monitoring and Evaluation

Action: The Action Agencies shall continue to fund, and expand, as appropriate, fish marking and recapturing programs aimed at defining juvenile migrant survival for both transported and non-transported migrants and adult returns for both groups. These studies will also compare the SARs of transported and non-transported fish to calculate the differential delayed mortality ("D"), if any, of transported fish.

Documenting juvenile migrant survival is an important measure of performance objective attainment. Current estimates of "D" have wide confidence intervals, and "D" values are one of the critical uncertainties that need to be resolved.

Action: The Action Agencies and NMFS shall work within regional prioritization and congressional appropriations processes to establish and provide the appropriate level of FCRPS funding for comparative evaluations of the behavior and survival of transported and downstream migrants to determine whether causes of "D" can be identified for the reach between Bonneville Dam and the mouth of the Columbia River.

In addition to further refining estimates of "D," investigations are needed to determine if delayed mortality occurs between Bonneville Dam and the mouth of the Columbia River. Differences in estuarine passage timing, behavior, survival, susceptibility to bird predation, and timing of ocean entry should be evaluated to determine whether any delayed mortality occurs before ocean entry. Studies linking timing of transport release to passage past predatory bird colonies in the estuary should be conducted. Timing barge releases to pass the bulk of the fish released past the bird colonies during times of low diel feeding patterns might significantly reduce estuarine mortality, particularly to steelhead. Methodologies could include PIT-tag deployments, and radio and sonic tracking.

Action: The Action Agencies and NMFS shall work within regional prioritization and congressional appropriations processes to establish and provide the appropriate level of FCRPS funding for studies and analyses to evaluate relationships between timing of ocean entry and SARs for transported and downstream migrants.

Limited data from transportation studies indicate that adult return rates for transported and downstream migrants can vary greatly by season, week, and perhaps by day. In general, adult return rates of transported fish are lower for fish transported during the early portion of the outmigration, but return rates can increase substantially for fish transported later. Inriver migrant return trends are opposite, starting out high and decreasing throughout the season. Understanding the causes of these variations could lead to improved adult returns by relating the effects of fish transport, or non-transport, to fish condition or to the physical and biological environment of the Columbia River plume at the time of ocean entry. Linking ocean entry timing to conditions at the time of entry would improve our understanding of aspects of the plume environment that influence early ocean survival. This could lead to improved management practices, such as smolt entry timing and flow volume, to improve survival rates.

Action: To test the assumption that differences in SARs between fish in the lower and upper rivers are due to passage through the hydrosystem, the Action Agencies and NMFS shall work within regional prioritization and congressional appropriations processes to establish and provide the appropriate level of FCRPS funding for studies to PIT-tag wild stocks from the lower river streams that were used to contrast stock productivity and hydrosystem effects.

Schaller et al. (1999) conclude that differences in productivity between upstream and downstream stocks are due to the number of dams through which each must pass. Comparing the outmigration timing, physiology, health, and condition of PIT-tagged wild fish from systems such as the John Day River to PIT-tagged wild fish from the Snake River in ongoing studies would enable comparisons between the two groups and assessment of similarities and differences.

Action: The Action Agencies and NMFS shall work within regional prioritization and congressional appropriations processes to establish and provide the appropriate level for FCRPS funding for studies to investigate the causes of discrepancies in adult return rates for juvenile salmonids that have different passage histories through the hydrosystem.

Adult returns from 1995 through 1998 indicate that SARs for smolts that have passed through the hydrosystem vary by year, number of juvenile bypass systems encountered, and specific bypass system, when compared to juveniles that were never detected when passing through the hydrosystem. To date, this is the only empirical evidence of delayed mortality associated with inriver passage through the hydrosystem. In general, SARs decreased as the number of bypass passages increased. These data suggest that juvenile bypass systems may be affecting adult return rates. In addition, return rates for fish that passed only through Lower Granite Dam are similar to those never detected in the hydrosystem, suggesting that individual bypass systems treat fish differently. This could be caused by a number of factors, including poor outfall locations, increased stress, reduced fitness associated with passage through mechanical components of the systems (such as separators and the PIT-tag detection systems), and the tendency for mechanical screen guidance efficiency to increase for fish with bacterial kidney disease. Studies relating the passage histories of individual smolts to changes in physiological parameters, behavioral responses, and survival rates are needed to determine the causes for the observed SARs and identify potential solutions. Furthermore, experimental management of the hydrosystem should be considered to address discrepancies in adult returns associated with passage history. These experiments might include pulling all screens at a dam to eliminate passage through bypass systems, or routing fish directly to outfall sites with full bypass flow so that little to no dewatering occurs.

9.6.5.6.2 Adult Monitoring and Evaluation

Action: The Action Agencies shall continue to implement adult salmonid counting programs at FCRPS dams, but shall improve the reporting of these counts.

In addition to the daily counts already provided, the Action Agencies shall work through FPOM to improve reporting of winter passage counts for all projects where winter counting currently occurs. These counts shall be reported in the same manner as other in-season counts (except that 3-day updates will be acceptable). These changes in reporting methods shall be implemented no later than the winter 2000-2001 adult migration. Pre-spawn, summer run steelhead are abundant near McNary Dam during the late fall and early winter months. Fallback through the juvenile bypass system at McNary can exceed 50 steelhead per day during the period before screen removal on December 15 (Paul Wagner, Washington Department of Fish and Wildlife, pers. comm.). Large concentrations of steelhead have also been observed in late fall in the vicinity of John Day Dam, and adult steelhead are known to pass Bonneville Dam all winter. The reporting requirements described above are designed to provide the level of information needed for decision-making during both normal and emergency fish passage management and consultation, especially during the winter maintenance period.

Action: The Action Agencies shall develop adult PIT-tag detectors for installation in adult salmonid passage facilities at appropriate FCRPS dams. These shall be used as needed for calculating transport benefits, conversion rates, and smolt-to-adult survival rates for listed salmon and steelhead.

By October 2000, a schedule for installing adult PIT-tag detectors at projects shall be developed by the Action Agencies, working through the annual planning process and the Regional Forum. The schedule shall maximize the ability to conduct research identified in this Biological Opinion in a timely manner and shall address the possibility of installing detectors at Bonneville and McNary dams by 2002. Adult detector installation identified in the annual planning process should be put in place as soon as possible.

The ability to interrogate PIT-tagged adult salmon and steelhead will allow more accurate assessments of critical adult passage information, including conversion rates between dams, steelhead kelt survival rates, travel time, and fallback rates with minimal adult handling mortality. This ability also will allow estimation of smolt-to-adult survival rates for transport studies and other survival studies specified in this Biological Opinion. Coordination of the schedule for installing adult PIT-tag detectors at FCRPS projects is necessary to ensure that the various studies requiring adult PIT-tag detection capability can be implemented in a timely manner.

Action: The Action Agencies shall investigate state-of-the-art, novel fish detection and tagging techniques for use, if warranted, in long-term research, monitoring, and evaluation efforts.

Fish tagging, detection, and tracking technologies suitable for use in assessing juvenile and adult salmonid survival, behavior, and distribution are limited. Key components of this tagging effort are:

- The need to discriminate between hatchery and wild fish (not all hatchery fish are currently marked)

- The ability to differentiate populations and their use of different ocean productivity zones

- The ability to determine growth and survival characteristics based on population, location, and oceanographic characteristics.

Development of new technologies may enhance opportunities to conduct necessary research, monitoring, and evaluation activities identified in this Biological Opinion. Development and application of new technologies should be coordinated with other entities to take into account needs across all life stages of salmonids.

9.6.5.7 Data Management

Action: The Action Agencies, in coordination with NMFS, USFWS, and other Federal agencies, NWPPC, states, and Tribes, shall develop a common data management system for fish populations, water quality, and habitat data.

The application of performance standards and measures and the use of offsite mitigation as partial compensation for unavoidable hydrosystem effects will require additional data collection and analysis. Validation of the approach, and of the specific actions taken, will require continual confirmation that these measures are sufficient to avoid jeopardy and facilitate recovery of listed salmonids. Evaluations of actions taken, the feasibility of future actions, and factors affecting mortality will depend on the availability of scientifically defensible findings. Development and implementation of offsite mitigation will require close coordination with relevant state actions such as water management and water quality compliance mechanisms. It will also require close coordination with Federal land managers and the EPA. NMFS' past year of work on the CRI analysis has identified a need for a single comprehensive system to ensure integration of monitoring and evaluation information described in this section with information from other sources, including but not limited to requirements described in other sections of this Biological Opinion.

9.7 ANALYSIS OF EFFECTS

The effects of the RPA are evaluated with respect to action-area biological requirements in Section 9.7.1 and with respect to species-level biological requirements in Section 9.7.2. These sections parallel those used to evaluate the proposed action in Section 6. Additionally, in Section 9.7.3, the effects of the RPA are compared to effects that would probably occur as a result of breaching four Snake River dams. This comparison is included because dam breaching is an alternative that was specified for consideration in the 1995 FCRPS Biological Opinion, and it is the main alternative to the RPA that the Federal agencies have considered (Corps 1999). It is also included because Section 9.4 describes breaching as a likely alternative action if the status of stocks has declined and/or the RPA is not as effective as expected, when assessed through the mid-point evaluation process. This analysis supports the elements of the RPA that require continued engineering and other preparations for possible future breaching.

9.7.1 Effects of RPA Measures on Action-Area Biological Requirements

As in Section 6.2, NMFS first evaluates the effects of the RPA within the action area. Effects are evaluated with respect to juvenile passage survival, adult passage survival, transportation, and various aspects of critical habitat within the action area.

9.7.1.1 Juvenile Salmonid Passage

Juvenile passage routing and survival is evaluated with respect to the various routes of passage at FCRPS dams. This section emphasizes changes from the proposed action that are expected from implementation of the RPA.

9.7.1.1.1 Turbine Units. Significant numbers of listed juvenile salmonids will continue to pass through FCRPS powerhouse turbines even with the relatively high proportion of fish passage through alternative routes (e.g., spill, bypass systems, and transportation). Previous FCRPS Biological Opinions (1995 and 1998) have required operation of turbines within guidelines that are expected to reduce mortality of juvenile migrants passing through turbines. These opinions also required investigations of juvenile and adult turbine passage mortality and investigation of turbine designs that reduce this mortality. Evaluation of a new turbine design using a minimum gap runner at Bonneville Dam has indicated a small but positive improvement (0 to 3%) in juvenile passage survival compared to the older runner design. These results are preliminary, and future evaluations are necessary before survival improvements can be statistically quantified. This RPA calls for research to answer these questions. In addition, this RPA includes the following:

- Investigations to improve fish survival in the tailrace

- Examination of the potential fish survival benefits of operating minimum gap runner turbine units at or beyond the current guidelines of turbine operation established to maximize fish survival

- Removal of unnecessary obstructions in the high-velocity areas of the turbine

- Periodic index testing of turbine families to ensure that the operating guidelines reflect current conditions

These studies will provide better understanding of the complicated interaction between fish survival and turbine design and operation. This knowledge will probably lead to improved turbine design and operation to benefit fish survival. Considering the information available to date, NMFS expects that installation of minimum gap runners at the Bonneville Dam First Powerhouse and at The Dalles Dam powerhouse would produce a 2% improvement in turbine survival at those two projects. Therefore, juvenile passage survival through the turbines at The Dalles and Bonneville First Powerhouse is expected to increase for both yearling spring and subyearling summer and steelhead migrants from 90%, under the current action (Appendix B, Tables B-4 to B-6), to 92% under the RPA (Appendix B, Tables B-1 to B-3).

9.7.1.1.2 Bypass Systems. The RPA is expected to increase FGE and bypass system survival at many of the FCRPS dams. The following section lists the expected increases at each dam for yearling spring migrants and subyearling summer migrants. The values estimated under the current configuration and operations can be found in Appendix B, Tables B-1 to B-3. The passage estimates expected under implementation of the RPA measures that were used in the SIMPAS passage survival modeling are shown in Appendix B, Tables B-4 to B-6.

Lower Granite Dam. Yearling and subyearling chinook and steelhead survival rates are expected to increase from 98% under the current action to 99% under the RPA, with juvenile fish bypass improvements.

Lower Monumental Dam. Yearling chinook FGE is expected to increase from 49% under the current action to 78% under the RPA with installation of extended-length intake screens and new vertical barrier screens. Bypass survival would increase from 95% to 99% with juvenile fish bypass improvements and outfall relocation. Subyearling FGE would increase from 4% to 56% with installation of extended-length intake screens and new vertical barrier screens. Steelhead FGE would increase from 82% to 84%.

McNary Dam. Yearling and subyearling chinook and steelhead bypass survival is expected to increase from 98% under the current action to 99% under the RPA with juvenile fish bypass improvements.

John Day Dam. Yearling chinook FGE is expected to increase from 73% under the current action to 82% under the RPA with installation of extended-length intake screens and new vertical barrier screens. Subyearling FGE is expected to increase from 32% to 60% with installation of extended-length intake screens and new vertical barrier screens. Steelhead FGE is expected to increase from 85% to 94%.

Bonneville First Powerhouse. Yearling FGE is expected to increase from 39% under the current action to 72% under the RPA with installation of extended-length intake screens. Bypass survival is expected to increase from 90% to 98% with juvenile fish bypass improvements. Subyearling FGE is expected to improve from 9% to 35% with installation of extended-length intake screens. Bypass survival would increase from 82% to 98% with juvenile fish bypass improvements. Steelhead FGE is expected to improve from 41% to 72%. Bypass survival would increase from 90% to 98%.

Bonneville Second Powerhouse. Yearling FGE is expected to increase from 48% under the current action to 60% under the RPA, with improved intake flows and screen performance. Subyearling FGE is expected to increase from 28% to 40% with improved intake flows and screen performance. Steelhead FGE is expected to increase from 48% to 60% under the RPA.

9.7.1.1.3 Spillway and Sluiceway Systems. In several ways, the RPA improves the current juvenile fish passage spill program, as defined in the 1995 FCRPS Biological Opinion and the 1998 Supplemental Biological Opinion. The RPA includes:

- Implementation of 24-hour spill at Lower Monumental Dam
- Evaluation of 24-hour spill at John Day Dam
- Evaluation of raising the daytime spill cap at Bonneville Dam
- Reduction of 24-hour spill at The Dalles Dam

The evaluations at John Day, The Dalles, and Bonneville dams may lead to additional changes in the spill program as the study results are assessed and implemented. These changes may occur as early as the 2002 spill season, but may be limited by transmission system constraints that will be addressed no later than 2005. These changes are expected to improve inriver survival of all juvenile salmon migrants by reducing passage through turbines. Decreased predation is also anticipated as a result of reduced juvenile residence time in predator-rich forebays. In the case of The Dalles Dam, immediate survival benefits are expected as a result of spill reduction. Lower amounts of spill combined with improved spill patterns are expected to help reduce physical injury and predation in the river immediately below the spillway.

The FCRPS fish passage spill program improvements included in the RPA are estimated to result in a systemwide inriver survival rate increase of approximately 4% and 1% for yearling and subyearling migrants, respectively. These values represent a relative increase of 8% and 10% over the existing system inriver survival rate as estimated for each respective chinook stock.

These estimated survival rate improvements do not include further spill increases made possible through additional or modified spillway deflectors, nor do they include pool survival increases that may result when migrants spend less time in project forebays as a result of 24-hour spill. The greatest portion of the survival rate increase expected as a result of the RPA spill changes is expected at The Dalles Dam, where spill passage survival is estimated to increase approximately 8% to10%.

New structural measures to pass juveniles in surface water are under development at several FCRPS dams. These surface bypass efforts are expected to increase spill efficiency, reduce stress related to dam passage, and potentially reduce dissolved gas supersaturation levels. Increased spill efficiency means that water spilled for fish passage is more efficiently used or, in other words, more fish are passed per unit volume of water. Stress and delay are reduced when fish use surface routes through dams. Fish pass more readily through direct surface routes, whereas passage through deeper routes takes them longer. Reducing delays in forebays reduces juvenile exposure to predators. Reduction in predation and passage stress is expected to increase survival.

Current FCRPS project pool mortality estimates were reduced by 10% in the SIMPAS model runs under RPA conditions (Table 9.7-1) in order to characterize this expected survival increase. The expected 10% reduction in pool mortality is primarily based on reduced exposure of smolts to predators, both from project operations and predator control programs. This expected benefit is further explained in Section 9.7.1.5 below.

Table 9.7-1. Project and System Survival of Transported Juvenile SR Spring/summer and Fall Chinook Salmon Outmigrants[1] Under the RPA

YEAR	LGR	LGS	LMN	IHR	MCN	JDA	TDA	BON	% Inriver Survival (LGR to BON)	% Inriver Survival (MCN to BON)	Prop. ESU Transported	Total System Survival	Total System Survival with "D"	
	Project Survival (% Dam + Pool Survival)													
SR spring/summer chinook salmon													"D"= 0.63	"D"= 0.73
1994	93.0	80.7	91.1	89.8	87.2	78.4	91.3	86.4	33.1	53.9	88.6	87.2	55.0	63.7
1995	91.7	90.4	96.4	93.0	91.6	86.4	93.7	90.7	50.0	67.3	43.9	67.7	51.8	56.1
1996	97.8	91.7	96.6	87.9	88.3	87.1	93.5	91.0	49.9	65.4	57.7	75.6	54.7	60.3
1997	85.0	94.4	92.5	90.1	90.4	83.8	92.1	89.0	41.5	62.1	47.6	64.0	46.7	51.4
1998	93.4	98.2	88.6	95.9	96.5	84.3	94.8	92.6	55.7	71.4	50.3	74.2	55.9	60.8
1999	95.1	95.2	95.1	95.3	95.8	87.1	95.9	94.8	62.3	75.9	51.9	78.2	59.4	64.5
6-YR Avg.	92.7	91.8	93.4	92.0	91.6	84.5	93.5	90.8	48.7	66.0	56.7	74.5	53.9	59.5
SR fall chinook salmon													D=0.24	
1994	No data collected in 1994.													
1995	72.7	89.5	81.3	89.2	84.1	77.0	90.3	85.2	23.6	49.8	65.3	64.8	16.2	
1996	57.4	90.3	79.8	88.9	84.6	75.8	90.0	84.7	18.0	48.9	51.3	51.1	12.8	
1997	47.4	60.4	67.5	72.7	63.8	37.3	77.5	62.1	1.6	11.5	36.3	35.6	8.6	
1998	63.9	78.8	92.4	89.3	84.7	77.0	90.3	85.5	20.9	50.3	55.6	55.2	13.8	

[1] Three flow conditions were estimated using NMFS' spreadsheet model (SIMPAS). Values shown are point estimates, based on juvenile survival studies rather than adult returns, and representing performance of mixed (wild + hatchery) runs. Spring/summer chinook salmon are yearling migrants; fall chinook salmon are subyearling migrants.

Table 9.7-1. (continued)

1999	80.6	69.3	89.7	83.6	77.9	63.4	86.1	77.4	13.8	32.9	66.2	65.5	16.3	
5-YR Avg.	64.4	77.7	82.1	84.7	79.0	66.1	86.9	79.0	15.6	38.7	54.9	54.5	13.5	
SR steelhead													"D"= 0.52	"D"= 0.58
1994	75.8	81.8	87.9	85.1	81.1	67.3	87.7	79.8	17.7	38.2	73.7	72.3	37.6	42.0
1995	95.0	92.2	97.5	95.1	94.2	91.0	95.2	93.5	62.0	76.3	48.6	76.6	53.9	56.7
1996	94.1	92.7	97.7	95.1	94.2	91.0	94.7	93.3	61.4	75.8	58.6	79.4	51.8	55.3
1997	96.8	97.8	93.6	92.0	92.3	90.6	94.2	93.1	59.8	73.4	58.1	80.4	53.1	56.5
1998	93.5	94.5	92.4	90.2	90.6	85.1	94.0	91.3	48.6	66.1	52.0	71.6	47.1	50.2
1999	84.3	94.1	94.7	92.0	92.3	93.1	95.5	83.9	47.6	68.9	47.9	66.6	44.0	46.8
6-YR Avg.	89.9	92.2	94.0	91.6	90.8	86.3	93.5	89.2	49.5	66.4	56.5	74.5	47.9	51

9.7.1.2 Adult Salmonid Passage

The RPA calls for a number of actions that are expected to reduce adult delays, injuries, and mortalities related to FCRPS passage. Aging adult fishway facilities will be updated and spare parts for critical components procured to ensure proper operations during the passage season and avoid injurious facility failures. Structural and operational measures in the RPA are expected to reduce inadvertent adult fallback and related mortalities. Understanding the cause of headburn in adults may lead to implementation of corrective measures to reduce this source of injury. Measures in the RPA focused on passage of downstream migrating adult steelhead kelts should increase their survival.

Overall, the RPA measures are expected to decrease adult losses through the FCRPS by 25% over the next 10 years. Table 9.7-2 summarizes how this expected 25% reduction in adult losses will increase the minimum adult survival rates through the FCRPS projects for listed species. For example, the current loss rate of SR spring/summer chinook migrations from Bonneville to Lower Granite Dam is estimated to be approximately 20%, and minimum survival is estimated to be approximately 80%. Reducing the loss rate by 25% produces a future expected loss rate of 15%, and raises minimum adult survival rates to approximately 85%. For SR fall chinook, which currently have a higher loss rate of approximately 39% from Bonneville to Lower Granite, the reduction of 25% in the loss rate produces a larger survival rate improvement. The SR fall chinook current loss rate is expected to drop by about 10%, which raises minimum survival to approximately 71%.

Furthermore, if studies identified in the RPA find that passage through the FCRPS has a delayed effect on adults by reducing their spawning success rate, it is likely that expected passage survival improvements will have an indirect positive effect on spawning rate success. If studies indicate that losses between Bonneville and Lower Granite dams are a result of factors unrelated to the FCRPS, this information will be useful in identifying non-FCRPS actions that would improve adult survival.

Table 9.7-2. Estimates of Adult Survival Based on Radio-Tracking Studies and PIT-Tag Data in the Eight-Project Reach Between Bonneville and Lower Granite Dams

	Multi-Year Radio-Tracking Studies		Reach Studies			Base and Current Condition				RPA Condition	
	1995 BiOp	1998 BiOp	RT 96	RT 97	PIT 98	Mean Loss	Mean Survival	Number of Dams	Per-Project Survival	Mean Survival	Per-Project Survival
Chinook Salmon											
SR spr/sum chinook	0.209	0.252	0.175	0.192	0.358	0.206	0.794	8	0.972	0.851	0.98
SR fall chinook	0.393				0.293	0.393	0.607	8	0.940	0.721	0.96
UCR spr chinook							0.891	4		0.922	0.98
LCR spr chinook							0.972	1		0.980	0.98
LCR fall chinook							0.940	1		0.960	0.96
Steelhead											
SR steelhead		0.165	0.244		0.196	0.205	0.796	8	0.972	0.851	0.98
UCR steelhead							0.892	4		0.922	0.98
MCR steelhead							0.892	4		0.922	0.98
LCR steelhead							0.972	1		0.980	0.98
SR sockeye salmon	0.154					0.154	0.846	8	0.979	0.851	0.98

9.7.1.3 Water Regulation and Impoundments

BPA assessed the effects of water management measures specified in Section 9.6.1.2 using its HYDSIM hydroregulation model. The HYDSIM model simulates operations on a monthly basis at the FCRPS and other Columbia basin projects to meet an array of purposes including flood control, anadromous and resident fish protection, projected energy loads, Columbia basin Treaty obligations, and other project-specific, non-power requirements. Outputs of interest include mean monthly discharge at various locations and end-of-month reservoir elevations for the major storage projects. A 50-year (1929 to 1978) hydrologic record was used in this modeling effort. A summer (June 30) reservoir refill priority was assumed in the modeling.

The base case model run placed priority on meeting the reservoir operating provisions specified in NMFS' 1995 and 1998 FCRPS Biological Opinions and USFWS' 1995 Biological Opinion on Kootenai River sturgeon. Summary of the base case (proposed action) model results are shown in Table 6.2-5. Subsequent modeling scenarios evaluated the effects of including VARQ and modified flood control curves, providing deeper reservoir drafts at selected FCRPS projects, and increasing the Mica and/or Revelstoke project's discharge during the summer period. Model output consisted of 50-year monthly flows at various projects and a summary of the effect of project operations by enumerating the frequency with which the NMFS flow objectives are met on a monthly and seasonal basis at Lower Granite, Priest Rapids, McNary, and Bonneville dams. The effect of flow operations on the frequency of storage reservoirs achieving upper (flood control) rule curve on April 10 and refill by June 30 was also summarized. Table 9.7-3 summarizes operational criteria for the most recent hydrosystem regulation studies.

9.7.1.3.1 Probability of Achieving NMFS Flow Objectives. Table 9.7-4 provides a summary of the percent of years flows at Lower Granite, Priest Rapids, McNary, and Bonneville dams that are expected to meet or exceed NMFS flow objectives under the RPA. In comparing the results of Table 9.7-4 to Table 6.2-5, there are little or no changes to monthly flows at Lower Granite Dam, except that September flows are about 4,100 cfs higher under the RPA due to the additional draft from Dworshak Reservoir for an adult fish passage evaluation (Section 9.6.1.2.6). In general, Snake River flows meet or exceed NMFS flow objectives during the spring migration except in the lowest 20 water years. In the summer months, NMFS flow objectives are not achieved in the Snake River except in the highest 10 water years.

For the Columbia River at Priest Rapids Dam, spring flow objectives in April and May are met under the RPA at about the same frequency as under the proposed action. However, the probability of achieving the 135-kcfs flow target in June under the RPA is 90%, an increase of 12% over the proposed action. In general, except in the lowest 8 water years, the NMFS flow target is achieved at Priest Rapids Dam.

For the Columbia River at McNary Dam, spring flow objectives in late April and May are met slightly less frequently under the RPA than under the proposed action, e.g., 50% compared to 52% in the second half of April and 66% vs 70% in May. June flow targets, however, have a 56% probability of being achieved under the RPA compared to a 52% probability of being achieved under the proposed action. Overall, spring flow objectives are achieved except in the lowest water years.

Water management actions under the RPA have the greatest effect on July and August flows at McNary Dam. For example, the likelihood of achieving the NMFS summer flow objective of 200 kcfs increases from 52% to 68% and from 10% to 20% in July and August, respectively. While this flow objective is attained in all but the lowest 8 water years during July, it is achieved only in the highest water years during August. Water management actions under the RPA increase summer flows by an average of 15 kcfs over the proposed action.

Fall and winter flows at Bonneville Dam for LCR chinook and CR chum salmon spawning and incubation through emergence were also evaluated. A flow objective of at least 125 kcfs was achieved in November in 30% of the years under the RPA, compared to only 20% under the proposed action. This flow objective was achieved in 90% of the years in December, a similar frequency as under the proposed action. In January, however, the flow objective was met in 76% of the years under the RPA compared to 90% under the proposed action. This decrease is most likely due to 1) restoring Canadian reservoir storage that was released in the previous summer months for salmon flows and 2) reduced flood control drafts as a result of VARQ flood control operations.

The flow objective was achieved with about the same probability during the months of February and March, e.g., at 74% under the RPA compared to 76% under the proposed action.

Table 9.7-3. Summary of Criteria for Hydrosystem Regulation Studies

Criteria added to base case (00fsh26) operations	Study 00FSH 27	Study 00FSH28	Study 00FSH29
1. Draft Dworshak to elev. 1,500 feet in September.	X	X	X
2. 20 kcfs from Mica/Revelstoke in July and August–restore in Jan/Feb/Mar.		X	X
3. Additional Grand Coulee draft in low water years (to elev. 1,280 feet if Apr to Aug runoff ≥92 Maf and to elev. 1,278 feet if Apr to Aug runoff < 92 Maf).	X	X	X
4. Banks Lake–reduced storage of 5 feet–water returned when most convenient for power and fishery purposes.	X	X	X
5. Biological Opinion spill levels.	X	X	X
6. Upper Snake water– no change from base case, i.e., 427 kaf.	X	X	X
7. VARQ flood control operation with smooth summer draft and USFWS minimum flows.	X–VARQ at Hungry Horse only	X–VARQ at Hungry Horse and Libby	NO VARQ
8. Fall spawning flows below Bonneville Dam.	X	X	X
9. Additional Hungry Horse draft in low water years (to elev. 3,530 feet if Apr to Aug runoff <80 Maf).	X	X	X
10. 20% reduction in system flood control draft.			X

Table 9.7-4. Percent of Years Flows at Lower Granite, Priest Rapids, Mcnary, and Bonneville Dams Are Expected to Meet or Exceed Specified Flow Objectives under the RPA Based on a 50-Year Continuous Hydrosystem Simulation (1929 through 1978)

	Project			
Period	Lower Granite	Priest Rapids	McNary	Bonneville
January	N/A	N/A	N/A	76
February	N/A	N/A	N/A	74

March	N/A	N/A	N/A	74
April	40	58	50	N/A
May	64	84	66	N/A
June	68	90	56	N/A
July	70	N/A	68	N/A
August	0	N/A	20	N/A
September	N/A	N/A	N/A	8
October	N/A	N/A	N/A	N/A
November	N/A	N/A	N/A	30
December	N/A	N/A	N/A	90

Source: BPA Hydrosim Run 0Y00.00FSH28.OPER.

9.7.1.3.2 FCRPS Reservoir Effects. Based on the results of BPA's hydrosystem modeling, which uses a 50-year water record, effects on FCRPS storage reservoir operations under the RPA compared to the proposed action (base case) are summarized below.

Grand Coulee. The 50-year hydrosystem study results indicate the RPA-proposed draft of an additional 2 feet below elevation 1280 in years when the April-August forecast is less than 92 Maf does not affect either 1) refill probability in subsequent years, or 2) the project's ability to achieve elevation 1283 or above by the end of September (see Section 9.6.1.2.3 for a description of Grand Coulee operations). For example, the modeling results for the RPA operation indicate that FDR Lake refills or reaches its upper rule curve elevation on June 30 in all 50 water years, and the project has a 50-year average elevation of 1283.4 feet by the end of September. In addition, the 50-year average draft of Grand Coulee reservoir by August 31 is to elevation 1280 feet.

Banks Lake and Columbia Basin Project Pumping. Under the RPA operation, pumping from FDR Lake into Banks Lake is reduced in August by an equivalent volume of the top 5 feet (127 kaf) of storage in Banks Lake in years when this water is needed to meet the McNary Dam flow objective (see Section 9.6.1.2.4 for a description of Banks Lake operations). Additional water is pumped from FDR Lake in the following January-April period to return Banks Lake elevation to its original elevation.

Libby. Libby Reservoir either refills or reaches its upper rule curve elevation by June 30 in twice as many years, 32 years versus 16 years, under the RPA operation than in the proposed action operation (see Section 9.6.1.2.3 for a description of Libby operations). In addition, the 50-year average draft of Libby reservoir at the end of August is elevation 2441 feet under the RPA operation, as compared to elevation 2439 feet under the proposed action.

Hungry Horse. Hungry Horse Reservoir either refills or reaches its upper rule curve elevation on June 30 in 7 more years, 34 years versus 27 years, in the RPA operation than under the proposed action (see Section 9.6.1.2.3 for a description of Hungry Horse operations). Under the RPA, the proposed draft of Hungry Horse Reservoir below 3540 occurs in 3 years in the 50-year water record, with the additional draft averaging 5.1 feet (the reservoir drafts to elevation 3530 feet in only one year). In those three years of additional draft, the project refills to its June 30 upper rule curve elevation in the following year in 2 of the 3 years. In addition, the reservoir elevation is between 3550 feet and 3560 (full pool) feet on August 31 in 6 years under the RPA, as opposed to 4 years under the proposed action.

Albeni Falls. In the 50-year hydroregulation studies under the RPA, and except for the USFWS kokanee spawning evaluation in three of the next 6 years, Albeni Falls project is operated to elevation 2051 feet during October through April of each year to assist in meeting chum salmon flow needs in the lower Columbia River (see Section 9.6.1.2.3 for a description of Albeni Falls operations).

Mica. The Mica project in Canada is operated according to the Columbia River Treaty Operating Plan between the United States and Canada. In addition to the Treaty operation, the RPA analysis considers release of up to an additional 20,000 cfs from Mica in July and August, as needed in each year to meet the McNary flow objective of 200,000 cfs. The volume of water released from Mica for salmon flow augmentation is restored to the reservoir in the following January and February by reducing project outflows in those months.

Dworshak. In the RPA operation as in the proposed action, Dworshak drafts to elevation 1520 feet by the end of August of each year, if needed to support Lower Granite Dam flow objectives and water temperature control (see Section 9.6.1.2.3 for a description of Dworshak operations). In September, the RPA proposes to draft the project an additional volume of 244 kaf, but no lower than elevation 1500 feet, for temperature reduction and to meet flow objectives in the lower Snake River as part of an adult fish passage evaluation (see Section 9.6.1.2.6 for a description of Dworshak's September temperature and adult passage evaluation operation). The 50-year hydroregulation study of Dworshak refill probability indicates the September adult study operation has little effect on reservoir refill by the end of June in subsequent years, i.e., there is only one additional refill failure at Dworshak on June 30, and even with this refill miss the reservoir elevation is within 3-4 feet from full pool.

9.7.1.4 Water Quality

Gas abatement measures in the RPA will reduce dissolved gas levels and thereby improve water quality and reduce the risk to listed salmonids. Installation of flow deflectors at Chief Joseph Dam will reduce gas entrainment and dissolved gas levels downstream during spill periods at that project. This measure will improve water quality conditions for UCR spring chinook and steelhead adults and juveniles downstream of Chief Joseph Dam. It will also help ensure that spill programs for passage of juvenile UCR spring chinook and steelhead at Wells, Rocky Reach, and Rock Island dams are not affected by elevated gas levels originating at Chief Joseph.

The deflector optimization program at the lower Snake and lower Columbia FCRPS projects will improve water quality and reduce gas entrainment during voluntary juvenile fish passage spill and during involuntary spill periods.

Temperature reduction measures identified in the RPA will help reduce elevated water temperature conditions in the lower Snake River and in fish bypass facilities to improve migration conditions and survival rates of subyearling fall chinook. For example, modifications to water supply intake facilities at Dworshak National Fish Hatchery would eliminate the current operating restrictions on releases of cooler water from Dworshak Reservoir, which would allow for flow volume increases and lower water temperatures in the lower Snake River to improve migratory conditions for juvenile fall chinook. Hatchery supply water that is cooler than 54°F has been shown to negatively affect the growth of juvenile fish reared at the hatchery. With the required modifications to the hatchery water supply system, it would be possible to augment Snake River flows using Dworshak discharges with temperatures as low as 48°F, providing a greater cooling effect downstream.

Thermal-related stress is known to contribute to juvenile fish collection mortality at McNary Dam. Hydro-thermal computational fluid dynamics (CFD) modeling has the potential to provide quantitative information that would enable the Corps, NMFS, and fishery co-managers to determine the physical effects on water temperature of selected project operation and/or structural modifications at McNary Dam. CFD modeling could help evaluate the potential ability of alternative powerhouse operations to decrease the inflow of elevated summertime water temperatures into gatewells, the juvenile fish collection channel, and raceways.

9.7.1.5 Effects of Predator Control

Improvements in predator control include improvements to the Northern Pikeminnow Management Program and evaluations of avian and marine mammal predation near and above Bonneville Dam. These evaluations may lead to actions that can be implemented to reduce predation. The direct effects of these predator control efforts on juvenile survival are difficult to quantify. However, on the basis of information in the NMFS Predation White Paper, NMFS estimates that implementing the RPA measures will reduce FCRPS project pool mortalities of both yearling and subyearling juveniles by an average of approximately 10%. Accordingly, NMFS applied the 10% average reduction in the SIMPAS model.

To illustrate: estimated mortality for yearling spring/summer chinook in John Day Reservoir is approximately 12% (Table 6.2-8). A 10% reduction in mortality would therefore be an absolute change of 1.2%. The White Paper cites the estimate from Peterson (1994) that approximately 7.3% of all juvenile salmonids entering John Day Reservoir annually are lost to predation by northern pikeminnow. Table 10 of the White Paper lists model predictions for the expected reduction in the pikeminnow predation rate due to continuation of the predation control program. At John Day, for the years 2000 to 2006, the model estimates that the predation rate will be reduced by approximately 9% annually. Reducing the estimated current pikeminnow predation loss of 7.3% by 9% gives an approximate 0.66% annual reduction in pool mortality due to the predator control program alone. This is about half of the 10% (1.2% absolute) assumed in the RPA analysis.

Other measures in the RPA, such as spill operations and future surface passage facilities, are all expected to further reduce delay at the dam, and therefore exposure to predators. In addition, measures to reduce mortalities due to other piscine and avian predators will also reduce pool mortality rates. Although the pool mortality reduction rate expected from these other measures cannot be quantified at this time, it appears reasonable to expect that these measures, when combined with the reduction expected from the pikeminnow control program, will be sufficient to result in a 10% reduction in pool mortality.

9.7.1.6 Juvenile Transportation Program

9.7.1.6.1 Percentage of Each Species Transported. Under the aggressive program, the proportion of the SR mixed stock yearling chinook population potentially collected and transported from the three Snake River collector dams is estimated to average about 57%, with a range from 44% to 89% depending on river conditions. For summer migrating SR fall chinook, the proportion transported is lower than that for yearling chinook because of significant mortality that occurs before these fish first reach Lower Granite Dam. The proportion of fall chinook potentially collected and transported is estimated to average about 55%, with a range from 36% to 66% depending on river conditions. Similar estimates for SR steelhead average 57%, with a range from 48% to 74% (NMFS, SIMPAS analyses, 2000x).

9.7.1.6.2 Survival Benefits to Each Species. Without transportation, the average survival of combined mixed stock SR yearling chinook salmon from Lower Granite Dam to below Bonneville Dam is estimated to be about 49%, with a range from 33% to 62% depending on river conditions. With transportation, combined transport and inriver survival to below Bonneville Dam is estimated to be about 75%, with a range from 64% to 87%. For summer migrating SR fall chinook, the proportion of the population surviving to below Bonneville Dam without transportation is estimated to be about 16%, with a range from about 2% to 24%. With transportation, the proportion of the population surviving to below Bonneville Dam is about 55%, with a range from 36% to 66%. Similar estimates for SR steelhead average about 50% without transportation (range 18% to 62%), and 75% (range 67% to 80%) with transport (NMFS, SIMPAS analyses, 2000x).

9.7.1.6.3 Effects of Extended Barging Season. This measure addresses the concerns of the ISAB and others in the region regarding potential adverse effects on juvenile fish that are transported by truck as compared to barging. Collected juveniles that migrate early and late in the season have been transported by truck for release below Bonneville Dam. Unlike the summer migrants, which are trucked, all of the early transported migrants are released from the shoreline at selected locations thought to afford the best available release conditions (strong downstream current, deep water in close proximity, no avian predators). Due to safety concerns, trucked fish are routinely released during daylight, a period when avian predators are most active. In contrast, barged fish are released at various mid-river locations under more favorable hydraulic conditions where predators have less opportunity to forage.

9.7.1.6.4 Potential Release of Trucked Fish from the New Bonneville Juvenile Fish Bypass Outfall. As described above, juvenile fish that are trucked at the beginning of the season are released from the shoreline, where there is increased likelihood of consumption by predators. The new Bonneville juvenile fish bypass outfall was sited to afford bypassed fish a higher survival rate. If the post-construction evaluation of the new outfall does not show any problems, there should be a survival advantage for trucked fish released from that location.

9.7.1.6.5 Transportation from McNary Dam. The potential benefits to listed Upper Columbia species are unknown. Transportation around the remaining three lower Columbia dams would avoid FCRPS-related mortality in that reach and thereby increase their relative survival. On the other hand, collection and transportation from McNary may result in indirect mortality. Evaluations of transport benefits conducted during the 1980s relied on juvenile fish collected by sampling from the juvenile facility. Those fish were most likely a mix of upper Columbia and Snake River fish.

Currently, transport barges from the lower Snake River bypass the McNary Dam juvenile facility and arrive below Bonneville earlier than would otherwise occur. More barged fish are released in daylight instead of after dark, which was the case before transport was suspended.

More juvenile salmon and steelhead that migrate in June would remain inriver to complete their migration if the decision to initiate transportation is based on a daily average riverflow and water temperature criteria. In the past 2 years, collection and transport began when inriver migratory conditions were more favorable to their survival through the lower Columbia River. Because spring migrant transport operations at McNary will continue to be suspended until new studies demonstrate positive benefits, there is no scientific basis for transporting summer migrants passing the project under springlike conditions. Available data do not show a transport benefit for summer migrants transported during the early portion of the migration, and only a slight benefit for the middle segment of the run. Studies in the 1980s were conducted when fish handling facilities and practices were less favorable than they are now, and the mainstem dams were operated without juvenile fish protection considerations. Future evaluations are desirable to help determine whether summer migrants should be removed from the river under good inriver migratory conditions.

Installation of adult PIT-tag detectors in main fishways at McNary Dam will allow collection of adult return data without any handling. These facilities are essential to conduct transport research at McNary.

9.7.1.6.6 Improvements to the Transportation Program. Planning transport operations at the dams so that fish are released from specific areas at specific times to enhance their post-release survival has the potential to reduce estuarine-related predation. At present, fish barges at the uppermost dam are loaded on the day shift in the morning. That schedule determines the barge loading schedule at the downriver projects. No consideration is given to the optimum times that fish would need to be released below Bonneville to ensure the survival rate. Staff resource and safety issues are the primary considerations. Researchers have speculated that survival at the saltwater interface may be higher if transported fish arrive at the estuary concurrent with an outgoing tide. This could reduce delay and potential negative interactions with avian predators (i.e., at Rice Island).

9.7.1.6.7 NMFS' Issuance of Section 10 Permits for the Juvenile Transportation Program and the Smolt Monitoring Program. The juvenile transportation program is an integral component of the current action in this Biological Opinion. The Corps' existing permit expires on December 31, 2000. Issuance of a new Section 10 permit for the transportation program will be necessary for 2001 and beyond. Effects of bypass and collection of smolts on SR steelhead, UCR steelhead, and SR spring/summer chinook survival are described in Section 6.2.2.2. Effects of adult fallback through bypass systems are assessed in Section 6.2.3. Effects of transportation, in terms of direct survival to below Bonneville Dam and relative survival to adulthood compared to inriver migrants, are discussed in Section 6.2.7. Biological information regarding all aspects of the transportation program and its effect on listed steelhead and salmon is included in the Transportation White Paper (NMFS 2000).

The smolt monitoring program is also an integral component of the current action. Issuance of the Section 10 permit for the smolt monitoring program is also necessary for 2001 and beyond.

9.7.1.7 Summary: Effects of the RPA on Juvenile and Adult Survival

The information in Table 9.7-5 summarizes the effects of the RPA on the listed salmon and steelhead juvenile survival rates, estimated using the SIMPAS model, and minimum adult survival rates, estimated from radio-tag study results and listed in Table 9.7-2. Also included in Table 9.7-4, for comparison purposes, are summaries of the effects of the current action on juvenile survival rates, estimated using the SIMPAS model and listed in Appendix B, Tables B-1 through B-3. Minimum adult survival rates, estimated from radio-tag study results, are listed in Table 6.1-1.

Table 9.7-5. Summary of Estimated Effects of the RPA in the Action Area

ESU	Estimated Inriver Juvenile Survival through FCRPS		Estimated Inriver and Transport Juvenile Survival With "D" through FCRPS		Estimated Adult Survival through FCRPS	
	Current	RPA	Current	RPA	Current	RPA
Chinook Salmon						
SR spr/sum chinook (D = 0.63-0.73)	0.26-0.52	0.33-0.62	0.46-0.64	0.47-0.65	0.80	0.85
SR fall chinook (D = 0.24)	0.01-0.17	0.02-0.24	0.06-0.15	0.09-0.16	0.60	0.72
UCR spring chinook	0.45-0.66	0.54-0.76	N/A	N/A	0.89	0.92
UWR chinook	N/A	N/A	N/A	N/A	N/A	N/A
LCR chinook-spring	0.83-0.91	0.86-0.95	N/A	N/A	0.97	0.98
LCR chinook-fall	0.55-0.81	0.62-0.85	N/A	N/A	0.94	0.96
Steelhead						
SR steelhead (D = 0.52-0.56)	0.12-0.51	0.18-0.62	0.36-0.53	0.38-0.57	0.80	0.85
UCR steelhead	0.30-0.67	0.38-0.76	N/A	N/A	0.89	0.92
MCR steelhead	0.30-0.67	0.38-0.76	N/A	N/A	0.89	0.92
UWR steelhead	N/A	N/A	N/A	N/A	N/A	N/A
LCR steelhead	0.75-0.91	0.80-0.94	N/A	N/A	0.97	0.98
CR chum salmon	0.55-0.81	0.62-0.85	N/A	N/A	0.94	0.96
SR sockeye salmon	N/A	N/A	N/A	N/A	0.84	0.8

9.7.2 Analysis of the Effects of the RPA on Biological Requirements Over the Full Life Cycle

9.7.2.1 Snake River Spring/Summer Chinook Salmon

Evaluation of species-level effects of the RPA requires placing the action-area effects in the context of the full life cycle. The factors described in Section 9.7.1 affect elements of critical habitat and the survival and recovery of SR spring/summer chinook salmon in the action area. A large number of additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix A) limit this ESU over its full range, including habitat degradation in many areas due to forestry, grazing and mining practices (loss of pools, high temperatures, low flows, poor overwintering conditions, and high sediment loads).

In this section, NMFS evaluates quantitatively the action-area effects associated with the RPA, along with the effects of human activities affecting survival in other parts of the life cycle.

9.7.2.1.1 Survival and Recovery Components of the Jeopardy Standard. NMFS used Leslie matrices (Section 6.1.2) to evaluate the likely status of stocks under the RPA relative to the jeopardy standard indicator (Sections 1.3.1.1 and 6.1.2). The matrix analysis incorporated the survival rates in other life stages that NMFS expects to result from likely actions described in the All-H Paper. One matrix was developed for each of seven index stocks in the Snake River basin (Appendix A), as described in Section 6.3.1.1. As described in Sections 6.1.2 and 6.3.1.1, the elements of the Leslie matrices were first parameterized to reflect, as closely as possible, the average survival rates that influenced the 1980 to 1994 brood year returns (base matrix). Section 6.3.1.1 contains a description of the base matrix used in this evaluation.

NMFS then changed juvenile and adult passage survival rates to reflect effects of the hydrosystem measures specified in the RPA (RPA matrix). No other survival rates were estimated to have changed between the average base and the RPA condition. Table 9.7-5 shows smolt passage direct survival estimates. Table 9.7-2 shows adult survival estimates. NMFS then estimated a new equilibrium rate of annual population growth from the RPA matrix and compared it to the base population growth rate.

As in the analysis of the proposed action, the base and the RPA matrix contained two estimates of total (direct and indirect) juvenile passage survival. Each represented an average of the 0.63-to-0.73 range of differential delayed mortality (D) estimates described in Section 6.2. The high and low juvenile passage survival estimates differed only in their treatment of delayed mortality of non-transported fish. Under the low delayed mortality assumption, no post-Bonneville mortality of non-transported fish was attributed to the hydrosystem. Under the high delayed mortality assumption, post-Bonneville mortality attributed to the hydrosystem was the average of the PATH lambda-n estimate (Marmorek and Peters 1998) associated with D equals 0.63, which associated with D equals 0.73. These estimates of mortality were 0.709 and 0.743, respectively.

Table 6.3-1 shows estimates of survival rates included in the base matrix. Table 9.7-6 shows survival estimates included in the RPA matrix. The average per-generation survival rate associated with the RPA represents a 30% increase (1.30 multiplier) from the base survival rate for all seven SR spring/summer chinook index stocks.

The estimated change in base to RPA population growth rate was then compared with the changes needed to achieve the following:

- Reduce extinction risk to 5% or less in 24 and 100 years (Tables A-6 and A-7)
- Increase the likelihood of meeting 8-year geometric mean recovery levels to 50% or more in 48 and 100 years (Tables A-8 and A-9)

This comparison took place after converting the necessary incremental changes in lambda (annual population growth rate) in those tables to necessary incremental changes in survival over a generation (i.e., egg-to-spawner survival rate).

Table 9.7-6. Matrix Life-Stage Survival and Harvest Rate Estimates, RPA Leslie Matrix

Snake River Spring/ Summer Chinook	Mean Egg-to-Smolt Survival	Mean Smolts per Spawner	Low Delayed Mortality Assumption: Mean Juvenile FCRPS Hydro Survival (including delayed effects)	Low Delayed Mortality Assumption: Mean Non-Hydro Estuary/ Early Ocean Survival	High Delayed Mortality Assumption: Mean Juvenile FCRPS Hydro Survival (including delayed effects)	High Delayed Mortality Assumption: Mean Non-Hydro Estuary /Early Ocean Survival	Mean Ocean Exploi-tation Rate	Mean Ocean Non-Harvest Survival Rate (Multiply [1-exp. Rate] for total O2+ ocean survival)	Mean Inriver Harvest Rate	Mean Adult FCRPS Passage Survival Rate	Mean Upper Dam to Spawning Survival Rate	Mean Egg-to-Adult Survival Rate	Mean Adult-to-Adult Return
Marsh	0.019	**52.700**	0.567	0.062	0.155	0.227	0.000	0.566	0.082	0.851	0.900	**0.00026**	**0.736**
Sulphur	0.039	**109.800**	0.567	0.062	0.155	0.227	0.000	0.566	0.082	0.851	0.900	**0.00055**	**1.534**
Bear Valley	0.029	**80.400**	0.567	0.062	0.155	0.227	0.000	0.566	0.082	0.851	0.900	**0.00040**	**1.124**
Johnson	0.027	**75.500**	0.567	0.062	0.155	0.227	0.000	0.566	0.025	0.851	0.900	**0.00040**	**1.120**
Poverty Flats	0.024	**68.600**	0.567	0.062	0.155	0.227	0.000	0.566	0.025	0.851	0.900	**0.00036**	**1.018**
Imnaha	0.013	**36.500**	0.567	0.062	0.155	0.227	0.000	0.566	0.053	0.851	0.900	**0.00019**	**0.526**
Minam	0.025	**69.600**	0.567	0.062	0.155	0.227	0.000	0.566	0.082	0.851	0.900	**0.00035**	**0.973**

Note: These data represent hydrosystem measures included in the reasonable and prudent alternative. All non-bold survival rates were estimated through methods described in Section 6.1.2 and Appendix C and input to the matrix, with two exceptions. Mean egg-to-smolt survival was adjusted to other elements of the base matrix and to mean 1980 to 1994 ln(recruits/spawner) estimates. Mean non-hydro estuary/early ocean survival was adjusted to estimates of direct and indirect hydro survival and total smolt survival in the base matrix. **Bold** survival rates are summary statistics derived from the other survival rates.

Table 9.7-7 displays the additional improvements in survival that would be necessary, beyond the 30% improvement associated with the RPA, to reduce extinction risk to 5% and increase the likelihood of recovery to 50%. Values less than or equal to 1.0 indicate that no further survival improvements are necessary to achieve the risk levels associated with these indicator metrics. Values greater than 1.0 indicate the multiplier by which survival would have to improve to achieve these indicator risk levels. For example, the survival change necessary to reduce the risk of extinction in 24 years to 5% (third column of Table 9.7-7) is 0.77 for the Marsh Creek index stock. This means that the RPA, combined with expected survival in other life stages, is sufficient to reduce 24-year extinction risk to 5% or less. On the other hand, the survival change necessary for a 50% likelihood of meeting proposed recovery abundance levels in 48 years (fourth column of Table 9.7-7) is 1.14 to 1.37 for the Marsh Creek index stock. This means that an additional 14 to 37% increase in egg-to-adult survival, or any component life-stage specific survival rate, would be necessary to achieve a 50% likelihood of meeting proposed recovery abundance levels in 48 years.

NMFS estimates both best- and worst-case situations. Best case represents the high estimate of juvenile smolt survival (Tables 6.3-1 and 9.7-6), coupled with needed survival improvements based on 1) the 1980 to 2004 observed and projected spawning escapements (Table A-7 and A-9) and 2) an assumption that productivity of wild-origin spawners is high when the spawning population includes hatchery-origin fish. In this case, productivity of hatchery-origin spawners is assumed to be low (20% as effective as naturally produced spawners). Worst case represents the low estimate of juvenile smolt survival, coupled with needed survival improvements based on 1) the 1980 to 1999 observed spawning escapements (Tables A-6 and A-8) and 2) an assumption that productivity of wild-origin spawners is low when the spawning population includes hatchery origin fish. In this case, productivity of hatchery-origin spawners is assumed to be high (80% as effective as naturally produced spawners).

Under the best-case assumptions, the increased survival expected from the RPA, coupled with expected survival in other life stages, is sufficient to reduce the likelihood of extinction to 5% and to result in at least a 50% likelihood of recovery for three of the seven index stocks (Bear Valley Creek [Middle Fork Salmon River], Johnson Creek [South Fork Salmon River], and the Poverty Flats reach of the South Fork Salmon River). Additional survival improvements ranging from 9 to 109% (1.09 to 2.09 survival multipliers) would be necessary to reduce extinction risk and increase the likelihood of recovery for the other four index stocks.

Under the worst-case assumptions, only Johnson Creek meets the identified extinction risk and recovery levels under the RPA. Additional survival improvements ranging from 3 to 1,103% (1.03 to 12.03 survival multipliers) would be necessary to reduce extinction risk and increase the likelihood of recovery for the other six index stocks.

Table 9.7-7. Snake River Spring/Summer Chinook Estimated Range of Per-Generation Survival Improvements

Population	5% extinct, 100 years	5% extinct, 24 years	50% Recovery 48 years	50% Recovery 100 years	Natural River
Marsh Creek					
Best Case	0.86	0.77	1.14	0.97	1.45
Worst Case	1.09	0.77	1.37	1.16	5.30
Sulphur Creek					
Best Case	1.09	0.77	1.09	0.93	1.45
Worst Case	1.42	1.05	1.21	1.03	5.30
Bear Valley Creek					
Best Case	0.77	0.77	0.92	0.82	1.45
Worst Case	0.84	0.77	1.03	0.92	5.30
Johnson Creek					
Best Case	0.77	0.77	0.78	0.73	1.45
Worst Case	0.77	0.77	0.89	0.84	5.30
Poverty Flats					
Best Case	0.77	0.77	0.84	0.79	1.45
Worst Case	1.03	0.77	1.22	1.14	5.30
Imnaha River					
Best Case	1.61	0.77	2.09	1.88	1.45
Worst Case	10.43	6.68	8.69	7.82	5.30
Minam River					
Best Case	1.73	0.94	1.92	1.69	1.45
Worst Case	12.03	8.18	9.85	8.70	5.30

Note: These improvements are needed to satisfy five jeopardy standard indicator metrics, given implementation of the hydrosystem measures in the RPA. Numbers less than or equal to 1.0 indicate that additional survival improvements are not necessary. Numbers greater than 1.0 are the necessary survival multipliers. See the text for details and definition of best and worst case.

9.7.2.1.2 Full Mitigation Component of the Jeopardy Standard. As described in Section 6.1.2, a metric indicative of the full mitigation component of the jeopardy standard is NMFS' best estimate of the natural survival rate of juveniles and adults that would occur without the FCRPS. The estimated SR spring/summer chinook natural survival through the hydrosystem is approximately 82% for juveniles, 85% for adults, and 70% for the combined juvenile and adult survival.

As described in Table 9.7-6, the high estimate of juvenile survival (as described above, including indirect effects) associated with the RPA is 56.7%, while the low estimate is 15.5%. The estimate of adult survival is 85.1%, which leads to 13.2 to 48.3% combined juvenile and adult survival when moving through the hydrosystem.

The estimated survival when moving through the hydrosystem under the RPA is clearly lower than that estimated to occur in the absence of the FCRPS. Table 9.7-6 describes the additional change in passage survival (including indirect effects) needed to meet NMFS' estimate of natural survival. The additional survival improvement ranges from 45% (1.45 multiplier) for the high survival estimate to 430% (5.30 multiplier) for the low survival estimate.

9.7.2.1.3 Consideration of All Components of the Jeopardy Standard. For five of the seven SR spring/summer chinook index stocks, the incremental change in survival needed to meet the survival and recovery indicator risk metrics is lower than that needed to achieve a natural survival rate through the FCRPS. Based on the construction of the jeopardy standard described in Section 1.3.1.1, the survival and recovery components are relevant for evaluating effects of the RPA on the Salmon River index stocks (the Poverty Flats reach of the South Fork Salmon River and Marsh, Sulphur, Bear Valley, and Johnson creeks). The full mitigation component of the jeopardy standard is most relevant for evaluating effects of the RPA on the Imnaha and Minam River index stocks.

9.7.2.2 Upper Columbia River Spring Chinook Salmon

Evaluation of species-level effects of the proposed action requires placing the action-area effects in the context of the full life cycle. The factors described in Section 9.7.1 affect elements of critical habitat and the survival and recovery of UCR spring chinook salmon in the action area. Additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix A) limit this ESU over its full range. Chief Joseph Dam (and Grand Coulee Dam) prevents access to historical spawning grounds farther upstream, and there are local problems related to irrigation diversions and hydroelectric development, as well as degraded riparian and instream habitat from urbanization and livestock grazing along riparian corridors.

In this section, NMFS evaluates quantitatively the action-area effects associated with the proposed action and the effects of human activities affecting survival in other parts of the life cycle.

9.7.2.2.1 Survival of Recovery Components of the Jeopardy Standard. NMFS used a Leslie matrix (Section 6.1.2) to evaluate the likely status of stocks under the proposed action relative to the jeopardy standard indicator metrics (Sections 1.3.1.1 and 6.1.2). The matrix analysis incorporated the survival rates in other life stages that NMFS expects to result from likely actions described in the All-H Paper. One matrix was developed for the Wenatchee population of Upper Columbia River spring chinook ESU. As described in Section 6.3.1.1, the Wenatchee population was chosen as an indicator of effects of the RPA on the ESU because, of the three populations tentatively identified as comprising this ESU (Ford et al. 2000), it requires the greatest change in survival to recover and avoid extinction (Cooney et al. 2000; McClure et al. 2000). Ford et al. (2000) identified interim recovery goals and included the criterion that all three populations must meet these goals for delisting. Therefore, the population requiring the greatest change is the critical population for this analysis.

As described in Sections 6.1.2 and 6.3.1.1, the elements of the Leslie matrix were first parameterized to reflect, as closely as possible, the average survival rates that influenced the 1980 to 1994 brood year returns (base matrix). The base matrix used in this evaluation was identical to that described in Section 6.3.1.2.

NMFS then changed four survival rates to reflect effects of the hydrosystem measures in the RPA (RPA matrix) and expected future survival improvements at the PUD projects as a result of the proposed Mid-Columbia HCP. The All-H Paper identified implementation of the HCP as an element of recovery planning that is likely to occur. It is, therefore, included in the analysis, consistent with Step 4 of the jeopardy analysis framework described in Section 1.3. Egg-to-smolt and juvenile survival through the three PUD projects were both increased from the base matrix estimates to reflect the survival rates anticipated in the proposed HCP, as described in Section 6.3.1.2. Juvenile and adult survival through the four FCRPS projects was modified to reflect the expected survival rates described in Section 6.2.8.3 (Tables 9.7-6 and 9.7-7). High and low juvenile survival assumptions matched those described in Section 6.3.1.2. No other survival rates appeared to change between the average base and RPA condition. A new equilibrium rate of annual population growth was then estimated from the RPA matrix and compared to the base population growth rate.

Table 9.7-8 shows estimates of survival rates included in the base and RPA matrices. The RPA average per-generation survival rate represents a 24% increase (1.24 survival multiplier) from the base survival rate for the Wenatchee spring chinook population.

Table 9.7-8. Wenatchee River Spring Chinook Life-Stage Survival and Harvest Rate Estimates, 1980 to 1994 Brood Year Base and Hydrosystem Measures of the Reasonable and Prudent Alternative (RPA) Leslie Matrices

			Low Delayed Mortality Assumption		High Delayed Mortality Assumption										
UCR spring Chinook - Wenatchee	Mean Egg-to-Smolt Survival	Mean Non-Fed. Juvenile Hydro Survival	Mean Juvenile FCRPS Hydro Survival (including delayed effects)	Mean Non-Hydro Estuary/ Early Ocean Survival	Mean Juvenile FCRPS Hydro Survival (including delayed effects)	Mean Non-Hydro Estuary/ Early Ocean Survival	Mean Total Fed. and Non-Fed. Juvenile Survival	Mean Ocean Exploi-tation Rate	Mean Ocean Non-Harvest Survival Rate (Multiply [1-exp. Rate] for total O2+ ocean survival)	Mean Inriver Harvest Rate	Mean Adult FCRPS Passage Survival Rate	Mean Adult Non-Fed. Passage Survival Rate	Mean Upper Dam to Spawn-ing Survival Rate	Mean Egg-to-Adult Survival Rate	Mean Adult-to-Adult Return
Base	0.050	0.662	0.707	0.030	0.194	0.111	0.014	0.000	0.583	0.088	0.891	0.860	0.900	**0.00030**	**0.651**
RPA	0.53	0.804	0.660	0.030	0.181	0.111	0.016	0.000	0.583	0.088	0.955	0.860	0.900	**0.00038**	**0.832**

Note: Implementation of the proposed Mid-Columbia HCP is also included. All non-bold survival rates were estimated through methods described in **Section 6.1.2** and **Appendix C** and input to the matrix, with one exception. Mean non-hydro smolt survival was adjusted to other elements of the base matrix and to mean 1980 to 1994 ln(recruits/spawner) estimates. **Bold** survival rates are summary statistics derived from the other survival rates.

The estimated change in base to RPA population growth rate was then compared with the changes needed to reduce risk to levels associated with the jeopardy standard indicator metrics, as described above for SR spring/summer chinook salmon. Table 9.7-9 displays the additional improvements in survival needed, beyond the level of survival expected from the RPA and implementation of the HCP, to reduce extinction risk to 5% and increase the likelihood of recovery to 50%. Interpretation of values above and below 1.0 is as described above for SR spring/summer chinook salmon. Estimates were made for best- and worst-case assumptions. Definitions of these cases were the same as those described above for SR spring/summer chinook salmon.

Table 9.7-9. Wenatchee River Spring Chinook Estimated Range of Per-Generation Survival Improvements

Population	5% extinct, 100 years	5% extinct, 24 years	50% Recovery 48 years	50% Recovery 100 years	Natural River
Wenatchee					
Best Case	1.13	0.80	1.73	1.63	1.31
Worst Case	2.53	1.20	3.79	3.22	4.78

Note: These improvements are needed to satisfy five jeopardy standard indicator metrics, given implementation of the hydrosystem measures of the RPA and implementation of the proposed Mid-Columbia HCP. Numbers less than or equal to 1.0 indicate that additional survival improvements are not necessary. Numbers greater than 1.0 are the necessary survival multipliers. See the text for details and definition of best and worst case.

Under the best-case assumptions, the survival rate expected from the RPA and HCP, coupled with expected survival in other life stages, results in 5% or less risk of extinction in 24 years. However, additional survival improvements, ranging from 13 to 73% (1.13 to 1.73 survival multipliers) are needed to reduce the likelihood of extinction in 100 years to 5% and to result in at least a 50% likelihood of recovery for Wenatchee River spring chinook. Under the worst-case assumptions, additional survival improvements ranging from 20 to 274% (1.20 to 3.79 survival multipliers) would be necessary to reduce extinction risk and increase the likelihood of recovery for this population.

9.7.2.2.2 Full Mitigation Component of the Jeopardy Standard. As described in Section 6.1.2, a metric indicative of the full mitigation component of the jeopardy standard is NMFS' best estimate of the natural survival rate of juveniles and adults that would occur without the FCRPS. In the case of UCR spring chinook, the river reach of interest extends from the head of McNary pool to Bonneville Dam. The estimate of natural survival through this reach is approximately 86.5% for juveniles, 95.5% for adults, and 82.6% for the combination of juvenile and adult survival.

As described in Table 9.7-7, the high estimate of juvenile FCRPS survival (as described above, including indirect effects) associated with the RPA is 66%, while the low estimate is 18.1%. The estimate of adult survival is 95.5%, which leads to 17.3 to 63.0% combined juvenile and adult survival when moving through the Federal hydrosystem.

The estimated survival when moving through the Federal hydrosystem under the RPA is clearly lower than that estimated to occur in the absence of the FCRPS. Table 9.7-9 describes the additional change in passage survival (including indirect effects) needed to meet NMFS' estimate of natural survival. The additional survival improvement ranges from 31% (1.31 survival multiplier) for the high survival estimate to 378% (4.78 survival multiplier) for the low survival estimate.

9.7.2.2.3 Consideration of All Components of the Jeopardy Standard. For the Wenatchee River UCR spring chinook population, the incremental change in survival needed to meet the natural survival indicator metric is lower than that needed to achieve the risk levels associated with the survival and recovery indicator metrics under the best-case assumptions. Based on the construction of the jeopardy standard described in Section 1.3.1.1, the full mitigation component is relevant for evaluating effects of the RPA. Based on this indicator metric, at least a 31% improvement in survival would be needed in addition to the effects of the RPA and implementation of the HCP. Under the worst-case assumptions, the natural survival indicator metric is lower, and at least a 378% improvement in survival (4.78 multiplier) is needed.

9.7.2.3 Snake River Fall Chinook Salmon

Evaluation of species-level effects of the proposed action requires placing the action-area effects in the context of the full life cycle. The factors described in Section 9.7.1 affect elements of critical habitat and the survival and recovery of SR fall chinook salmon in the action area. Additional factors (summarized in Myers et al. 1998, Section 4.1, and Appendix A) limit this ESU over its full range. Specifically, almost all of the historical spawning habitat in the Snake River basin is blocked by the Hells Canyon Complex. Other irrigation and hydroelectric projects block access to habitat in tributaries to the Columbia River below Hells Canyon. Habitat quality is degraded by agricultural water withdrawals, grazing, vegetation management, and forestry and mining practices (lack of pools, high temperatures, low flows, poor overwintering conditions, and high sediment loads).

In this section, NMFS evaluates quantitatively the action-area effects associated with the proposed action and the effects of human activities affecting survival in other parts of the life cycle.

9.7.2.3.1 Survival and Recovery Components of the Jeopardy Standard. NMFS used a Leslie matrix (Section 6.1.2) to evaluate the RPA relative to the jeopardy standard indicator (Sections 1.3.1.1 and 6.1.2). The matrix analysis incorporated the survival rates in other life stages that NMFS expects to result from likely actions described in the All-H Paper. One matrix was developed for the SR fall chinook ESU. The Snake River Salmon Proposed Recovery Plan (NMFS 1995) indicated that this ESU is composed of a single population, so this analysis represents the entire ESU.

As described in Section 6.1.2, the elements of the Leslie matrix were first parameterized to reflect, as closely as possible, the average survival rates that influenced the 1980 to 1991 brood years, represented by adult returns through 1996 (base matrix). The base matrix used in this evaluation was identical to that described in Section 6.3.1.3.

NMFS changed juvenile and adult passage survival rates to reflect effects of the hydrosystem measures in the reasonable and prudent alternative, changed harvest rates to reflect new exploitation rates implemented since 1993, and generated a new RPA matrix. Tables 9.7-5, 9.7-6, and 9.7-7 show smolt and adult survival estimates. High and low estimates of juvenile passage survival were the same as those described in Section 6.3.1.3. Section 6.3.1.3 also describes expected ocean and inriver harvest rates. A new equilibrium rate of annual population growth was then estimated from the RPA matrix and compared to the base population growth rate.

Table 9.7-10 shows estimates of survival rates included in the base and RPA matrices. The RPA average per-generation survival rate represents a 114% increase (2.14 survival multiplier) from the base survival rate for SR fall chinook.

Table 9.7-10. Snake River Fall Chinook Life-stage Survival and Harvest Rate Estimates, 1980 to 1991 Brood Year Base and RPA Leslie Matrices

	High Delayed Mortality Assumption		Low Delayed Mortality Assumption								
Snake River Fall Chinook	**Mean Juvenile FCRPS Hydro Survival (including delayed effects)**	**Mean Non-Hydro Combined Egg-to-Smolt and Estuary/Early Ocean Survival**	**Mean Juvenile FCRPS Hydro Survival (including delayed effects)**	**Mean Non-Hydro Combined Egg-to-Smolt Estuary/Early Ocean Survival**	**Mean Ocean Exploitation Rate**	**Mean Ocean Non-Harvest Survival Rate (Multiply [1-exp. Rate] for total O2+ ocean survival)**	**Mean Inriver Harvest Rate**	**Mean Adult FCRPS Passage Survival Rate**	**Mean Upper Dam to Spawning Survival Rate**	**Mean Egg-to-Adult Survival Rate**	**Mean Adult-to-Adult Return**
Base	0.082	0.056	0.101	0.046	0.170	0.412	0.315	0.607	0.900	**0.00059**	**0.850**
RPA	0.110	0.056	0.135	0.046	0.121	0.498	0.174	0.721	0.900	**0.00126**	**1.818**

Note: All non-bold survival rates were estimated through methods described in Section 6.1.2 and Appendix C and input to the matrix, with two exceptions. Mean first-year survival was adjusted to other elements of the base matrix and to mean 1980 to 1991 ln(recruits/spawner) estimates. Smolt survival during the first year was estimated independently, as described above, and the non-hydro first-year survival (including egg-to-smolt and estuary/early ocean survival) was the survival remaining after accounting for total base smolt survival and base hydro passage survival. **Bold** survival rates are summary statistics derived from the other survival rates.

NMFS then compared the estimated change in base to RPA population growth rate with the changes needed to reduce risk to levels associated with the jeopardy standard indicator metrics, as described above for SR spring/summer chinook salmon. Table 9.7-11 displays the additional improvements in survival needed, beyond the level of survival expected from the RPA and continuation of harvest reductions, to reduce extinction risk to 5% and increase the likelihood of recovery to 50%. Interpretation of values above and below 1.0 is as described above for SR spring/summer chinook salmon. Estimates were made for best- and worst-case assumptions. Definitions of these cases were the same as those described above for SR spring/summer chinook salmon.

Table 9.7-11. Snake River Fall Chinook Estimated Range of Per-Generation Survival Improvements Needed to Satisfy Five Jeopardy Standard Indicator Metrics, Given Implementation of the RPA

Population	5% extinct, 100 years	5% extinct, 24 years	50% Recovery 48 years	50% Recovery 100 years	Natural River
Snake River					
Best Case	0.86	0.47	1.19	1.07	3.48
Worst Case	2.66	1.19	3.56	3.21	4.04

Numbers less than, or equal to, 1.0 indicate that additional survival improvements are not necessary. Numbers greater than 1.0 are the necessary survival multipliers. See text for details and definition of best and worst case.

Under the best-case assumptions, the survival rate expected from the RPA and continuation of low harvest rates, coupled with expected survival in other life stages, results in 5% or less risk of extinction in 24 and 100 years. However, additional survival improvements, ranging from 7 to 19% (1.07 to 1.19 survival multipliers) are needed to result in at least a 50% likelihood of recovery for SR fall chinook. Under the worst-case assumptions, additional survival improvements ranging from 19 to 256% (1.19 to 3.56 survival multipliers) would be necessary to reduce extinction risk and increase the likelihood of recovery for this ESU.

9.7.2.3.2 Full Mitigation Component of the Jeopardy Standard. As described in Section 6.1.2, a metric indicative of the full mitigation component of the jeopardy standard is NMFS' best estimate of the natural survival rate of juveniles and adults that would occur without the FCRPS. The estimate of natural survival of juveniles through free-flowing river reaches was estimated using two alternative PATH methods (Peters et al. 1999). NMFS considers both methods equally valid; therefore, a range of natural survival estimates is evaluated for this ESU (Section 4, Appendix C). The estimate of juvenile survival when moving through the hydrosystem reach under natural conditions ranges from 32 to 77%, depending upon the method. Adult survival is estimated as 72%, and the combined juvenile and adult natural survival rate is 45.4 to 64.9%.

As described in Table 9.7-10, the high estimate of juvenile survival (including indirect effects)10 associated with the RPA is 13.5%, while the low estimate is 11.0%. The estimate of adult survival is 72.1%, which leads to 7.9 to 9.7% combined juvenile and adult survival when moving through the hydrosystem.

The estimated survival when moving through the hydrosystem under the RPA is clearly lower than that estimated to occur without the FCRPS. Table 9.7-11 describes the additional change in passage survival (including indirect effects) needed to meet NMFS' estimate of natural survival. The additional survival improvement ranges from 248% (3.48 multiplier) for the high survival estimate to 304% (4.04 multiplier) for the low survival estimate.

9.7.3.3.3 Consideration of All Components of the Jeopardy Standard. For SR fall chinook salmon, the incremental change in survival needed to meet the survival and recovery indicator risk metrics is lower than that needed to achieve a natural survival rate through the FCRPS. Based on the construction of the jeopardy standard described in Section 1.3.1.1, the survival and recovery components of the jeopardy standard are relevant for evaluating effects of the RPA. Based on these indicator metrics, at least an additional 19% improvement in survival would be needed in addition to the effects of the RPA and the continuation of recent low harvest rates.

9.7.2.4 Snake River Steelhead

Evaluation of species-level effects of the proposed action requires placing the action-area effects in the context of the full life cycle. The factors described in Section 9.7.1 affect elements of critical habitat and the survival and recovery of UCR spring chinook salmon in the action area. Additional factors (summarized in Section 4.1 and Appendix A) limit this ESU over its full range. Hydrosystem projects create several substantial habitat blockages in this ESU; the major ones are the Hells Canyon Dam complex (mainstem Snake River) and Dworshak Dam (North Fork Clearwater River). Minor blockages are common throughout the region. Steelhead spawning areas have been degraded by overgrazing, as well as by historical gold dredging and sedimentation due to poor land management. Hatchery fish are widespread and stray to spawn naturally throughout the region. In the 1990s, an average of 86% of adult steelhead passing Lower Granite Dam were of hatchery origin. However, hatchery contribution to naturally spawning populations varies across the region; some stocks are dominated by hatchery fish, whereas others are composed of all wild fish.

In this section, NMFS evaluates quantitatively the action-area effects associated with the proposed action and the effects of human activities affecting survival in other parts of the life cycle.

9.7.2.4.1 Survival and Recovery Components of the Jeopardy Standard. NMFS could not construct a Leslie matrix (Section 6.1.2) for SR steelhead at this time. It therefore conducted a simple incremental analysis and applied it to aggregate A-Run and aggregate B-Run SR steelhead. This analysis estimates expected proportional changes in average survival from the base (1980 brood year through approximately 1992 brood year [1997 returns]) to the survival rate associated with the RPA, without attempting to estimate survival rates through the entire life cycle. The analysis focuses only on those life-stage survival rates likely to have changed from base to RPA conditions.

CRI (McClure et al. 2000) estimated the needed change in annual population growth rate (lambda) with respect to each survival metric, and these data are presented in Section 4 and Appendix A. When converted to changes in per-generation survival, the needed changes from average 1980 to 1992 brood survivals range from 242 to 51,453% (3.42 to 515.53 survival multipliers), depending upon metric, run, and hatchery effectiveness assumption. NMFS has not proposed recovery abundance levels for this ESU, so evaluation of the recovery metric was not possible at this time.

Two survival rates appear to have changed from the average 1980 to 1992 brood survivals to current conditions. Harvest rates declined in the early 1990s, compared to average harvest rates during the base period (TAC 2000 - Beamesderfer 2/24/00 tables). Section 6.3.4 describes estimates of the proportional reductions. Juvenile passage survival probably was lower, on average, during the migration years associated with the 1980 to 1992 brood stocks than the estimate under the RPA. Section 9.7.1 contains estimates of juvenile passage survival for the RPA, but no estimates of average juvenile survival during the base period are available. For reasons described in Section 6.3.4, NMFS estimated that the proportional change in juvenile SR steelhead survival from the base to current (proposed action) condition equals the proportional change estimated for SR spring/summer chinook salmon (19%; 1.19 survival multiplier). To evaluate effects of the RPA, the change in survival from that expected under the proposed action to that expected from the RPA was estimated based on information in Section 9.7.1.

As in Section 6.3.4, two estimates of total (direct and indirect) juvenile passage survival were included explicitly in the current matrix and implicitly in the base matrix. Each represented an average of the 0.52 to 0.58 range of differential delayed mortality (D) estimates described in Section 6.2. The high and low juvenile passage survival estimates differed only in the treatment of delayed mortality of non-transported fish. Under the low delayed mortality assumption, no post-Bonneville mortality of non-transported fish was attributed to the hydrosystem. Under the high delayed mortality assumption, post-Bonneville mortality attributed to the hydrosystem was assumed to be no higher than that estimated for SR spring/summer chinook salmon (0.709 to 0.743).

Table 9.7-12 shows estimates of survival rates included in the incremental analysis. The average per-generation survival rate under the RPA represents a 40% increase (1.40 survival multiplier) from the base survival rate for A-Run steelhead and a 46% increase (1.46 survival multiplier) from the base survival rate for B-Run steelhead.

Table 9.7-12. Snake River Steelhead Juvenile and Adult Passage Survival and Harvest Rate Estimates 1980 to 1992 Brood Year Base Period and the RPA

		Low Delayed Mortality Assumption		High Delayed Mortality Assumption								
Snake River Steelhead	Mean Egg-to-Smolt Survival	Mean Juvenile FCRPS Hydro Survival (including delayed effects)	Mean Non-Hydro Estuary/Early Ocean Survival	Mean Juvenile FCRPS Hydro Survival (including delayed effects)	Mean Non-Hydro Estuary/Early Ocean Survival	Mean Ocean Exploitation Rate	Mean Ocean Non-Harvest Survival Rate (Multiply [1-exp. Rate] for total O2+ ocean survival)	Mean Inriver Harvest Rate	Mean Adult FCRPS Passage Survival Rate	Mean Upper Dam to Spawning Survival Rate	Mean Egg-to-Adult Survival Rate	Mean Adult-to-Adult Return
Base												
A-Run	N/A	0.391	N/A	0.107	N/A	0.000	1.00	0.137	0.796	0.90	N/A	N/A
B-Run	N/A	0.391	N/A	0.107	N/A	0.000	1.00	0.259	0.796	0.90	N/A	N/A
RPA												
A-Run	N/A	0.496	N/A	0.136	N/A	0.000	1.00	0.107	0.851	0.90	N/A	N/A
B-Run	N/A	0.496	N/A	0.136	N/A	0.000	1.00	0.201	0.851	0.90	N/A	N/A

Note: This information is used in an analysis of proportional changes in these specific life-stage survival rates.

The estimated change in base to RPA population growth rate was then compared with the changes needed to reduce risk to levels associated with the jeopardy standard indicator metrics, as described above for SR spring/summer chinook salmon. Table 9.7-13 displays the additional improvements in survival needed, beyond the level of survival expected from the RPA and continuation of harvest reductions, to reduce extinction risk to 5%. Interpretation of values above and below 1.0 is as described above for SR spring/summer chinook salmon. Estimates were made for best- and worst-case assumptions. Definitions of these cases were the same as those described above for SR spring/summer chinook salmon.

Table 9.7-13. Snake River Steelhead Estimated Range of Per-Generation Survival Improvements Needed to Satisfy Five Jeopardy Standard Indicator Metrics, Given Implementation

Snake River Steelhead	5% extinct, 100 years	5% extinct, 24 years	50% Recovery 48 years	50% Recovery 100 years	Natural River
A-Run					
Best Case	8.08	2.44	N/A	N/A	1.35
Worst Case	240.22	71.95	N/A	N/A	4.91
B-Run					
Best Case	10.21	3.28	N/A	N/A	1.35
Worst Case	352.92	104.50	N/A	N/A	4.91

Note: Numbers less than or equal to 1.0 indicate that additional survival improvements are not necessary. Numbers greater than 1.0 are the necessary survival multipliers. See the text for details and definition of best and worst case.

Under both the best- and worst-case assumptions, survival improvements in addition to those resulting from the survival rate expected from the RPA and continuation of low harvest rates are necessary to reduce the likelihood of extinction to 5% or less. The magnitude of the necessary change ranges from 144 to 35,292% (2.44 to 352.92 survival multipliers), depending on metric and assumption. The main factor influencing these results is the assumption regarding hatchery effectiveness. Very high survival improvements are needed if hatchery spawner effectiveness is 80%.

9.7.3.4.2 Full Mitigation Component of the Jeopardy Standard. As described in Section 6.1.2, a metric indicative of the full mitigation component of the jeopardy standard is NMFS' best estimate of the natural survival rate of juveniles and adults that would occur without the FCRPS. The estimate of juvenile survival through the hydrosystem reach under natural conditions is approximately 84%, adult survival is estimated as 85%, and the combined juvenile and adult natural survival rate is 71.3%.

As described in Table 9.7-12, the high estimate of juvenile survival (as described above, including indirect effects) associated with the RPA is 49.6%, while the low estimate is 13.6%. The estimate of adult survival is 85.1%, which leads to 11.6 to 42.2% combined juvenile and adult survival when moving through the hydrosystem.

The estimated survival when moving through the hydrosystem under the RPA is clearly lower than that estimated to occur without the FCRPS. Table 9.7-13 describes the additional change in passage survival (including indirect effects) needed to meet NMFS' estimate of natural survival. The additional survival improvement ranges from 35% (1.35 multiplier) for the high survival estimate to 391% (4.91 multiplier) for the low survival estimate.

9.7.2.4.3 Consideration of All Components of the Jeopardy Standard. For the SR steelhead, the incremental change in survival needed to achieve a natural survival rate through the FCRPS is lower than that needed to meet the survival and recovery indicator risk metrics. Based on the construction of the jeopardy standard described in Section 1.3.1.1, the full mitigation component is relevant for evaluating effects of the RPA. Based on this indicator metric, a minimum of an additional 35% improvement in survival would be needed in addition to the effects of the RPA and the continuation of recent low harvest rates.

9.7.2.5 Upper Columbia River Steelhead

9.7.2.5.1 Survival and Recovery Components of the Jeopardy Standard. NMFS used a Leslie matrix (Section 6.1.2) to evaluate the proposed action relative to the jeopardy standard indicator (Sections 1.3.1.1 and 6.1.2). The matrix analysis incorporated the survival rates in other life stages that NMFS expects to result from likely actions described in the All-H Paper. One matrix was developed for the Methow population of UCR steelhead ESU. The Methow population was chosen as an indicator of effects of the proposed action on the ESU because, of the three populations tentatively identified as comprising this ESU (Ford et al. 2000), it requires the greatest change in survival to recover and avoid extinction (Cooney et al. 2000; McClure et al. 2000). Ford et al. (2000) identified interim recovery goals and recommended that all three UCR steelhead populations meet these goals for delisting. Therefore, the population requiring the greatest change (Methow River) is the critical population for this analysis.

As described in Section 6.1.2 and 6.3.5, the elements of the Leslie matrix were first parameterized to reflect, as closely as possible, the average survival rates that influenced the 1980 to 1994 brood year returns (base matrix). The base matrix used in this evaluation was identical to that described in Section 6.3.5.

NMFS then changed four survival rates to reflect effects of the RPA and expected future survival improvements at the PUD projects as a result of the proposed Mid-Columbia HCP. The All-H Paper identified implementation of the HCP as an element of recovery planning likely to occur and that is, therefore, included in the analysis, consistent with Step 4 of the jeopardy analysis framework described in Section 1.3. Egg-to-smolt and juvenile survival through the three PUD projects were both increased from the base matrix estimates to reflect the survival rates anticipated in the proposed HCP. Juvenile and adult survival through the four FCRPS projects was modified to reflect the expected survival rates described in Section 9.7.2 (Tables 9.7-5 and

9.7-6). A new equilibrium rate of annual population growth was then estimated from the current matrix and compared to the base population growth rate.

As in the analysis of the proposed action in Section 6.3.5, the base and the current matrices both contained two estimates of total (including direct and indirect) juvenile passage survival. Each represented a historical differential delayed mortality (D) estimate of 1.0 from McNary dam, based on historical McNary transportation studies (Cooney et al. 2000; studies reviewed in NMFS 2000x - transportation white paper). For the RPA, only a small fraction of the run is transported, so an estimate of current D is not relevant for this ESU. Like SR spring/summer chinook salmon, the high and low juvenile passage survival estimates differed only in their treatment of delayed mortality of non-transported fish. Under the high assumption, no post-Bonneville mortality of non-transported fish was attributed to the hydrosystem. Under the low assumption, post-Bonneville mortality attributed to the hydrosystem was assumed to be no higher than that estimated for SR spring/summer chinook salmon (0.709-0.743).

Table 9.7-14 displays estimates of survival rates that were included in the base and RPA matrices. The average per-generation survival rate expected to result from the RPA represents a 37% change (1.37 survival multiplier) from the base survival rate for the Methow steelhead population.

Table 9.7-14. Methow River Steelhead Life-stage Survival and Harvest Rate Estimates, 1980 to 1994 Brood Year Base and RPA Leslie Matrices

			High Delayed Mortality Assumption		Low Delayed Mortality Assumption										
UCR spring Chinook - Wenatchee	**Mean Egg-to-Smolt Survival**	**Mean Non-Fed. Juvenile Hydro Survival**	**Mean Juvenile FCRPS Hydro Survival (including delayed effects)**	**Mean Non-Hydro Estuary/ Early Ocean Survival**	**Mean Juvenile FCRPS Hydro Survival (including delayed effects)**	**Mean Non-Hydro Estuary/ Early Ocean Survival**	**Mean Total Fed. and Non-Fed. Juvenile Survival**	**Mean Ocean Exploi-tation Rate**	**Mean Ocean Non-Harvest Survival Rate (Multiply [1-exp. Rate] for total O2+ ocean survival)**	**Mean Inriver Harvest Rate**	**Mean Adult FCRPS Passage Survival Rate**	**Mean Adult Non-Fed. Passage Survival Rate**	**Mean Upper Dam to Spawn-ing Survival Rate**	**Mean Egg-to-Adult Survival Rate**	**Mean Adult-to-Adult Return**
Base	0.038-0.063	0.550	0.190	0.113-0.240	0.692	0.031-0.065	0.012-0.025	0.000	0.668	0.110	0.892	0.859	0.900	**0.00018-0.00064**	**0.461-1.607**
Current (Proposed Action)	0.042-0.069	0.690	0.182	0.113-0.290	0.664	0.031-0.065	0.014-0.030	0.000	0.668	0.110	0.922	0.859	0.900	**0.00025-0.00088**	**0.632-2.203**

Note: All non-bold survival rates were estimated through methods described in **Section 6.1.2** and **Appendix C** and input to the matrix, with one exception. Mean non-hydro smolt survival was adjusted to other elements of the base matrix and to mean 1980 to 1994 ln (recruits/spawner) estimates. **Bold** survival rates are summary statistics derived from the other survival rates.

The estimated change in base-to-RPA population growth rate was then compared to the changes needed to reduce risk to levels associated with the jeopardy standard indicator metrics, as described above for SR spring/summer chinook salmon. For Methow River steelhead, the range of necessary survival improvements included those both CRI (McClure et al. 2000) and QAR (Cooney et al. 2000) estimated. Table 9.7-15 displays the additional improvements in survival needed, beyond the level of survival expected from the proposed action and implementation of the HCP, to reduce extinction risk to 5% and increase the likelihood of recovery to 50%. Interpretation of values above and below 1.0 is the same as those described above for SR spring/summer chinook salmon. Estimates were made for best- and worst-case assumptions. Definitions of these cases were the same as those described above for SR spring/summer chinook salmon.

Table 9.7-15. Methow River Steelhead Estimated Range of Per-Generation Survival Improvements

Population	5% extinct, 100 years	5% extinct, 24 years	50% Recovery 48 years	50% Recovery 100 years	Natural River
Methow Steelhead					
Best Case	1.57	0.73	1.13	1.13	1.36
Worst Case	36.73	14.85	54.93	48.70	4.97

Note: These improvements are needed to satisfy five jeopardy standard indicator metrics, given implementation of the proposed action. Numbers less than or equal to 1.0 indicate that additional survival improvements are not necessary. Numbers greater than 1.0 are the necessary survival multipliers. See the text for details and definition of best and worst case.

Under the best-case assumptions, the survival rate expected from the RPA and the HCP, coupled with expected survival in other life stages, results in 5% or less risk of extinction for the 24-year extinction metric. However, additional survival improvements ranging from 13 to 57% (1.13 to 1.57 survival multipliers) are needed for all four metrics. Under worst-case assumptions, additional survival improvements, ranging from 1,385 to 5,393% (14.85 to 54.93 survival multipliers) are needed.

9.7.2.5.2 Full Mitigation Component of the Jeopardy Standard. As described in Section 6.1.2, a metric indicative of the full mitigation component of the jeopardy standard is NMFS' best estimate of the natural survival rate of juveniles and adults that would occur without the FCRPS. In the case of UCR steelhead, the river reach of interest extends from the head of the McNary pool to Bonneville Dam. The estimate of natural survival through this reach is approximately 90.7% for juveniles, 92.2% for adults, and 83.6% for the combined juvenile and adult survival.

As described in Table 9.7-14, the high estimate of FCRPS juvenile survival (including indirect effects) associated with the proposed action is 66.4%, while the low estimate is 18.2%. The estimate of adult survival is 92.2%, which leads to 16.8 to 61.2% combined juvenile and adult survival when moving through the hydrosystem.

The estimated survival when moving through the hydrosystem under the proposed action is clearly lower than that estimated to occur in the absence of the FCRPS. Table 9.7-15 describes the additional change in passage survival (including indirect effects) needed to meet NMFS' estimate of natural survival. The additional survival improvement ranges from 36% (1.36 survival multiplier) for the high survival estimate to 397% (4.97 survival multiplier) for the low survival estimate.

***9.7.2.5.3 Consideration of All Components of the Jeopardy Standard*.** For the Metlow River UCR steelhead population, the incremental change in survival needed to meet the natural survival indicator metrics is lower than that needed to achieve the risk levels associated with the survival and recovery indicator metrics under the best-case assumptions. Based on the construction of the jeopardy standard described in Section 1.3.1.1, the full mitigation component of the jeopardy standard is relevant for evaluating effects of the proposed action. Based on this indicator metric, survival would have to increase between 36% and 397%.

9.7.2.6 Summary of Findings for Middle and Lower River ESUs and Sockeye Salmon

As described in Section 6.3.13.1, a large number of factors affect current populations trends of Columbia basin salmonids. The hydro actions in the RPA address mortality in the action area. Actions in habitat, harvest, and hatcheries address human-caused factors limiting survival and recovery elsewhere in the life cycle. For example, habitat actions include protecting productive habitat, restoring tributary flows, screening and combining water diversions, reducing passage obstructions, and improving or restoring degraded habitat (Table 9.7-16). The Federal agencies will focus these near-term actions on a set of three priority subbasins for each ESU. Hatchery reforms expected to reduce adverse interactions with wild fish include developing new, local broodstocks (and eliminating inappropriate broodstocks) and managing the number of hatchery fish allowed to spawn naturally. The harvest actions will cap harvest rates at recent levels, allowing time for other recovery measures to take effect.

Each set of actions is expected to benefit Columbia basin salmonids, although clearly measures that address hydrosystem passage will benefit the upper river chinook salmon and steelhead ESUs, discussed in Sections 9.7.2.1 through 9.7.2.5, SR sockeye salmon, and MCR steelhead more than they will benefit the lower river ESUs. In the short term, benefits to the lower river ESUs will result primarily from the habitat, harvest, and hatchery actions. In the long term, ongoing studies may link the effects of FCRPS flow management to elements of critical habitat in the estuary and plume. These studies may lead to additional hydro actions (i.e., through the comprehensive 5- and 8-year checkins (Section 9.1.5) that provide high survival benefits to all 12 ESUs.

Table 9.7-16. Summary of Expected Effects of the RPA on Critical Habitat at the Species-level. Effects in the Action Area Shown in **Bold**. Effects of Offsite Mitigation Shown in *Italics*.

ESU	Juv Rearing Areas	Juv Migration Corridors	Areas - Growth/Develop	Adult Migration Corridor	Spawning Habitat
SR spr/sum chinook	*In 3 priority subbasins:* *- protect productive habitat* *- address flow, passage, and screening problems* *- improve/restore degraded habitat*	**Inriver migrants:** **- deflector optimization improves water quality (dissolved gas) during involuntary spill** **- inriver survival increases by ~9% due to passage improvements at 8 FCRPS projects** **- expected 10% reduction in reservoir mortality due to predator control actions and reduced delay** **- potential for reduced delayed mortality due to FCRPS passage** **Transported fish: - potential for reduced delayed mortality** *- hatchery reforms may reduce adverse interactions with wild fish*	**- potential habitat degradation in the plume** *- hatchery reforms may reduce adverse interactions with wild fish* *- potential reduction in incidental take to reduce ocean harvest*	**- expected 6% increase in survival during passage through 8 FCRPS projects** **- deflector optimization improves water quality (dissolved gas) during involuntary spill** **- potential indirect improvement in spawning rate success** *- potential reduction in incidental take to reduce mainstem harvest*	*In 3 priority subbasins:* *- protect productive habitat* *- address flow, passage, and screening problems* *- improve/restore degraded habitat*

ESU	Juv Rearing Areas	Juv Migration Corridors	Areas - Growth/Develop	Adult Migration Corridor	Spawning Habitat
SR fall chinook	**<u>Inriver</u> migrants:** **- flows and water quality (temperature) improve during summer and early fall in the Snake River due to additional cold water releases from Dworshak Reservoir** **- inriver survival increases by ~5% due to passage improvements at 8 FCRPS projects** **- expected 10% reduction in reservoir mortality due to predator control actions and increased summer flows** **- potential for reduced delayed mortality due to FCRPS passage** **<u>Transported</u> fish:** **-improved transportation due to extended barging** **-potential for reduced delayed mortality** *- hatchery reforms may reduce adverse interactions with wild fish*		*- acquire, protect, and restore high quality estuarine habitat* *- hatchery reforms may reduce adverse interactions with wild fish* *- potential reduction in incidental take to reduce ocean harvest*	**-expected 11% increase in survival during passage through 8 FCRPS projects** **- water quality (temperature) improves during summer and early fall in the Snake River due to additional cold water releases from Dworshak Reservoir** **- potential indirect improvement in spawning rate success** *- potential reduction in incidental take to reduce mainstem harvest*	**- unknown effects of flow management on use of spawning habitat below Lower Granite, Little Goose, and Ice Harbor dams** *In 3 priority subbasins:* *- protect productive habitat* *- address flow, passage, and screening problems* *- improve/restore degraded habitat* *- hatchery reforms may reduce adverse interactions with wild fish*

ESU	Juv Rearing Areas	Juv Migration Corridors	Areas - Growth/Develop	Adult Migration Corridor	Spawning Habitat
UCR spring chinook	*In 3 priority subbasins:* *- protect productive habitat* *- address flow, passage, and screening problems* *- improve/restore degraded habitat*	**- deflector optimization improves water quality (dissolved gas) during involuntary spill** **- inriver survival increases by ~9% due to passage improvements at 4 FCRPS projects** **- expected 10% reduction in reservoir mortality due to predator control actions and reduced delay** **- potential for reduced delayed mortality due to FCRPS passage** - mortality due to passage past up to 5 PUD projects *- hatchery reforms may reduce adverse interactions with wild fish*	**- potential habitat degradation in the plume** *- hatchery reforms may reduce adverse interactions with wild fish*	**- expected 3% increase in survival during passage through 4 FCRPS projects** **- deflector optimization improves water quality (dissolved gas) during involuntary spill** **- potential indirect improvement in spawning rate success** - mortality due to passage past up to 5 PUD projects *- potential reduction in incidental take to reduce mainstem harvest*	*In 3 priority subbasins:* *- protect productive habitat* *- address flow, passage, and screening problems* *- improve/restore degraded habitat*
UWR chinook	*In 3 priority subbasins:* *- protect productive habitat* *- address flow, passage, and screening problems* *- improve/restore degraded habitat*	**- deflector optimization improves water quality (dissolved gas) during involuntary spill**	*- acquire, protect, and restore high quality estuarine habitat* *- hatchery reforms may reduce adverse interactions with wild fish* *- potential reduction in incidental take to reduce ocean harvest*	*In 3 priority subbasins:* *- protect productive habitat* *- address flow, passage, and screening problems* *- improve/restore degraded habitat*	*In 3 priority subbasins:* *- protect productive habitat* *- address flow, passage, and screening problems* *- improve/restore degraded habitat*

ESU	Juv Rearing Areas	Juv Migration Corridors	Areas - Growth/Develop	Adult Migration Corridor	Spawning Habitat
LCR chinook	*In 3 priority subbasins:* *- protect productive habitat* *- address flow, passage, and screening problems* *- improve/restore degraded habitat*	**- deflector optimization improves water quality (dissolved gas) during involuntary spill** **- inriver survival increases by ~5% due to passage past Bonneville Dam for a limited number of subbasin populations**	*- acquire, protect, and restore high quality estuarine habitat* *- hatchery reforms may reduce adverse interactions with wild fish*	**- expected 1-2% increase in survival during passage past Bonneville Dam for a limited number of subbasin populations** **- deflector optimization improves water quality (dissolved gas) during involuntary spill**	**- access to and quantity and quality of habitat at Ives Island improved by FCRPS flows** *In 3 priority subbasins:* *- protect productive habitat* *- address flow, passage, and screening problems* *- improve/restore degraded habitat*
SR steelhead	*In 3 priority subbasins:* *- protect productive habitat* *- address flow, passage, and screening problems* *- improve/restore degraded habitat*	**Inriver migrants:** **- deflector optimization improves water quality (dissolved gas) during involuntary spill** **- inriver survival increases by ~9% due to passage improvements at 8 FCRPS projects** **- expected 10% reduction in reservoir mortality due to predator control actions and reduced delay** **- potential for reduced delayed mortality due to FCRPS passage** **Transported fish:** **- potential for reduced delayed mortality** *- hatchery reforms may reduce adverse interactions with wild fish*	**- potential habitat degradation in the plume**	**- expected 5-6% increase in survival during passage through 8 FCRPS projects** **- deflector optimization improves water quality (dissolved gas) during involuntary spill** **- potential indirect improvement in spawning rate success** *- potential reduction in incidental take to reduce mainstem harvest*	*In 3 priority subbasins:* *- protect productive habitat* *- address flow, passage, and screening problems* *- improve/restore degraded habitat*

ESU	Juv Rearing Areas	Juv Migration Corridors	Areas - Growth/Develop	Adult Migration Corridor	Spawning Habitat
UCR steelhead	*In 3 priority subbasins:* *- protect productive habitat* *- address flow, passage, and screening problems* *- improve/restore degraded habitat*	**- deflector optimization improves water quality (dissolved gas) during involuntary spill** **- Inriver survival increases by ~9% due to passage improvements at 4 FCRPS projects** **- expected 10% reduction in reservoir mortality due to predator control actions and reduced delay** **- potential for reduced delayed mortality due to FCRPS passage** - mortality due to passage past up to 5 PUD projects *- hatchery reforms may reduce adverse interactions with wild fish*	**- potential habitat degradation in the plume**	**- expected 3% increase in survival during passage through 4 FCRPS projects** **- deflector optimization improves water quality (dissolved gas) during involuntary spill** **- potential indirect improvement in spawning rate success** - mortality due to passage past up to 5 PUD projects *- potential reduction in incidental take to reduce mainstem harvest*	*In 3 priority subbasins:* *- protect productive habitat* *- address flow, passage, and screening problems* *- improve/restore degraded habitat*

ESU	Juv Rearing Areas	Juv Migration Corridors	Areas - Growth/Develop	Adult Migration Corridor	Spawning Habitat
MCR steelhead	*In 3 priority subbasins:* *- protect productive habitat* *- address flow, passage, and screening problems* *- improve/restore degraded habitat*	**- deflector optimization improves water quality (dissolved gas) during involuntary spill** **- Inriver survival increases by ~9% due to passage improvements at 4 FCRPS projects** **- expected 10% reduction in reservoir mortality due to predator control actions and reduced delay** **- potential for reduced delayed mortality due to FCRPS passage**	**- potential habitat degradation in the plume**	**- expected 3% increase in survival during passage through 4 FCRPS projects** **- deflector optimization improves water quality (dissolved gas) during involuntary spill** **- potential indirect improvement in spawning rate success** *- potential reduction in incidental take to reduce mainstem harvest*	*In 3 priority subbasins:* *- protect productive habitat* *- address flow, passage, and screening problems* *- improve/restore degraded habitat*
UWR steelhead	*In 3 priority subbasins:* *- protect productive habitat* *- address flow, passage, and screening problems* *- improve/restore degraded habitat*	**- deflector optimization improves water quality (dissolved gas) during involuntary spill** *- hatchery reforms may reduce adverse interactions with wild fish*	*- acquire, protect, and restore high quality estuarine habitat* *- hatchery reforms may reduce adverse interactions with wild fish*	**- deflector optimization improves water quality (dissolved gas) during involuntary spill** *- potential reduction in incidental take to reduce mainstem harvest*	*In 3 priority subbasins:* *- protect productive habitat* *- address flow, passage, and screening problems* *- improve/restore degraded habitat*

ESU	Juv Rearing Areas	Juv Migration Corridors	Areas - Growth/Develop	Adult Migration Corridor	Spawning Habitat
LCR steelhead	*In 3 priority subbasins:* *- protect productive habitat* *- address flow, passage, and screening problems* *- improve/restore degraded habitat*	**- deflector optimization improves water quality (dissolved gas) during involuntary spill** **- Inriver survival increases by ~4% due to passage improvements at Bonneville Dam for a limited number of subbasin populations**	**- potential habitat degradation in the plume** *- hatchery reforms may reduce adverse interactions with wild fish*	**- deflector optimization improves water quality (dissolved gas) during involuntary spill** **- expected 1% increase in survival during passage past Bonneville Dam for a limited number of subbasin populations** *- potential reduction in incidental take to reduce mainstem harvest*	*In 3 priority subbasins:* *- protect productive habitat* *- address flow, passage, and screening problems* *- improve/restore degraded habitat*
CR chum	*In 3 priority subbasins:* *- protect productive habitat* *- address flow, passage, and screening problems* *- improve/restore degraded habitat*	**- deflector optimization improves water quality (dissolved gas) during involuntary spill** **- Inriver survival increases by ~5% due to passage past Bonneville Dam for a limited number of subbasin populations**	*- acquire, protect, and restore high quality estuarine habitat*	**- expected 1-2% increase in survival during passage past Bonneville Dam for a limited number of subbasin populations** **- deflector optimization improves water quality (dissolved gas) during involuntary spill** *- potential reduction in incidental take to reduce mainstem harvest*	**- access to Hamilton Creek and Spring Channel improved by FCRPS flows** **- access to, quantity of, and quality of habitat at Ives Island improved by FCRPS flows** *In 3 priority subbasins:* *- protect productive habitat* *- address flow, passage, and screening problems* *- improve/restore degraded habitat*

ESU	Juv Rearing Areas	Juv Migration Corridors	Areas - Growth/Develop	Adult Migration Corridor	Spawning Habitat
SR sockeye	N/A	**Inriver migrants:** **- deflector optimization improves water quality (dissolved gas) during involuntary spill** **- survival increase due to passage improvements at 8 FCRPS projects** **- expected 10% reduction in reservoir mortality due to predator control actions** **- potential for reduced delayed mortality due to FCRPS passage** **Transported fish:** **- potential for reduced delayed mortality**	**- potential habitat degradation in the plume**	**- expected ~1% increase in survival during passage through 8 FCRPS projects** **- deflector optimization improves water quality (dissolved gas) during involuntary spill** *- potential reduction in incidental take to reduce mainstem harvest*	N/A

9.7.2.7 Summary of Quantitative Findings for Five ESUs

The metrics for assessing jeopardy described in Section 1.3.1.2 provide information on extinction risks and recovery probabilities and timeframes for recovery. A full mitigation metric is also described. NMFS considers the critical metric to be the survival improvement necessary to achieve either the highest of the four extinction/recovery metrics or the full mitigation standard, whichever is lower.

The tables in Sections 9.7.2.1 through 9.7.2.5 summarize all four metrics for each of the ESUs and populations analyzed. Table 9.7-17 summarizes the range of values for the critical metric for each ESU and population.

As described in Section 6.3.13, the minimum and maximum changes necessary under the base case depend on assumptions about the productivity of hatchery spawners and future ocean conditions. The effectiveness of hatchery spawners ranges from a high of 80% to a low of 20%. The estimated productivity of wild fish increases with decreases in the assumed effectiveness of hatchery spawning in the wild. For future ocean conditions, returns from 1980 to 1999 were used as the minimum value. The maximum value was returns for spring chinook ESUs from 1980 to 2004. Returns for 2000 through 2004 were estimated using 1) preliminary 2000 returns, 2) returns for 2001 projected from 2000 jack returns, and 3) for 2002 to 2004, revised averages for 1980 to present. Recent adult returns indicate higher ocean survival than for most other years of the base period. For the Upper Columbia ESUs, a range resulted from using two different analyses (CRI and QAR). Where differences between the two could not be reconciled, the lower and higher estimates from the methods were incorporated in the range.

For the full mitigation indicator metric, the minimum and maximum changes necessary under the base case depend on assumptions about the delayed mortality of non-transported smolts. An assumption of no delayed mortality given the minimum necessary survival change. The maximum change is associated with delayed, mortality assumed equal to the PATH “extra mortality” estimate, fully attributed to hydrosystem effects. (PATH also offered other potential causes).

Table 9.7-17 summarizes the expected survival change resulting from the RPA. NMFS incorporated changes in survival through some other life stages into the analysis to reflect ongoing and anticipated future actions. They include recent changes in harvest rates for SR steelhead, SR fall chinook, and UCR steelhead (projected by the All-H paper to continue into the future), and attainment of the survival standard in the proposed Mid-Columbia HCP.

Table 9.7-17. Summary of Quantitative Estimates of Effects of RPA on Achievement of Jeopardy Standard Indicator Metrics

Species ESU Stream	Critical Metric	Needed Survival Change: Minimum Estimate	Needed Survival Change: Maximum Estimate	Survival Change Expected from RPA[1]: Low Delayed Mortality	Survival Change Expected from RPA[1]: High Delayed Mortality	Additional Needed Survival Improvements: Low Estimate[2]	Additional Needed Survival Improvements: High Estimate[3]
Chinook Salmon							
Snake River Spring/Summer ESU							
Bear Valley Creek	48-recovery	1.20	1.30	1.30	1.30	0.92	1.05
Imnaha River	full mitigation	1.87	6.86	1.30	1.30	1.45	5.30
Johnson Creek	48-recovery	1.00	1.15	1.30	1.30	0.78	0.89
Marsh Creek	48-recovery	1.48	1.77	1.30	1.30	1.14	1.37
Minam River	full mitigation	1.87	6.86	1.30	1.30	1.45	5.30
Poverty Flats (S. Fork Salmon R.)	48-recovery	1.09	1.59	1.30	1.30	0.84	1.22
Sulphur Creek	100-extinction	1.41	1.84	1.30	1.30	1.09	1.42
Snake River Fall ESU	48-recovery	2.54	7.63	2.14	2.14	1.19	3.56
Upper Columbia River Spring-run ESU							
Wenatchee River	48-recovery	2.15	4.71	1.24	1.24	1.73	3.78
	full mitigation	1.31	4.78	1.00	1.00	1.31	4.78
Steelhead							
Upper Columbia River ESU							
Methow River	48-recovery	1.55	75.31	1.37	1.37	1.13	54.93
	full mitigation	1.36	4.94	0.99	0.99	1.36	4.97
Snake River ESU							
A-Run component	full mitigation	1.82	6.65	1.36	1.36	1.35	4.91
B-Run component	full mitigation	1.82	6.65	1.36	1.36	1.35	4.91

Note: Units are multipliers for changes in survival per generation. Numbers in "Needed Change" columns less than or equal to 1.0 indicate that additional survival improvements are not necessary. Numbers greater than 1.0 in these columns are the necessary survival multipliers.

1 Change in per-generation survival, except when referenced to "Full Mitigation." In that case, survival represents juvenile times adult passage survival, including any delayed effects.

2 Minimum estimate of needed survival change, coupled with high estimate of action effect.

3 Maximum estimate of needed survival change, coupled with low estimate of action effect.

The expected change in survival (either passage or per-generation, depending on the critical metric) ranges from -1% for UCR steelhead to 114% for SR fall chinook (Table 9.7-17). SR spring/summer chinook index stocks are expected to improve 30%, and UCR spring chinook are expected to improve 0 to 24%, depending upon the critical metric. The expected change in FCRPS passage survival is identical to the change in per-generation survival for SR spring/summer chinook because no changes in other life stages are expected. There is essentially no change in FCRPS passage survival for UCR stocks, although changes in per-generation survival are expected to be 24 to 36%. Sections 9.7.2.2 and 9.7.2.5 explain the low passage survival estimates.

Table 9.7-17 also summarizes additional survival changes that are needed to meet the critical metrics, after accounting for the proposed action and recovery measures described above. The lowest estimates of additional survival changes range from zero for three SR spring/summer chinook index stocks to 35% for SR steelhead. At least a 45% change in survival would be necessary for 80% of available SR spring/summer chinook index stocks to meet the critical metrics. These low estimates are based on the minimum estimate of the critical metric, coupled with the highest estimates of the survival change expected from the action. Note that, for the low estimate, the critical metric is full mitigation for UCR spring chinook and 48-year recovery for UCR steelhead. The highest estimates of necessary survival changes range from zero for one SR spring/summer chinook index stock to 397% for UCR steelhead.

Some of the uncertainties associated with these estimates are described above. Others that are described in Sections 6.3.1 through 6.3.5 and in Appendix C. They include the following:

- The analysis does not consider the effects of ongoing habitat and hatchery recovery efforts by other Federal agencies and non-Federal recovery efforts, except for the Mid-Columbia HCP. The efforts are described in the All-H Paper and discussed in Section 8.

- The analysis projects the effect of immediate implementation of the survival improvements expected from the proposed action. It is clear that actions will not produce immediate biological effects. In the case of the hydro survival standards, for example, the plan provides for attainment by 2010. Habitat restoration activities will in many cases have even longer time frames before biological benefits are realized. The estimate of risk would be higher if a schedule for attainment of biological benefits were included. Because this analysis is intended primarily to provide a standardized measure of risk against which to judge the significance of the action to the continued existence of the ESU, rather than a strict pass/fail test, NMFS has not attempted to quantify the effects of delays.

9.7.3 Evaluation of Snake River Four-Dam Breach in Comparison to the RPA

Sections 9.7.1 and 9.7.2 reviewed the action-area and species-level effects of the hydrosystem components of the RPA, given concurrent expectations in other life stages resulting from a continuation of current harvest rates and implementation of the Mid-Columbia HCP. For several ESUs, significant additional changes in survival are necessary, beyond those expected from implementation of the hydrosystem components of the RPA. Effects of expected improvements in other parts of the life cycle that were not captured in Sections 9.7.1 and 9.7.2 are described in the All-H Paper and are summarized in Section 9.x ( ). The qualitative results of these sections suggest that a significant portion of the needed additional survival changes is likely to be achieved through ongoing federal activities and implementation of the off-site mitigation component of the RPA.

Regional debate in recent years has focused on the advisability of breaching four Snake River dams as an alternative to hydrosystem operations similar to those described in the RPA. NMFS includes an analysis of the effects of this action in Section 9.7.3, to place the effects of the RPA in the context of of the primary alternative option that has been discussed within the region.

This analysis is presented, in part, to demonstrate the effects of critical uncertainties on the estimated survival changes associated with breaching four Snake River dams. These uncertainties support the biological component of the rationale described in Section 9.(1?) for not including immediate dam breaching in this RPA. Additionally, this analysis is presented, in part, to support the possible future need to implement dam breaching following 5- and 10-year reviews (Section 9.xx) of species' status, effectiveness of RPA measures, and new research results that may resolve some of the key uncertainties associated with effectiveness of breaching. This analysis supports the elements of the RPA that require continued engineering and other preparations for possible future breaching.

9.7.3.1 Effects of Snake River Four-Dam Breach on Action Area Biological Requirements

In its report "Return to the River," the Independent Scientific Group (ISG 1996) calls for the re-establishment of "normative" ecosystem features of the Columbia and Snake rivers and tributaries that are essential to salmon restoration. The term "normative" describes a condition that provides "essential ecological conditions and processes needed to maintain diverse and productive salmonid populations." The ISG characterizes the normative river as a continuum of conditions ranging from slightly better than current at one end of the spectrum to nearly pristine on the other. The ISG asserts that only by approaching more normative ecosystem conditions would recovery goals for salmonids be attained. Moreover, sustained productivity will require a network of complex and interconnected habitats that are created, altered, and maintained by natural physical processes in freshwater, the estuary, and the ocean (ISG 1996).

Natural river drawdown of the four Federal hydroprojects on the lower Snake River could reestablish a continuum of riverine habitat. Drawdown to natural river level of the four lower

Snake River reservoirs is expected to improve conditions for both juveniles and adults of some salmonid species by exposing more of the shoreline and allowing the river to redistribute gravel and nutrients, thereby restoring spawning, rearing, and feeding habitat. It is also expected to increase the connectivity of channel, groundwater, floodplain, and upland components of the catchment ecosystem and create more diverse, high-quality habitat, which is crucial for salmonid spawning, rearing, migration, maintenance of food webs, and predator avoidance (ISG 1996).

9.7.3.1.1 Dam Passage Survival During Removal and Transition Periods. The Corps has developed a tentative schedule for breaching the four lower Snake River dams (Corps 1999 [FR/EIS and Appendix D]). After receiving Congressional authorization, the Corps indicates that the project would be completed in 8 or 9 years, with drawdown of Lower Granite and Little Goose reservoirs in year 5 or year 6, and drawdown of Lower Monumental and Ice Harbor reservoirs in the following year. During this 2-year removal period, each of the four reservoirs would be drawn down to natural river level during the months of August through December. The Corps predicts a 3- to 8-year transition period after drawdown is complete, during which major changes in the riverine environment — such as sediment scour and redeposition and the redistribution of predators — would stabilize. During the transition period, mortality rates of juvenile and adult salmon and steelhead may be affected by these factors, as well as deviation from normal operations at the dams. For example, normal operations would not be possible during transition from full pool to riverine conditions (August to December). Turbines would operate at less than maximum efficiency, spill conditions would be altered, and transportation of fish would not be possible. All of these conditions could increase mortality of fall chinook and sockeye outmigrating during the 2-year removal period.

Under the Corps' drawdown plan in the draft FR/EIS, turbines would be modified before the 2-year removal period so that they could be operated under the unusual low-head conditions for primary discharge while the reservoirs are lowered. As a result, up to 3 units per project would not be available during part of the preceding spring spill season, and the reduced powerhouse capacity could result in increased spill and potentially undesirable dissolved gas levels in the river downstream. NMFS expects that these effects, if they occur, would be transitory and would most likely occur during May (Table 9.7-18).[4] Effects of elevated dissolved gas could be severe if flows are unusually high while the powerhouse is running under reduced capacity.

[4] The analysis shown in Table 9.7-18 suggests that the Corps should schedule turbine retrofits such that work is completed by April 1 of each year, to minimize potential TDGS problems.

Table 9.7-18. Estimated Safe Discharge[1] and Probability of Involuntary Occurrence of Flows Exceeding This Level Under Existing Project Capacities and Under Project Capacities Estimated to Exist While the Three Low-Capacity Turbines are Being Replaced at Each Lower Snake River Project

	Current Conditions				Replacement-year Conditions			
	Total Safe Discharge	Probability of Exceedence (%)			Total Safe Dischage	Probability of Exceedence (%)		
Project	(kcfs)	April	May	June	(kcfs)	April	May	June
Lower Granite	178.8	0	2	2	126	8	25	27
Little Goose	162.3	4	6	8	110.4	22	41	33
Lower Monumental	162.7	4	6	8	105.1	29	45	21
Ice Harbor	198.9	0	0	2	161.4	4	8	8

[1] Safe discharge is the discharge that would result in 120% TDGS downstream from each project assuming maximum powerhouse capacity and known project TDGS characteristics.

Removal and Transition Period Effects on Juvenile Salmon. During the removal period, conditions at the dams (i.e., at juvenile bypass systems) would be outside the criteria of systems designed to improve the passage survival of migrating juvenile salmon and steelhead. By scheduling the dam breaching process between August and December, when relatively few juveniles are passing the projects, the Corps would minimize potential adverse effects on most Snake River ESUs. However, substantial numbers of juvenile fall chinook salmon are in the lower Snake River at this time (FPC Annual Fish Passage Report) and this ESU could be adversely affected by higher dam passage mortality. Juvenile fall chinook salmon could also become stranded in pools when the reservoir elevations are reduced. These potential short-term and transitory adverse effects are difficult to quantify but could be severe, affecting two year-classes.

Removal and Transition Period Effects on Adult Salmon. Three factors could influence the success of adult salmon and steelhead migration during the removal period and early in the transition period: suspended sediment concentrations, passage around breach and shoreline protection structures, and access into tributaries.

Suspended sediment concentrations would be elevated during drawdown (August through December work period) and then, with decreasing intensity, during subsequent spring freshets (April through June) for several years (the transition period). During removal operations, high concentrations of suspended sediment may cause increased delays and straying of fall migrants (fall chinook salmon and steelhead). Also, spring and summer chinook salmon could be delayed or could be caused to stray by turbidity events during subsequent spring freshets.

Upstream passage facilities at the dams would be inoperable during the fall/winter periods when dams are breached. This period encompasses most of the fall chinook and steelhead migrations. Specific actions would be implemented to ensure that adult fish move upstream. Under the current two-tiered, two-dam removal plan, the Corps recommends that adult fish be transported by truck around the construction reaches. Adults would probably be collected at Ice Harbor and Little Goose dams, respectively, during the two removal periods. Separating Lyons Ferry or

Tucannon River adults from adults destined for tributaries above Lower Granite would be of concern to NMFS during this trap and haul operation.

Adult movement past the former dam sites would probably not be impeded during the transition period or thereafter. Under current conditions in the lower Snake River, adults typically stop migrating when flows reach 170,000 cfs. Flows of this magnitude are expected to occur only for a brief period once every 5 years on average (Corps 1999). The Corps would develop the breach areas around each dam such that river velocities up to the 170,000 cfs flow level would not impede adult passage. The following Corps' criteria for adult passage through the new channels are based on published information about fish behavior and modeled velocity conditions in the breach area (Corps 1999 [Appendix D]):

- Channel velocities below 1.5 meters per second (m/s) (5 feet per second [ft/s]) require no supplemental fish passage features.
- Higher channel velocities require features in the river that provide rest areas.
- As velocities increase above 1.5 m/s, the density of required rest areas increases.

The Corps will use model studies to determine the extent of appropriate rest structure layout during the next stage of the design process (Corps 1999 [Appendix D]).

In summary, NMFS finds that the greatest potential risk of reduced survival of juvenile and adult salmon and steelhead would occur during and immediately after the 2-year dam removal period. Risk would decrease each subsequent year as environmental conditions stabilize. The Snake River fall chinook salmon ESU appears to be most vulnerable to drawdown effects because at least part of both the juvenile and adult migration periods coincides with the August to December drawdown period. The risk to adults would be reduced by the Corps' planned trap and haul operation, but subsequent indirect effects of this operation are unknown. NMFS concludes that there is not sufficient information currently available to quantify these risks. If the Corps obtains Congressional authorization to breach the lower Snake River dams, NMFS would recommend that the Corps develop detailed operations and demolition plans for the projects and consult with NMFS and USFWS on those plans.

9.7.3.1.2 Effects of Breaching on Sedimentation and Fluvial Geomorphology. Over time, breaching the four lower Snake River dams would restore riverine conditions to what is currently a series of impounded reservoirs. Rivers exist in dynamic equilibrium with the environmental forces that form them, including the hydrologic regime, underlying geology, and sediment supply. Whereas other multipurpose developments (e.g., flood control and irrigation) upstream from Lower Granite Dam have somewhat changed the hydrologic regime in the lower Snake River, sediment yields and channel-forming flows appear to be little changed (Corps 1999 [Appendix

H]).[5] These observations, combined with the fact that the lower Snake River is confined within a basalt gorge, lead NMFS to conclude that, following dam removal, a river greatly resembling the pre-dam Snake River would emerge. The rate at which this likely outcome would occur would depend on sediment transport and thus on river discharge and channel form, properties that are difficult to forecast with precision. The Corps predicts that the bulk of the morphological changes would occur during the first decade after dam removal, as sediment deltas in the reservoirs erode (Corps 1999 [Appendix F]).

Estimates of the amount of sediment stored in reservoirs upstream from Ice Harbor Dam range from 100 to 150 million cubic yards (Corps 1999 [Appendix H]), with the majority stored in Lower Granite Reservoir (72 to 96 million cubic yards). About half this stored sediment would be transported out of the Snake River basin within the first few years following breaching (Corps 1999 [Appendix H]). Much of the sediment that would remain currently covers areas that would become uplands after dam removal, where the erosive forces of the river would become slight to nonexistent. These deposits would be recolonized and stabilized by vegetation and could become relatively permanent features on the landscape. Sediments stored in the active channel would mobilize and be redeposited in accordance with their size relative to the erosive energy of the stream. Sand and finer particles would be readily mobilized and either move as a bedload or become suspended in the water column and move as part of the river's suspended sediment load. These small particles would be deposited in relatively quiescent areas, primarily along the river's shoreline, or would be transported through the Snake River to the Columbia River confluence and beyond. Gravel and larger particles would move primarily as bedload and be sorted and deposited in accordance with local conditions (shear stress). Large particles are the most difficult to move and would tend to dominate the fastest water as smaller particles were washed away. Bedload transport would virtually stop at Lake Wallula (Columbia River confluence), and a substantial sediment deposit would form along the shoreline downstream from the Snake River confluence and other quiescent and backwater areas between the confluence and McNary Dam (Corps 1999, Appendix F). These deposits are expected to be 3 feet deep or less.

Erosion of the sediment body presently located in Lower Granite Reservoir would be severe near the face of the existing sediment delta (between RM 110 and RM 122). A single channel would rapidly emerge as the particles at its base were transported away and the channel rapidly cut upstream. This downcutting would leave portions of the sediment body perched above the active channel, forming steep banks. Subsequent high flows that fill the channel would flatten the banks. These effects would probably occur within 1 or 2 years of dam removal, assuming near-normal streamflow conditions. Due to the large sediment supply, the channel in and immediately downstream from this sediment body would be subject to the greatest changes in bedform, including tendencies to form islands and large bars.

---

[5] Channel bedform changes almost continually over a wide range of discharges. However, as the product of the probability of occurrence and the channel-forming forces exerted, bank full discharge (or the 1.5- to 2-year return period flood) is generally accepted to represent the dominant channel-forming flow.

After dam breaching, the annual sediment yield upstream from Lower Granite Dam would pass unimpeded through the lower river, replenishing gravels and adding to turbidity events. This would add about 3 to 4 million cubic yards to the river's sediment load (Corps 1999 [Appendix H]). These effects would be permanent.

Suspended sediment concentrations in the lower Snake and Columbia rivers would also increase after breaching, as demonstrated during the 1992 partial drawdown test in Lower Granite Reservoir. Suspended sediment concentrations increased from a background level of 9.5 ppm to a high reading of 1,928 ppm. However, the highest concentrations occurred soon after drawdown and declined rapidly; most measurements were lower than 510 ppm (IDFG 1998, Lower Snake River Drawdown Study Fish and Wildlife Coordination Act Report). The Corps estimates that concentrations as high as 9,000 mg/l might occur immediately following breaching at Ice Harbor Dam (Corps 1999).

Suspended sediment concentrations would be highest during the first few years following dam breaching and the exposure of the sediment body to the erosive force of the river. Annual peaks would occur immediately after breaching and drawdown operations (August to December) and then again during the spring freshet (April through June). This seasonal flushing would continue several years after removal, but with decreasing intensity (Corps 1999).

Suspended sediment concentrations would increase permanently as upstream suspended sediment loads pass through the river. It is anticipated that within a decade after dam breaching operations were complete, suspended sediment loads in the affected reach would approximate incoming loads from the upper basin (Corps 1999, Appendix H).

<u>Effects of Sedimentation and Changes in Fluvial Geomorphology on Juvenile Survival</u>. The expected increase in suspended sediment concentrations following dam breaching (between 2,000 and 9,000 mg/l during part of the spring freshet), in each of several years after breaching could affect juvenile salmonid survival. Salmon and steelhead smolts are known to survive suspended sediment concentrations as high as 20,000 mg/l (Sigler et al. 1984). However, some researchers have observed juvenile salmon mortalities at suspended sediment concentrations as low as 500 mg/l (Waters 1995). Thus, some direct mortality of migrating juveniles is likely during peak suspended sediment events (corresponding with the rising limb of the spring freshet hydrograph). However, such effects would be transitory (a few weeks) and would only affect a fraction of several subsequent juvenile migrations. While the Corps has analyzed some sediment cores for toxicants, NMFS expects that a much more thorough sampling effort would be carried out before drawdown to ensure that resuspended sediments are not toxic.

If foraging areas of salmonid predators become smaller as turbidity increases, predation rates may be reduced by post-drawdown suspended sediment events. However, this effect could be offset somewhat by an increased predator density (at least temporarily) following dam removal, as the assemblage of fishes now occupying the reservoirs vies to occupy smaller volumes of suitable habitat (Corps 1999). It is difficult to predict how drawdown will affect predation rates on salmonids without any direct evidence.

Effects of Sedimentation and Changes in Fluvial Geomorphology on Spawning Habitat. Two potential effects of the morphological changes likely to occur following breaching are increased spawning habitat in the mainstem Snake River, and passage barriers at tributary mouths.

Mainstem spawning habitat would re-emerge between RM 10 (the current site of Ice Harbor) to RM 140 (upper end of Lower Granite Reservoir) and would probably be enhanced by a plentiful sediment supply for decades following dam breaching. The Corps (1999 [Appendix H]) estimated that suitable fall chinook spawning habitat in the lower Snake River could increase from 226 acres under current conditions to 3,521 acres following breaching, an almost 16-fold increase.

In the rapid erosion zone (RM 110 to RM 122) there is some risk that established redds would be subsequently scoured, buried, or dewatered as the channel form changes in the first few years following dam removal. Because few fish are expected to use this habitat during the breaching and transition period, such potential adverse effects are expected to be minor and short-term.

In the short term, breaching activities would disrupt tailrace spawning habitat for fall chinook at Lower Granite and Little Goose dams. At the same time, new spawning habitat would emerge. Currently accessible tributary habitat may become inaccessible due to the exposure of large sediment fans at the tributary mouths. During 30-plus years of impoundment, sediment has accumulated and formed deltas where tributaries enter the lower Snake River reservoirs. Following drawdown, these deltas would impede upstream fish passage until the streams move sediment back into the original riverbed or the sediment is moved by mechanical means. Schuck (1992) observed a large deposit of sediment at the mouth of Alpowa Creek during the 1992 Lower Granite Reservoir drawdown test and noted a vertical bedform at the mouth of this stream that would have been impassable to steelhead. Tributary sediment deltas are expected to erode rapidly, but human intervention may be necessary to ensure access to all suitable spawning habitat.

9.7.3.1.3 Estimated Juvenile Survival Following Transition Period. After a natural channel configuration has developed in the 210-km reach and riparian vegetation has become established, NMFS expects that juvenile survival rates will approximate the rates observed in free-flowing reaches above the head of Lower Granite pool. Estimates of survival from the Salmon River trap at Whitebird to Lower Granite Dam are available for wild spring chinook salmon during 1966 through 1968 (Raymond 1979) and for wild spring/chinook salmon and steelhead during 1993 through 1998 (Smith et al. 1998; Hockersmith et al. 1999; Smith et al. 2000). The estimates for both periods include survival through Lower Granite Reservoir. Those for the recent period also include survival past Lower Granite Dam. Using the methods described in Appendix C to factor out the reservoir and dam mortality, NMFS calculates an average per-km survival rate through the free-flowing stretch of 0.999689614 per km for spring chinook and 0.999656 per km for steelhead. Interannual variation was high (Appendix C). The average estimates can be expanded to survival through the entire 210-km reach, resulting in a mean reach survival of 92.2% for SR spring/summer chinook salmon and 93.0% for steelhead (Table 9.7-18). These estimates compare to a range of 85% to 95% estimated by the PATH team (Marmorek et al. 1998). The PATH estimates ranged from historical Whitebird trap estimates (95%) to combined Whitebird and Imnaha trap estimates for the period 1993 through 1996 (85%).

NMFS did not incorporate the Imnaha trap or other Salmon River traps into the estimates. Traps in the Salmon River above Whitebird were not used in estimates for the following reasons:

- The estimates are already captured in the Whitebird to Lower Granite estimate, because it includes fish from all of the tributaries caught at the upstream traps.

- The Whitebird estimate is through a river reach that is more similar to the reach below Lower Granite Dam (in terms of river width and depth and flow characteristics) than are the reaches further up in the tributaries. The Imnaha trap is in a tributary habitat that is more dissimilar to the reach below Lower Granite Dam than is the Whitebird trap.

- The upstream traps are closer to spawning areas, so survival rates from those traps probably represent a culling process that would be greater than that included in the survival rate below Whitebird. To elaborate, culling may result from size, degree of smoltification, or river stretches through which the smolts migrated. These stretches are likely to be more dissimilar among Lower Granite and tributary smolts than among Lower Granite and Whitebird smolts. Imnaha trap estimates were not used because the trap is closer to the spawning grounds than is the Whitebird trap.

To test the hypothesis that survival is lower in reaches closer to spawning grounds than in reaches farther downstream, survival of Whitebird and Imnaha releases was compared in the reach between each trap and Lower Granite Dam and in two reaches below Lower Granite Dam (Appendix C). Survival between the Imnaha trap and Lower Granite Dam, expressed as a per-km rate, was much lower than between the Whitebird trap and Lower Granite Dam, whereas survival estimates for the two traps were nearly identical when compared between Lower Granite Dam and Little Goose Dam, and between Little Goose Dam and Lower Monumental Dam. This suggests that after initial losses of fish occur, there are no inherent differences in smolt survival between stocks released at Imnaha and Whitebird. Thus, the Whitebird trap provides the best estimates of expected survival in downstream stretches of natural river.

The estimates of survival through the breached section of the Snake River can be combined with estimates of survival through the four lower Columbia River projects to derive an estimate of system survival after the drawdown transition period has passed. Estimates of SR spring/summer chinook survival through the four lower Columbia River projects are shown in Table 9.7-1.[6] Inriver survival from McNary to Bonneville dams would range from 54% to 71%, depending upon water year. When survival through the free-flowing reach in the lower Snake River is combined with survival through the impounded reach in the lower Columbia River, system survival of SR spring/summer chinook salmon is expected to range from 50% to 70% (average = 60.9%, Table 9.7-19). Using a similar method (and data shown in Table 9.7-1) for steelhead, system survival for juveniles from this ESU is expected to range from 36% to 71% (average = 61.8%, Table 9.7-19).

Empirical estimates of free-flowing reach survival for juvenile SR fall chinook salmon is more limited and difficult to interpret. The PATH participants used two methods to group and extrapolate recent PIT-tag survival estimates (Peters et al. 1999). The first (hereafter called Method A) results in a free-flowing survival rate of 0.9978 per km, and the second (Method B) in a rate of 0.9995 per km. NMFS finds that both methods are credible and that there is no basis for concluding that one better represents the best available scientific information than the other. Therefore, NMFS uses both methods and establishes a range of likely survival estimates. When expanded to the 210-km reach, Method A estimates an average survival of 63.0% versus 90.0% for Method B (Table 9.7-19). Using a method similar to that applied to SR spring/summer chinook salmon, and the data shown in Table 9.7-1 for the survival of fall chinook salmon through the lower Columbia reach, the system survival of juvenile Snake River fall chinook is expected to range from 7.2% to 31.7% (average = 24.4%) with Method A and from 10.3% to 45.3% (average = 34.8%) with Method B (Table 9.7-19).

NMFS has not estimated the survival of juvenile Snake River sockeye salmon through free-flowing river reaches or through the four lower Columbia River projects under the RPA. Based on the similar size and migration timing of juvenile sockeye salmon, yearling chinook salmon, and steelhead, it is likely that a four-dam breach will result in Snake River sockeye survival that is similar to that estimated for the other two spring migrating ESUs (approximately 60%, on average). Breaching four dams in the Snake River will not change the estimates of juvenile survival for ESUs spawning outside of the Snake River basin, so NMFS applies the juvenile survival rates associated with the RPA.

[6] NMFS assumes that juvenile fish would not be transported from McNary Dam if the Snake River dams are breached.

Table 9.7-19. Estimates of Juvenile Survival for Three Snake River ESUs Following a Transition Period After Breaching Four Snake River Dams

ESU	Avg Survival/Km Thru Free-Flowing Reach	Survival Thru 210-km Reach After 4-Dam Breach	Lower River (MCN to BON) Survival	Total System Survival After 4-Dam Breach
SR spr/sum chinook salmon	99.9614%	92.2%	66.0% (53.9% - 71.4%)	60.9% (49.7% - 70.0%)
SR fall chinook				
Method A	99.78%	63.0%	38.7% (11.5% - 50.3%)	24.4% (7.2% - 31.7%)
Method B	99.95%	90.0%	38.7% (11.5% - 50.3%)	34.8% (10.3% - 45.3%)
SR Steelhead	99.9656%	93.0%	66.4% (38.2% - 76.3%)	61.8% (35.5% - 70.9%)

9.7.3.1.4 Estimated Adult Survival Following Transition Period. After a natural channel configuration has developed in the 210-km reach and riparian vegetation has become established, NMFS expects that adult survival rates through the lower Snake River will approximate the rates observed in free-flowing reaches above the head of Lower Granite pool.

The PATH participants estimated free-flowing survival of wild SR spring/summer chinook salmon by applying the absolute difference in Bjornn's (1989) mean dam-count to redd-count ratios at Ice Harbor Dam for two periods, 1962 through 1968 and 1975 through 1988 (Marmorek et al. 1998). Ice Harbor was the furthest upstream hydroproject during the first period. The difference between the mean ratios for each period estimates the effect of the three dams that were constructed above Ice Harbor during the latter period (1975 through 1988). Extrapolating Bjornn's result over all four dams, the estimate of survival of adult spring/summer chinook salmon traversing the post-drawdown reach between the current location of the tailrace of Ice Harbor Dam and the head of Lower Granite pool would be 97% (i.e., 99% per-project). This method assumes that survival from the current location of the head of Lower Granite pool to the various spawning areas did not change between the two time periods. In applying this method, NMFS assumes that survival through the four-dam lower Snake reach, as currently configured and operated, is equivalent to survival through that reach during the 1975 through 1988 period. In fact, recent reach survival studies indicate survival rates have improved with changes in FCRPS configuration and operations (NMFS 2000 - passage white paper), suggesting that this method may overestimate survival through a free-flowing lower Snake River reach if the dams were removed.

An alternative method is to evaluate the survival of radio-tagged adults through free-flowing reaches above Lower Granite Dam, in a manner similar to that used to estimate juvenile survival.

Bjornn et al. (1995) estimated adult loss of spring chinook salmon from Ice Harbor Dam to reference points in tributaries to the Snake River above Lower Granite Dam. NMFS estimated survival from Ice Harbor to Lower Granite and adjusted total survival rates to derive estimates of survival through the free-flowing reach, using methods documented in Table 6.1-1. The resulting survival rate was 0.994 per km, equal to 88.2% (97% per-project) survival through the 210-km reach that would be affected by breaching four lower Snake River dams. In using this approach, NMFS made numerous assumptions to adjust the original empirical estimates of adult loss. NMFS also assumed that any delayed effects of passing eight dams before entering the free-flowing reach above Lower Granite Dam would be equivalent to the delayed effects of passing only four dams following breaching.

This second method may underestimate survival of adults through free-flowing river sections. In addition to consideration of the assumptions described above, comparison of the estimate of survival generated by the second method with estimates of survival under current conditions (Table 6.1-7) indicates that this method predicts slightly lower adult survival under free-flowing conditions (88.2%) than under impounded conditions ($0.972^4 = 89.3\%$). Although adults travel through impounded sections of the Snake River at approximately the same speed as they travel through free-flowing reaches (e.g., Bjornn et al. 1998, NMFS 2000-passage white paper), it is not clear that survival rates through impounded and unimpounded reaches are equivalent.

NMFS considers the best estimate of adult spring/summer chinook survival following breaching to be intermediate to estimates derived from the two methods described above. The survival rate expected to result from the RPA represents survival through an impounded reach with all possible improvements short of breaching. The estimate of adult survival, when the RPA is fully implemented, is 98% per project, intermediate to the survival rate estimated by the first and second methods (97% and 99% per project, respectively). Using the preferred method, expected survival of adult SR spring/summer chinook through the FCRPS, without breaching, is 85.1% (Table 9.7-2).

One advantage of the method used for estimating the survival of SR spring/summer chinook salmon is that it is directly applicable to other ESUs, whereas the other two methods are not. Therefore, estimates of adult survival for all ESUs are as described in Table 9.7-2. The expected survival rates are 72.1% for SR fall chinook salmon, 85.1% for steelhead, and 85.1% for SR sockeye salmon.

9.7.3.2 Analysis of the Effects of Snake River Four-Dam Breach on Biological Requirements Over the Full Life Cycle

Quantitative analyses were possible for three of the four Snake River ESUs that would be affected by breaching Snake River dams. Details of the analyses used to evaluate the effects of the proposed action on biological requirements over the full life cycle are described in Appendix C. Specifics of the analyses for each ESU are nearly identical to those described in Section 6.2.1. Results are summarized for the three Snake River ESUs in the following sections.

9.7.3.2.1 Snake River Spring/Summer Chinook Salmon

Survival and Recovery Components of the Jeopardy Standard. NMFS used Leslie matrices (Section 6.1.2) to evaluate dam breaching, relative to the jeopardy standard indicator (Sections 1.3.1.1 and 6.1.2). The matrix analysis incorporated the survival rates in other life stages that NMFS expects to result from likely actions described in the All-H Paper. One matrix was developed for each of seven index stocks in the Snake River basin (Appendix A), as described in Section 6.3.1.1. As described in Sections 6.1.2 and 6.3.1.1, the elements of the Leslie matrices were first parameterized to reflect, as closely as possible, the average survival rates that influenced the 1980 to 1994 brood year returns (base matrix). The base matrix used in this evaluation was identical to that described in Section 6.3.1.1.

Juvenile and adult passage survival rates were then changed to reflect effects of breaching four Snake River dams (breach matrix). No other survival rates were estimated to have changed between the average base and breach condition. Section 9.7.2.6 describes smolt passage direct survival estimates. Section 9.7.2.7 describes adult survival estimates. NMFS then estimated a new equilibrium rate of annual population growth from the RPA matrix and compared it to the base population growth rate.

As in the analysis of the proposed action, two estimates of total (direct and indirect) juvenile passage survival were included in both the base and the breach matrices. These are the same as those described in Section 6.3.1.1, with one exception. In the case of the breach matrix, the low survival estimate assumes no delayed mortality of non-transported fish, rather than the PATH estimate of 0.709 to 0.743. By including this assumption, the range of possible effects of breaching includes no change in post-Bonneville mortality following breaching (high estimate, in which there was no delayed mortality either before or after breaching) and a very large reduction in post-Bonneville mortality (low estimate, in which removing four of the eight dams is assumed to eliminate 100% of the PATH estimate of post-Bonneville mortality). The estimate of differential delayed mortality of transported fish is not important in this analysis because it was assumed that no transportation from McNary would occur following breaching.

Table 6.3-1 displays estimates of survival rates that were included in the base matrix. Table 9.7-20 shows survival estimates included in the breach matrix. The average per-generation survival rate associated with the RPA represents a 39% increase (1.39 survival multiplier) from the base survival rate under the low delayed mortality assumption and a 409% increase (5.09 survival multiplier) under the assumption that delayed mortality was higher in the base period but would be zero after breaching. These results were identical for all seven SR spring/summer chinook index stocks.

Table 9.7-20. Matrix Life-Stage Survival and Harvest Rate Estimates, Breach Leslie Matrix

Snake River Spring/ Summer Chinook	Mean Egg-to-Smolt Survival	Mean Smolts per Spawner	Low Delayed Mortality Assumption: Mean Juvenile FCRPS Hydro Survival (including delayed effects)	Low Delayed Mortality Assumption: Mean Non-Hydro Estuary/Early Ocean Survival	High Delayed Mortality Assumption (0 After Breaching): Mean Juvenile FCRPS Hydro Survival (including delayed effects)	High Delayed Mortality Assumption (0 After Breaching): Mean Non-Hydro Estuary/ Early Ocean Survival	Mean Ocean Exploi-tation Rate	Mean Ocean Non-Harvest Survival Rate (Multiply [1-exp. Rate] for total O2+ ocean survival)	Mean Inriver Harvest Rate	Mean Adult FCRPS Passage Survival Rate	Mean Upper Dam to Spawning Survival Rate	Mean Egg-to-Adult Survival Rate	Mean Adult-to-Adult Return
Marsh	0.019	**52.700**	0.609	0.062	0.609	0.227	0.000	0.566	0.082	0.851	0.900	**0.00028-0.00103**	**0.793-2.892**
Sulphur	0.039	**109.800**	0.609	0.062	0.609	0.227	0.000	0.566	0.082	0.851	0.900	**0.00059-0.00215**	**1.652-6.025**
Bear Valley	0.029	**80.400**	0.609	0.062	0.609	0.227	0.000	0.566	0.082	0.851	0.900	**0.00043-0.00157**	**1.210-4.413**
Johnson	0.027	**75.500**	0.609	0.062	0.609	0.227	0.000	0.566	0.025	0.851	0.900	**0.00043-0.00157**	**1.206-4.398**
Poverty Flats	0.024	**68.600**	0.609	0.062	0.609	0.227	0.000	0.566	0.025	0.851	0.900	**0.00039-0.00143**	**1.097-4.000**
Imnaha	0.013	**36.500**	0.609	0.062	0.609	0.227	0.000	0.566	0.053	0.851	0.900	**0.00020-0.00074**	**0.566-2.064**
Minam	0.025	**69.600**	0.609	0.062	0.609	0.227	0.000	0.566	0.082	0.851	0.900	**0.00037-0.00136**	**1.048-3.822**

Note: These data represent expected effects of breaching four Snake River dams. All non-bold survival rates were estimated through methods described in Section 6.1.2 and Appendix C and input to the matrix, with two exceptions. Mean egg-to-smolt survival was adjusted to other elements of the base matrix and to mean 1980 to 1994 ln(recruits/spawner) estimates. Mean non-hydro estuary/early ocean survival was adjusted to estimates of direct and indirect hydro survival and total smolt survival in the base matrix. **Bold** survival rates are summary statistics derived from the other survival rates.

The estimated change in base-to-breach population growth rate was then compared with the changes needed to achieve the following:

- Reduce extinction risk to 5% or less in 24 and 100 years (Tables A-6 and A-7)
- Increase the likelihood of meeting 8-year geometric mean recovery levels to 50% or more in 48 and 100 years (Tables A-? and A-??)

This comparison was made after converting the necessary incremental changes in lambda (annual population growth rate) in those tables to necessary incremental changes in survival over a generation (i.e., egg-to-spawner survival rate).

Table 9.7-21 displays the additional improvements in survival that would be necessary, beyond the 39 to 409% improvement associated with the proposed action, to reduce extinction risk to 5% and increase the likelihood of recovery to 50%. Values less than or equal to 1.0 indicate that no further survival improvements are necessary to achieve the risk levels associated with these indicator metrics. Values greater than 1.0 indicate the multiplier by which survival would have to improve to achieve these indicator risk levels.

Table 9.7-21. Snake River Spring/Summer Chinook Estimated Range of Per-Generation Survival Improvements

Population	5% extinct, 100 years	5% extinct, 24 years	50% Recovery 48 years	50% Recovery 100 years	Natural River
Marsh Creek					
Best Case	0.22	0.20	0.29	0.25	1.35
Worst Case	1.02	0.72	1.27	1.08	1.35
Sulphur Creek					
Best Case	0.28	0.20	0.28	0.24	1.35
Worst Case	1.32	0.97	1.13	0.96	1.35
Bear Valley Creek					
Best Case	0.21	0.20	0.24	0.21	1.35
Worst Case	0.78	0.72	0.96	0.85	1.35
Johnson Creek					
Best Case	0.20	0.20	0.20	0.19	1.35
Worst Case	0.72	0.72	0.83	0.78	1.35
Poverty Flats					
Best Case	0.20	0.20	0.21	0.20	1.35
Worst Case	0.95	0.72	1.14	1.06	1.35
Imnaha River					
Best Case	0.41	0.20	0.53	0.48	1.35
Worst Case	9.68	6.20	8.07	7.26	1.35
Minam River					
Best Case	0.44	0.24	0.49	0.43	1.35
Worst Case	11.17	7.59	9.14	8.08	1.35

Note: These improvements are needed to satisfy five jeopardy standard indicator metrics, given a four-dam Snake River breach. Numbers less than or equal to 1.0 indicate that additional survival improvements are not necessary. Numbers greater than 1.0 are the necessary survival multipliers. See the text for details and definition of best and worst case.

NMFS estimates both best- and worst-case situations. Best case represents the high estimate of juvenile smolt survival (Tables 6.3.1 and 9.7-20), coupled with needed survival improvements based on 1) the 1980-to-2004 observed and projected spawning escapements (Table A-7 and A-9) and 2) an assumption that hatchery-produced adults that spawn in the wild are 20% as effective as naturally produced spawners. Worst case represents the low estimate of juvenile smolt survival, coupled with needed survival improvements based on 1) the 1980 to1999 observed spawning escapements (Tables A-6 and A-8) and 2) an assumption that hatchery-produced adults that spawn in the wild are 80% as effective as naturally produced spawners.

Under the best-case assumptions, the increased survival expected from breaching four Snake River dams, coupled with expected survival in other life stages, is sufficient to reduce the likelihood of extinction to 5% and to result in at least a 50% likelihood of recovery for all seven index stocks. Under worst-case assumptions, these goals are met for only two index stocks (Bear Valley Creek [Middle Fork Salmon River] and Johnson Creek [South Fork Salmon River]). Additional survival improvements ranging from 14 to 1,017% (1.14 to 11.17 survival multipliers) would be necessary to reduce extinction risk and increase the likelihood of recovery for the other four index stocks.

<u>Full Mitigation Component of the Jeopardy Standard</u>. As described in Section 6.1.2, a metric indicative of the full mitigation component of the jeopardy standard is NMFS' best estimate of the natural survival rate of juveniles and adults that would occur without the FCRPS. The estimated SR spring/summer chinook natural survival through the hydrosystem is approximately 82% for juveniles, 85% for adults, and 70% for combined juvenile and adult survival.

As described in Table 9.7-20, the estimate of juvenile survival (as described above, including indirect effects) associated with breaching four dams is 60.9%. The estimate of adult survival is 85.1%, and the combined juvenile and adult survival when passing through the hydrosystem is 51.8%.

The estimated survival when passing through the hydrosystem after breaching four dams is clearly lower than that estimated to occur in the absence of the FCRPS. Table 9.7-21 describes the additional change in passage survival (including indirect effects) that would be necessary to meet NMFS' estimate of natural survival. The additional survival improvement is 35% (1.35 multiplier).

<u>Consideration of All Components of the Jeopardy Standard</u>. For all seven SR spring/summer chinook index stocks, the incremental change in survival needed to meet the survival and recovery indicator risk metrics is lower than that needed to achieve a natural survival rate through the FCRPS under best case assumptions. Based on the construction of the jeopardy standard described in Section 1.3.1.1, the survival and recovery components are relevant for evaluating the effects of the proposed action on this ESU under the best-case assumption. This is also true for five index stocks under the worst-case assumption. However, the full mitigation component of

the jeopardy standard is most relevant for evaluating the effects of the proposed action on the Imnaha and Minam River index stocks under the worst-case assumptions.

9.7.3.2.2 Snake River Fall Chinook Salmon. NMFS used a Leslie matrix (Section 6.1.2) to evaluate the likely status of stocks under the proposed action relative to the jeopardy standard indicator (Sections 1.3.1.1 and 6.1.2). The matrix analysis incorporated the survival rates in other life stages that NMFS expects to result from likely actions described in the All-H Paper. One matrix was developed for the SR fall chinook ESU. The Snake River Salmon Proposed Recovery Plan (NMFS 1995) indicated that this ESU is composed of a single population, so this analysis represents the entire ESU.

As described in Section 6.1.2, NMFS first parameterized the elements of the Leslie matrix to reflect, as closely as possible, the average survival rates that influenced the 1980 to 1991 brood years, represented by adult returns through 1996 (base matrix). The base matrix used in this evaluation was identical to that described in Section 6.3.1.3.

NMFS then changed juvenile and adult survival rates to reflect effects of breaching four Snake River dams, changed harvest rates to reflect new exploitation rates implemented since 1993, and generated a new breach matrix. Section 9.7.2.6 describes smolt passage direct survival estimates. Section 9.7.2.7 describes adult survival estimates. NMFS then estimated a new equilibrium rate of annual population growth from the RPA matrix and compared it to the base population growth rate.

Assumptions included in the low and high smolt passage assumptions were identical to those described for SR spring/summer chinook salmon in Section 9.7.2.8.1, with the PATH delayed mortality assumption specified for fall chinook (0.19; see Section 6.3.1.3).

Table 9.7-22 displays estimates of survival rates that were included in the base and breach matrices. The breach average per-generation survival rate represents a 285% increase (3.85 survival multiplier) from the base survival rate under the low estimate and a 578% increase (6.78 survival multiplier) under the high case.

Table 9.7-22. Snake River Fall Chinook Life-stage Survival and Harvest Rate Estimates, 1980 to 1991 Brood Year Base and Breach Leslie Matrices

Snake River Fall Chinook	Low Delayed Mortality Assumption: Mean Juvenile FCRPS Hydro Survival (including delayed effects)	Low Delayed Mortality Assumption: Mean Non-Hydro Combined Egg-to-Smolt and Estuary/Early Ocean Survival	High Delayed Mortality in Base Period (0 after Breaching) Assumption: Mean Juvenile FCRPS Hydro Survival (including delayed effects)	High Delayed Mortality in Base Period (0 after Breaching) Assumption: Mean Non-Hydro Combined Egg-to-Smolt Estuary/Early Ocean Survival	Mean Ocean Exploita-tion Rate	Mean Ocean Non-Harvest Survival Rate (Multiply [1-exp. Rate] for total O2+ ocean survival)	Mean Inriver Harvest Rate	Mean Adult FCRPS Passage Survival Rate	Mean Upper Dam to Spawning Survival Rate	Mean Egg-to-Adult Survival Rate	Mean Adult-to-Adult Return
Base	0.082	0.056	0.101	0.046	0.170	0.412	0.315	0.607	0.900	**0.00059**	**0.850**
RPA	0.244	0.056	0.348	0.046	0.121	0.498	0.174	0.721	0.900	**0.00279-0.00324**	**3.272-5.764**

Note: These data represent expected effects of breaching four Snake River dams. All non-bold survival rates were estimated through methods described in Section 6.1.2 and Appendix C and input to the matrix, with two exceptions. Mean first-year survival was adjusted to other elements of the base matrix and to mean 1980 to 1991 ln(recruits/spawner) estimates. Smolt survival during the first year was estimated independently, as described above, and the non-hydro first-year survival (including egg-to-smolt and estuary/early ocean survival) was obtained after accounting for total base smolt survival and base hydro passage survival. **Bold** survival rates are summary statistics derived from the other survival rates.

NMFS then compared the estimated change in base-to-breach population growth rate to the changes needed to reduce risk to levels associated with the jeopardy standard indicator metrics, as described above for SR spring/summer chinook salmon. Table 9.7-23 displays the additional improvements in survival that would be necessary, beyond the level of survival expected from the RPA and continuation of harvest reductions, to reduce the extinction risk to 5% and increase the likelihood of recovery to 50%. Interpretation of values above and below 1.0 is as described above for SR spring/summer chinook salmon. Estimates were made for best- and worst-case assumptions. Definitions of these cases were the same as those described above for SR spring/summer chinook salmon.

Table 9.7-23. Snake River Fall Chinook Estimated Range of Per-Generation Survival Improvements

Population	5% extinct, 100 years	5% extinct, 24 years	50% Recovery 48 years	50% Recovery 100 years	Natural River
Snake River					
Best Case	0.27	0.15	0.37	0.34	1.27
Worst Case	1.48	0.66	1.98	1.78	1.57

Note: These improvements are needed to satisfy five jeopardy standard indicator metrics, given breaching of four Snake River dams. Numbers less than or equal to 1.0 indicate that additional survival improvements are not necessary. Numbers greater than 1.0 are the necessary survival multipliers. See the text for details and definition of best and worst case.

Under the best-case assumptions, the survival rate expected from the dam breaching and continuation of low harvest rates, coupled with expected survival in other life stages, results in 5% or less risk of extinction in 24 and 100 years and 50% likelihood of recovery in 48 and 100 years. However, additional survival improvement, up to 98% (1.98 survival multiplier) is needed under the worst-case assumptions.

Full Mitigation Component of the Jeopardy Standard. As described in Section 6.1.2, a metric indicative of the full mitigation component of the jeopardy standard is NMFS' best estimate of the natural survival rate of juveniles and adults that would occur without the FCRPS. Natural survival of juveniles through free-flowing river reaches was estimated using two alternative methods by PATH (Peters et al. 1999). NMFS considers both methods equally valid; therefore, a range of natural survival estimates is evaluated for this ESU (Section 4, Appendix C). The estimate of juvenile survival through the hydrosystem reach under natural conditions ranges from 32 to 77%, depending upon the method. Adult survival is estimated as 72%, and the combined juvenile and adult natural survival rate is 45.4 to 64.9%.

As described in Table 9.7-22, the high estimate of juvenile survival (as described above, including indirect effects) associated with the RPA is 34.8%, while the low estimate is 24.4%. The estimate of adult survival is 72.1%, which leads to17.6 to 25.1% combined juvenile and adult survival when passing through the hydrosystem.

The estimated survival when passing through the hydrosystem, assuming that the four lower Snake dams are breached, is clearly lower than that estimated to occur without the FCRPS. Table 9.7-23 describes the additional change in passage survival (including indirect effects) needed to meet NMFS' estimate of natural survival. The additional survival improvement ranges from 27% (1.27 multiplier) for the high survival estimate to 57% (1.57 multiplier) for the low survival estimate.

Consideration of All Components of the Jeopardy Standard. For SR fall chinook salmon, the incremental change in survival needed to meet the survival and recovery indicator risk metrics is lower than that needed to achieve a natural survival rate through the FCRPS under the best-case assumptions. Based on the construction of the jeopardy standard described in Section 1.3.1.1, the natural survival components of the jeopardy standard are relevant for evaluating the effects of four-dam breach. Based on these indicator metrics, no improvement in survival would be needed in addition to the effects of the a four-dam breach and the continuation of recent low harvest rates. Under the worst-case assumptions, however, the full mitigation standard is relevant, and a survival improvement of at least 57% is necessary.

9.7.3.2.3 Snake River Steelhead

Survival and Recovery Components of the Jeopardy Standard. NMFS could not construct a Leslie matrix (Section 6.1.2) for SR steelhead at this time. Therefore, it conducted a simple incremental analysis for aggregate A-Run and aggregate B-Run SR steelhead to assess the effects of breaching four Snake River dams. This approach is identical to that used to evaluate effects of the proposed action on Snake River steelhead in Section 6.3.1.4. This analysis estimates expected proportional changes in average survival from the base (1980 brood year through approximately 1992 brood year [1997 returns]) to the breach condition, without attempting to estimate survival rates through the entire life cycle. The analysis focuses only on those life-stage survival rates likely to change from base to breach conditions. These changes include expected survival rates in other life stages resulting from other likely actions (All-H Paper) and are evaluated with respect to the metrics that are indicative of the survival and recovery components of the jeopardy standard (Sections 1.3.1.1 and 6.1.2).

CRI estimated the needed change in annual population growth rate (lambda) with respect to each survival metric (McClure et al. 2000), and results are presented in Section 4 and Appendix A. When lambda is converted to per-generation survival, the needed changes from average 1980 to 1992 brood survivals range from 242 to 51,453% (3.42 to 515.53 survival multipliers), depending upon metric, steelhead run, and hatchery effectiveness assumption. NMFS has not proposed any recovery abundance levels for this ESU, so no evaluation of the recovery metric was possible at this time.

As described in Section 6.3.1.4, two survival rates (smolt passage survival and [1-harvest rate]) appear to have changed from the average 1980-to-1992 brood survivals to current (proposed action) conditions. In addition to those changes, both adult and juvenile passage survival are expected to change from current survival rates to those associated with breaching four Snake River dams. Section 9.7.2.6 contains estimates of smolt passage direct survival following breaching. Section 9.7.2.7 describes adult survival estimates. Definitions of the low and high smolt passage assumptions were identical to those described for SR spring/summer chinook salmon in Section 9.7.2.8.1.

Table 9.7-24 displays estimates of survival rates included in the incremental analysis. Under the low delayed mortality smolt passage assumption, the average per-generation survival rate associated with breaching represents a 75% increase (1.75 survival multiplier) from the base survival rate for A-Run steelhead and an 82% increase (1.82 survival multiplier) from the base survival rate for B-Run steelhead. Under the smolt passage assumption of high delayed mortality during the base period, which is eliminated following breaching, the corresponding estimates are a 538% increase (6.38 survival multiplier) from the base survival rate for A-Run steelhead and a 564% increase (6.64 survival multiplier) from the base survival rate for B-Run steelhead.

NMFS then compared the estimated proportional change in relevant base-to-breach life-stage survival rates to the changes needed to reduce risk to levels associated with the jeopardy standard indicator metrics, as described above for SR spring/summer chinook. Table 9.7-25 displays the additional improvements in survival that would be necessary, beyond the level of survival expected from breaching and continuing harvest reductions, to reduce extinction risk to 5%. Interpretation of values above and below 1.0 is the same as that described above for SR spring/summer chinook salmon. Estimates were made for best-case and worst-case assumptions. Definitions of these cases were the same as those described above for SR spring/summer chinook salmon.

Under both the best- and worst-case assumptions, survival improvements in addition to those resulting from the survival rate expected from breaching four dams and continuing low harvest rates are necessary to reduce the likelihood of extinction in both 24 and 100 years to 5% or less. The magnitude of the necessary change ranges from 78 to 28,212% (1.78 to 283.12 survival multipliers), depending upon metric and assumption. The main factors influencing these results are the assumption regarding hatchery effectiveness and the assumption regarding how much delayed mortality disappears after breaching. Very high survival improvements are needed if hatchery spawner effectiveness is 80% and if breaching has no effect on delayed mortality.

Table 9.7-24. Snake River Steelhead Juvenile and Adult Passage Survival and Harvest Rate Estimates, 1980 to 1992 Brood Year Base Period and Snake River Four-Dam Breach (Breach)

		Low Hydro Assumption		High Hydro Assumption								
Snake River Steelhead	**Mean Egg-to-Smolt Survival**	**Mean Juvenile FCRPS Hydro Survival (including delayed effects)**	**Mean Non-Hydro Estuary/Early Ocean Survival**	**Mean Juvenile FCRPS Hydro Survival (including delayed effects)**	**Mean Non-Hydro Estuary/Early Ocean Survival**	**Mean Ocean Exploitation Rate**	**Mean Ocean Non-Harvest Survival Rate (Multiply [1-exp. Rate] for total O2+ ocean survival)**	**Mean Inriver Harvest Rate**	**Mean Adult FCRPS Passage Survival Rate**	**Mean Upper Dam to Spawning Survival Rate**	**Mean Egg-to-Adult Survival Rate**	**Mean Adult-to-Adult Return**
Base												
A-Run	N/A	0.107	N/A	0.391	N/A	0.000	1.00	0.137	0.796	0.90	N/A	N/A
B-Run	N/A	0.107	N/A	0.391	N/A	0.000	1.00	0.259	0.796	0.90	N/A	N/A
Breach Four Snake River Dams												
A-Run	N/A	0.618	N/A	0.618	N/A	0.000	1.00	0.107	0.851	0.90	N/A	N/A
B-Run	N/A	0.618	N/A	0.618	N/A	0.000	1.00	0.201	0.851	0.90	N/A	N/A

Note: This information is used in an analysis of proportional changes in these specific life-stage survival rates.

Table 9.7-25. Snake River Steelhead Estimated Range of Per-generation Survival Improvements

Snake River Steelhead	5% extinct, 100 years	5% extinct, 24 years	50% Recovery 48 years	50% Recovery 100 years	Natural River
A-Run					
Best Case	1.78	0.54	N/A	N/A	1.08
Worst Case	192.71	57.27	N/A	N/A	1.08
B-Run					
Best Case	2.24	0.72	N/A	N/A	1.08
Worst Case	283.12	83.83	N/A	N/A	1.08

Notes: These improvements are needed to satisfy five jeopardy standard indicator metrics, if four Snake River dams are breached. Numbers less than or equal to 1.0 indicate that additional survival improvements are not necessary. Numbers greater than 1.0 are the necessary survival multipliers. See the text for details and definition of best and worst case.

Full Mitigation Component of the Jeopardy Standard. As described in Section 6.1.2, a metric indicative of the full mitigation component of the jeopardy standard is NMFS' best estimate of the natural survival rate of juveniles and adults that would occur in the absence of the FCRPS. The estimate of SR steelhead juvenile survival when passing through the hydrosystem reach under natural conditions is approximately 84%, adult survival is estimated as 85%, and the combined juvenile and adult natural survival rate is 71.3%.

As described in Table 9.7-24, both the high and low estimates of juvenile survival (as described above, including indirect effects) associated with breaching are 61.8%. The estimate of adult survival is 85.1%, which leads to 52.6% combined juvenile and adult survival when passing through the hydrosystem.

The estimated survival when passing through the hydrosystem following breaching is clearly lower than that estimated to occur without the FCRPS. Table 9.7-23 describes the additional change in passage survival (including indirect effects) that would be necessary to meet NMFS' estimate of natural survival. The additional survival improvement is 8% (1.08 multiplier) for both the high and low survival estimates.

Consideration of All Components of the Jeopardy Standard. For SR steelhead, the incremental change in survival needed to achieve a natural survival rate through the FCRPS is lower than that needed to meet the survival and recovery indicator risk metrics. Based on the construction of the jeopardy standard described in Section 1.3.1.1, the full mitigation component is relevant for evaluating effects of breaching four Snake River dams. Based on this indicator metric, at least an 8% improvement in survival would be needed in addition to the effects of dam breaching and the continuing recent low harvest rates.

9.7.3.2.4 Snake River Sockeye Salmon. Because the abundance of SR sockeye salmon is extremely low, the risk of extinction cannot be calculated using the methods that NMFS employs in this Biological Opinion. However, current risk is undoubtedly very high.

Due to the extreme low abundance of SR sockeye salmon in recent years, this ESU has not been used in passage survival studies. Therefore, NMFS has not estimated natural system survival or total system survival associated with breaching four Snake River dams for this ESU. Assuming that juvenile mortality in the action area is similar to that of other yearling migrants, dam breaching has the potential to increase action-area survival substantially if delayed mortality is currently high and if it is eliminated by breaching four of the eight FCRPS dams that sockeye must pass. However, even under this optimistic assumption, additional survival improvements are needed to meet natural survival and survival/recovery criteria for SR steelhead (Table 9.7-24). Because the extinction risk for SR sockeye is most likely greater than that for SR steelhead, additional survival improvements would also be needed for SR sockeye. If, on the other hand, delayed mortality is currently low or if there is no change in delayed mortality following breaching, dam breaching will result in action-area survival similar to the RPA. In this case, substantial survival improvements in addition to breaching would also be needed.

Because a quantitative analysis was not possible for this species, it is difficult to place the effects of the hydrosystem following a four-dam breach in the context of other factors influencing this ESU's survival and recovery. Other factors also affect elements of critical habitat and thus contribute to this ESU's high risk of extinction (summarized in Section 4.1 and Appendix A), but the FCRPS is a significant factor. These other factors include tributary hydropower and irrigation storage projects that block or restrict fish passage, water withdrawls that dewater streams, and unscreened diversions. The high risk of extinction is partially mitigated by a captive breeding program that is funded by the Action Agencies. That program provides some assurance that Snake River sockeye will not go extinct in the immediate future. However, long-term survival and recovery in the wild requires a substantial increase in survival through the FCRPS and in other life stages.

9.7.3.2.5 Eight Other ESUs. Because eight of the ESUs addressed in this Biological Opinion are distributed downstream of the Snake River dams, the effect of dam breaching would be identical to that of the RPA for UCR spring chinook, LCR chinook, UWR chinook, UCR steelhead, MCR steelhead, LCR steelhead, UWR steelhead, and CR chum salmon.

9.7.3.2.6 Summary - Effects of Snake River Four-Dam Breach on Biological Requirements Over the Full Life Cycle. Breaching four Snake River dams is expected to have no effect on eight of the ESUs considered in this biological opinion because they do not pass through the lower Snake River. For these ESUs, the effect of dam breaching is identical to that of the RPA. For the four Snake River ESUs that would be affected by dam breaching, the effect of this action, relative to the RPA, is determined almost entirely by delayed mortality assumptions.

Assumption: Breaching Does Not Reduce Post-Bonneville Mortality. If delayed mortality of non-transported fish is assumed non-existent or unchanged (regardless of magnitude) following breaching four of the eight FCRPS dams, this action has a similar effect to the RPA. For example, the survival improvement for SR spring/summer chinook stocks attributed to breaching under this assumption is 39%, compared to a 30% improvement expected from the RPA under all assumptions considered (Table 9.7-17). Differences are greater for SR steelhead and fall chinook, primarily because for these ESUs we have included assumptions of relatively high differential delayed mortality of transported fish. This differential effect disappears following breaching and elimination of transportation. As reported in previous sections, NMFS' estimate of SR steelhead differential delayed mortality is based on very few adult returns. NMFS does not have an estimate of this factor for SR fall chinook, so the one (of several) PATH estimates that appeared to be most empirically based was used in these analyses. All estimates of this factor should be considered very preliminary and subject to change as new information is collected.

Under an assumption of no delayed mortality (or no change in delayed mortality following breaching), substantial additional improvements in survival would be necessary to meet the critical metrics for SR spring/summer and fall chinook salmon (Table 9.7-26). A smaller survival improvement would be needed for SR steelhead.

Assumption: Breaching Greatly Reduces Post-Bonneville Mortality. If delayed mortality of non-transported fish is assumed to be high currently and if it is further assumed that it will be eliminated following breaching of four of the eight FCRPS dams, substantial survival improvements over the RPA can be expected from breaching. Survival under these assumptions would be expected to increase 409 to 578% (Table 9.7-27) following breaching. No additional survival improvements would be necessary for SR spring/summer and fall chinook to meet critical metrics and only an 8% additional improvement would be needed for SR steelhead (Table 9.7-27).

Conflicting Assumptions Cannot Be Resolved at Present. The primary biological issue regarding breaching is the extent to which breaching four Snake River dams is likely to modify post-Bonneville survival of Snake River ESUs. If post-Bonneville survival improves significantly after breaching, this option is biologically superior to the RPA and has the potential to recover the four Snake River ESUs, even without additional offsite mitigation. However, if the principal effect is constrained to the area that would be modified above Bonneville Dam, breaching represents only a marginal improvement over the RPA, and additional improvements through off-site mitigation would still be required. As described in previous sections, NMFS considers empirical information bearing on the question of delayed mortality of non-transported fish to be lacking and information related to differential delayed mortality of transported fish to be very limited. The RPA includes a substantial research effort to help resolve the issue and built-in check points to evaluate new research results with respect to possible future modification of the RPA.

Table 9.7-26. Summary of Quantitative Estimates of Effects of Four-Dam Breach on Achievement of Jeopardy Standard Indicator Metrics

Species ESU Stream	Critical Metric	Needed Survival Change: Minimum Estimate	Needed Survival Change: Maximum Estimate	Survival Change Expected from Four-Dam Breach[1]: Low Delayed Mortality	Survival Change Expected from Four-Dam Breach[1]: High Delayed Mortality[4]	Additional Needed Survival Improvements: Best Case[2]	Additional Needed Survival Improvements: Worst Case[3]
Chinook Salmon							
Snake River Spring/Summer ESU							
Bear Valley Creek	48-recovery	1.20	1.30	1.39	5.09	**0.24**	**0.96**
Imnaha River	full mitigation	1.87	6.86	1.39	5.09	1.34	1.35
	48-recovery	2.70	11.25	1.39	5.09	0.53	8.07
Johnson Creek	48-recovery	1.00	1.15	1.39	5.09	**0.20**	**0.83**
Marsh Creek	48-recovery	1.48	1.77	1.39	5.09	**0.29**	1.27
Minam River	full mitigation	1.87	6.86	1.39	5.09	1.34	1.35
	48-recovery	2.48	12.76	1.39	5.09	0.49	9.14
Poverty Flats (S. Fork Salmon R.)	48-recovery	1.09	1.59	1.39	5.09	**0.21**	1.14
Sulphur Creek	100-extinction	1.41	1.84	1.39	5.09	**0.33**	1.32
Snake River Fall ESU	full mitigation	5.54	6.44	3.53	5.05	1.27	1.57
	48-recovery	2.54	7.63	3.85	6.78	0.37	1.98
Steelhead							
Snake River ESU							
A-Run component	full mitigation	1.82	6.65	1.69	6.16	1.08	1.08
B-Run component	full mitigation	1.82	6.65	1.69	6.16	1.08	1.08

Note: Units are multipliers for changes in survival per generation. Numbers in "Needed Change" columns less than or equal to 1.0 indicate that additional survival improvements are not necessary. Numbers greater than 1.0 in these columns are the necessary survival multipliers.

[1] Change in per-generation survival, except when referenced to "Full Mitigation." In that case, survival represents juvenile times adult passage survival, including any delayed effects.

[2] Minimum estimate of needed survival change, coupled with high estimate of action effect.

[3] Maximum estimate of needed survival change, coupled with low estimate of action effect.

[4] High delayed mortality in base case, which is assumed to be eliminated after breaching four dams.

Table 9.7-27. Minimum Estimated Percentage of Additional Improvement in Life Cycle Survival Needed to Meet NMFS' Jeopardy Standard After Achieving RPA and Four-Dam Breach Hydro Survival Improvements.

Species ESU Stream	Low Estimate[1] of Needed Improvement (%) RPA	Low Estimate[1] of Needed Improvement (%) 4-Dam Breach	High Estimate[2] of Needed Improvement (%) RPA	High Estimate[2] of Needed Improvement (%) 4-Dam Breach
Chinook Salmon				
SR Spring/Summer ESU				
Bear Valley	0	0	5	0
Imnaha	45	0	430	35
Johnson	0	0	0	0
Marsh	14	0	37	27
Minam	45	0	430	35
Poverty Flats	0	0	22	14
Sulphur	9	0	42	32
SR Fall ESU	19	0	256	57
Steelhead				
SR ESU				
A-Run	35	8	391	8
B-Run	35	8	391	8

[1] For the RPA, low estimate represents delayed mortality of non-transported fish equal to zero for both the base and RPA. For breaching, low estimate represents high delayed mortality for the base, but zero after breaching four dams.

[2] For the RPA, high estimate represents delayed mortality of non-transported fish equal to attributing all PATH "extra mortality" to effects of the hydrosystem for both the base and RPA. For breaching, high estimate represents zero delayed mortality for both the base and RPA.

9.7.4 RPA Conclusions

The analysis in the preceding sections of this biological opinion forms the basis for conclusions as to whether this RPA for operation of the FCRPS, and BOR projects satisfies the standards of the ESA, Section 7(a)(2). To do so, the Action Agencies must ensure that the RPA is not likely to jeopardize the continued existence of any listed species or destroy or adversely modify the designated critical habitat of such species. Chapter 4 of this opinion defines the biological requirements and the current status of each of the 12 listed salmonid species. Chapter 5 evaluates the relevance of the environmental baseline to each species' current status. Chapter 6 details the likely effects of the proposed action both on individuals of the species in the action area and also on the listed population as a whole across its range and life-cycle. Chapter 7 considers cumulative effects of relevant non-Federal actions within the action area. Based on this information and analysis, NMFS draws its conclusions about the effects of the operation of the FCRPS and BOR projects, as described in this RPA upon the survival and recovery of the 12 listed salmonid species.

As discussed above in Section 1.3 of this Biological Opinion, NMFS must now determine "whether the species can be expected to survive with an adequate potential for recovery under the effects of the RPA, the environmental baseline and any cumulative effects, and considering measures for survival and recovery specific to other life stages." The information available to NMFS for this determination is both quantitative and qualitative. For some species, such as SR spring/summer chinook, the available information is relatively abundant with a substantial amount of quantitative data, based upon empirical observations. For other species, however, such as SR sockeye salmon, the available information is largely qualitative based on the best professional judgement of knowledgeable scientists. Despite an increasing trend toward more quantitative understanding of the critical life signs for these fish, critical uncertainties limit the ability to project future conditions and effects. As a result, there are currently no hard and fast numerical indices available for any of these stocks on which to base a determination about jeopardy or adverse modification of critical habitat, the Section 7(a)(2) standards. Ultimately, for all 12 listed species, these conclusions are qualitative judgements based upon the best quantitative and qualitative information available species-by-species.

9.7.4.1 General Conclusions For All ESUs

Section 8 of this biological opinion indicated that eight ESUs would be jeopardized by the proposed action. For these ESUs, NMFS determined that mortality in the action area associated with the proposed action would be substantial and that critical habitat elements, such as water quality and (in the case of CR chum salmon) spawning habitat, would be adversely modified. NMFS determined that the proposed action was not specific enough regarding measures to improve survival and avoid adverse modification of critical habitat in the action area. Performance standards for guiding these improvements also were not specific enough and were tied to biological requirements throughout the life cycle.

Section 8 also indicated that the effects of the proposed action, when combined with anticipated survival improvements in other life stages, were not sufficient to ensure survival and recovery of these eight ESUs. Some additional survival improvements, beyond those considered in analyses of effects, were considered likely to occur as a result of Federal conservation measures related to habitat improvements and hatchery reforms described generally in the All-H Paper. However, NMFS concluded that the sufficiency of these measures to augment survival improvements associated with the FCRPS' proposed action and to ensure a high likelihood of survival and moderate-to-high likelihood of recovery of each ESU was uncertain and unlikely, without a more reliable expectation of progress on comparable complimentary non-Federal actions. The RPA remedies these two primary shortcomings of the proposed action.

Measures to improve survival in the action area are specified in detail in Section 9.6.1 of this Biological Opinion. These measures are expected to result in higher survival in the action area than would be expected under the proposed action (Section 9.7.1) and are guided by explicit action-area performance standards that are integrated with life-cycle performance standards (Section 9.2). Measures include specific remedies for adverse modifications to critical habitat, such as a gas abatement program to reduce adverse modification of water quality.

Additional improvements in survival over the life cycle are still necessary after implementing the hydrosystem measures of the RPA (Section 9.3). However, Section 9.2.2.2 of the RPA specifies that the Action Agencies will ensure implementation of off-site mitigation sufficient to achieve at least NMFS' minimum estimate of the needed additional survival improvement. The All-H Paper includes a program of conservation measures outside of the action area, which are considered feasible for achieving survival and recovery of Columbia basin ESUs. Specifics for implementing elements of this program as the Action Agencies' off-site mitigation action are included in Sections 9.6.2 through 9.6.4. The reliability of implementing the non-Federal conservation measures described in the All-H Paper is, thereby, greatly increased by the RPA. This contrasts with the original proposed action. This reliability, together with other ongoing Federal measures for survival and recovery specific to other life stages and the improved survival from the hydropower measures of this RPA, ensure that each of the eight ESUs will have a high likelihood of survival and a moderate-to-high likelihood of recovery.

In Section 8, NMFS concluded that four ESUs were not jeopardized by the proposed action (UWR steelhead, UWR chinook, LCR steelhead, and LCR chinook). The RPA will have no adverse effects beyond those in the proposed action, so these ESUs also will not be jeopardized by the RPA.

9.7.4.2 Snake River Spring/Summer Chinook Salmon

After reviewing the current status of SR spring/summer chinook salmon, the environmental baseline for the action area, the effects of the RPA (particularly Sections 9.7.1 and 9.7.2), and the cumulative effects, it is NMFS' biological opinion that the RPA is not likely to jeopardize the continued existence of SR spring/summer chinook salmon or to destroy or adversely modify designated critical habitat. This conclusion is based on elements of the RPA that remedy shortcomings of the proposed action, as described in Sections 8 and 9.7.4.1. Specifically, the RPA includes measures to improve survival within the action area beyond those anticipated from the original proposed action and to meet action-area performance standards that have been integrated with performance standards for the full life cycle. Additionally, the RPA will result in implementation of offsite mitigation sufficient to meet the biological requirements of SR spring/summer chinook salmon, when combined with other elements of the RPA and conservation measures anticipated in other life stages, as described in the All-H Paper.

9.7.4.3 Snake River Fall Chinook Salmon

After reviewing the current status of SR fall chinook salmon, the environmental baseline for the action area, the effects of the RPA (particularly Sections 9.7.1 and 9.7.2) and the cumulative effects, it is NMFS' biological opinion that the RPA is not likely to jeopardize the continued existence of SR fall chinook salmon or to destroy or adversely modify designated critical habitat. This conclusion is based on elements of the RPA that remedy shortcomings of the proposed action, as described in Sections 8 and 9.7.4.1. Specifically, the RPA includes measures to improve survival within the action area beyond those anticipated from the original proposed action and to meet action-area performance standards that have been integrated with performance standards for the full life cycle. Additionally, the RPA will result in implementation of offsite mitigation sufficient to meet the biological requirements of SR fall chinook salmon, when combined with other elements of the RPA and conservation measures anticipated in other life stages, as described in the All-H Paper.

9.7.4.4 Upper Columbia River Spring Chinook Salmon

After reviewing the current status of UCR spring chinook salmon, the environmental baseline for the action area, the effects of the RPA (particularly Sections 9.7.1 and 9.7.2), and the cumulative effects, it is NMFS' biological opinion that the RPA is not likely to jeopardize the continued existence of UCR spring chinook salmon or to destroy or adversely modify designated critical habitat. This conclusion is based on elements of the RPA that remedy shortcomings of the proposed action, as described in Sections 8 and 9.7.4.1. Specifically, the RPA includes measures to improve survival within the action area beyond those anticipated from the original proposed action and to meet action-area performance standards that have been integrated with performance standards for the full life cycle. Additionally, the RPA will result in implementation of offsite mitigation sufficient to meet the biological requirements of UCR spring chinook salmon, when combined with other elements of the RPA and conservation measures anticipated in other life stages, as described in the All-H Paper.

9.7.4.5 Upper Willamette River Chinook Salmon

Salmonids in this ESU spawn and rear in tributaries that enter the Columbia River downstream from all FCRPS projects. The only effects of operation of the FCRPS on this ESU are potential habitat degradation in the estuary and plume. The magnitude of these effects is uncertain and appears to be minor, compared to other factors influencing the status of this species (Table 6.3-12).

NMFS concluded in Section 8 that the original proposed action was not likely to jeopardize this ESU or adversely modify its critical habitat. After reviewing the current status of UWR chinook salmon, the environmental baseline for the action area, the effects of the RPA, and the cumulative effects, it is NMFS' biological opinion that the RPA also is not likely to jeopardize the continued existence of UWR chinook salmon or to destroy or adversely modify designated critical habitat.

9.7.4.6 Lower Columbia River Chinook Salmon

As discussed in Sections 6.2 and 9.7.2, this ESU is distributed primarily in spawning and rearing areas below Bonneville Dam. Within the action area, the key effects on this species are summarized in Sections 6.2.9 and 9.7.1. Effects of the FCRPS include passage mortality of juveniles and adults through one dam and reservoir for a limited number of subbasin populations. For the small portion of the ESU that spawns in the Ives Island area below Bonneville Dam, access to, and quantity and quality of, that spawning habitat can be affected by FCRPS flow regulation.

At the species level, this ESU has multiple populations within the Columbia River basin, most of which are below FCRPS projects. Quantitative evaluations of the effect of the RPA on this ESU's species-level biological requirements were not possible, but Tables 6.3-13 and 9.7-15 indicate that most populations comprising this ESU are subjected to factors other than the FCRPS that limit their potential for survival and recovery.

NMFS previously concluded in Section 8 that the original proposed action was not likely to jeopardize this ESU or adversely modify its critical habitat. After reviewing the current status of LCR chinook salmon, the environmental baseline for the action area, the effects of the RPA, and the cumulative effects, it is NMFS' biological opinion that the RPA also is not likely to jeopardize the continued existence of LCR chinook salmon or to destroy or adversely modify designated critical habitat.

9.7.4.7 Snake River Steelhead

After reviewing the current status of SR steelhead, the environmental baseline for the action area, the effects of the RPA (particularly Sections 9.7.1 and 9.7.2), and the cumulative effects, it is NMFS' biological opinion that the RPA is not likely to jeopardize the continued existence of SR steelhead or to destroy or adversely modify designated critical habitat. This conclusion is based on elements of the RPA that remedy shortcomings of the proposed action, as described in Sections 8 and 9.7.4.1. Specifically, the RPA includes measures to improve survival within the action area beyond those anticipated from the original proposed action and to meet action-area performance standards that have been integrated with performance standards for the full life cycle. Additionally, the RPA will result in implementation of offsite mitigation sufficient to meet the biological requirements of SR steelhead, when combined with other elements of the RPA and conservation measures anticipated in other life stages, as described in the All-H Paper.

9.7.4.8 Upper Columbia River Steelhead

After reviewing the current status of UCR steelhead, the environmental baseline for the action area, the effects of the RPA (particularly Sections 9.7.1 and 9.7.2), and the cumulative effects, it is NMFS' biological opinion that the RPA is not likely to jeopardize the continued existence of UCR steelhead or to destroy or adversely modify designated critical habitat. This conclusion is based on elements of the RPA that remedy shortcomings of the proposed action, as described in Sections 8 and 9.7.4.1. Specifically, the RPA includes measures to improve survival within the action area beyond those anticipated from the original proposed action and to meet action-area performance standards that have been integrated with performance standards for the full life cycle. Additionally, the RPA will result in implementation of offsite mitigation sufficient to meet the biological requirements of UCR steelhead, when combined with other elements of the RPA and conservation measures anticipated in other life stages, as described in the All-H Paper.

9.7.4.9 Middle Columbia River Steelhead

After reviewing the current status of MCR steelhead, the environmental baseline for the action area, the effects of the RPA (particularly Sections 9.7.1 and 9.7.2), and the cumulative effects, it is NMFS' biological opinion that the RPA is not likely to jeopardize the continued existence of MCR steelhead or to destroy or adversely modify designated critical habitat. This conclusion is based on elements of the RPA that remedy shortcomings of the proposed action, as described in Sections 8 and 9.7.4.1. Specifically, the RPA includes measures to improve survival within the action area beyond those anticipated from the original proposed action and to meet action-area performance standards that have been integrated with performance standards for the full life cycle. Additionally, the RPA will result in implementation of offsite mitigation sufficient to meet the biological requirements of MCR steelhead, when combined with other elements of the RPA and conservation measures anticipated in other life stages, as described in the All-H Paper.

9.7.4.10 Upper Willamette River Steelhead

Salmonids in this ESU spawn and rear in tributaries that enter the Columbia River downstream from all FCRPS projects. The only effects of operation of the FCRPS on this ESU are potential habitat degradation in the estuary and plume. The magnitude of these effects is uncertain and appears to be minor, compared to other factors influencing the status of this species (Table 6.3-12).

NMFS previously concluded in Section 8 that the original proposed action was not likely to jeopardize this ESU or adversely modify its critical habitat. After reviewing the current status of UWR steelhead, the environmental baseline for the action area, the effects of the RPA, and the cumulative effects, it is NMFS' biological opinion that the RPA also is not likely to jeopardize the continued existence of UWR steelhead or to destroy or adversely modify designated critical habitat.

9.7.4.11 Lower Columbia River Steelhead

As discussed in Sections 6.2 and 9.7.2, this ESU is distributed primarily in spawning and rearing areas below Bonneville Dam. Within the action area, the key effects on this species are summarized in Sections 6.2.9 and 9.7.1. Effects of the FCRPS include passage mortality of juveniles and adults through one dam and reservoir for a limited number of subbasin populations (Table 6.3-2).

At the species level, this ESU has multiple populations within the Columbia River basin, most of which are below FCRPS projects. Quantitative evaluations of the effect of the RPA on this ESU's species-level biological requirements were not possible, but Table 9.7-16 indicates that most populations comprising this ESU are subjected to factors other than the FCRPS that limit their potential for survival and recovery.

NMFS concluded in Section 8 that the original proposed action was not likely to jeopardize this ESU or adversely modify its critical habitat. After reviewing the current status of LCR steelhead, the environmental baseline for the action area, the effects of the RPA, and the cumulative effects, it is NMFS' biological opinion that the RPA is not likely to jeopardize the continued existence of LCR steelhead or to destroy or adversely modify designated critical habitat.

9.7.4.12 Columbia River Chum Salmon

After reviewing the current status of CR chum salmon, the environmental baseline for the action area, the effects of the RPA (particularly Sections 9.7.1 and 9.7.2), and the cumulative effects, it is NMFS' biological opinion that the RPA is not likely to jeopardize the continued existence of CR chum salmon or to destroy or adversely modify designated critical habitat. This conclusion is based on elements of the RPA that remedy shortcomings of the proposed action, as described in Sections 8 and 9.7.4.1. Specifically, the RPA includes measures to improve survival within the action area beyond those anticipated from the original proposed action for the component of this ESU that migrates above Bonneville Dam and to meet action-area performance standards that have been integrated with performance standards for the full life cycle. Additionally, the RPA will result in implementation of offsite mitigation sufficient to meet the biological requirements (particularly those affecting critical spawning habitat) of CR chum salmon, when combined with other elements of the RPA and conservation measures anticipated in other life stages, as described in the All-H Paper.

9.7.4.13 Snake River Sockeye Salmon

After reviewing the current status of SR sockeye salmon, the environmental baseline for the action area, the effects of the RPA (particularly Sections 9.7.1 and 9.7.2), and the cumulative effects, it is NMFS' biological opinion that the RPA is not likely to jeopardize the continued existence of SR sockeye salmon or to destroy or adversely modify designated critical habitat. This conclusion is based on elements of the RPA that remedy shortcomings of the proposed action, as described in Sections 8 and 9.7.4.1. Specifically, the RPA includes measures to improve survival within the action area beyond those anticipated from the original proposed action and to meet action-area performance standards that have been integrated with performance standards for the full life cycle. Additionally, the RPA will result in implementation of offsite mitigation sufficient to meet the biological requirements of SR sockeye salmon, when combined with other elements of the RPA and conservation measures anticipated in other life stages, as described in the All-H Paper.