MEMORANDUM

FOR: FCRPS Biological Opinion Remand Files

FROM: James D. Ruff, FCRPS Branch Chief
FCRPS Branch staff

SUBJECT: Analytical Approach, Methods, and Biological Opinion Gap Analysis Survival Results for the Snake River (SR) and Upper Columbia River (UCR) Listed Salmon and Steelhead ESUs

Purpose

The purpose of this paper is to describe the analysis used to distinguish the effects of the existence of the FCRPS from the effects of discretionary annual operation and authorized purposes of the FCRPS, since only the latter is the subject of ESA consultation. This paper will describe the methods, analytical approach, and modeling survival results for the following ESUs: SR spring/summer chinook salmon, UCR and LCR spring chinook salmon, SR steelhead, and UCR, MCR and LCR steelhead. As explained below, a quantitative analysis was not conducted for SR fall chinook salmon.

Background

For purposes of this consultation, NOAA Fisheries must estimate the effects attributable to the FCRPS environmental baseline. The first step is to establish a reference operation to which the considerations for the limits of Action Agency discretion may be qualitatively applied. The value of this reference operation and analytical method described herein is to describe a mortality rate attributable to the existing configuration of the FCRPS that is a “conservative” estimate, e.g., one that is most protective, giving the benefit of the doubt to the listed species, and provides the basis for a quantitative assessment of the environmental baseline hydro effects (see Section 5.2 in the revised FCRPS Biological Opinion for a more complete description of the environmental baseline and reference operation).

By comparing the reference operation to the Action Agencies’ proposed hydro operation, the incremental effect of discretionary annual hydro operations can be estimated. The difference in survival rates between these two operations is referred to as a “gap,” and the method of estimating this gap is referred to as a “gap analysis.” Under this approach, NOAA Fisheries has defined a reference operation of the existing FCRPS structures that is most conservative for the listed species to quantitatively estimate a “reference survival rate” as a starting point for a qualitative assessment of environmental baseline effects. Since four federal mainstem “collector” dams are currently configured to collect and load listed juvenile fish into barges for transport around FCRPS projects, the reference operation also includes a transportation operation that utilizes existing fish passage facilities to the extent that, in NOAA Fisheries' judgment, transportation of listed fish results in higher survival.

NOAA Fisheries used its SIMPAS spreadsheet model to compare the survival rates resulting from this reference operation to the survival rates estimated for the Action Agencies' proposed hydro operations and fish passage facilities in both 2004 and 2010, which is intended to implement existing 2000 FCRPS Biological Opinion operations and achieve all project purposes. The differences in survival identified by this method of comparison, or gap analysis, represent the effects to the listed species that may be attributable to the existence of the dams and the proposed near-term and longer-term hydro operations.

Description of the Reference Operation and Proposed Action Operations

This section describes NOAA Fisheries' approach to defining an operation of the FCRPS that maximizes the survival of listed ESUs using existing dam configurations. The reference operation was developed based on information and data from: (a) the three NWFSC draft technical memoranda; (b) a literature review of available fish passage information, including fish passage information contained in Appendix D of 2000 FCRPS Biological Opinion; and (c) the best professional judgment of NOAA Fisheries Hydro Division staff. A hypothetical reference operation was developed to maximize survival for all 13 ESUs, including the hatchery/wild mixture of SR juvenile spring/summer chinook salmon, UCR spring chinook salmon, SR steelhead, UCR steelhead and SR fall chinook salmon. It does not, however, describe an operation that could actually be implemented, since the FCRPS must be operated to meet certain other authorized project purposes such as flood control.

<u>Development of Average Spring Flows for the Reference Operation</u>
For the reference operation, spring flow objectives remain as seasonal average values. The reference operation is based on full use of an unconstrained Federal hydropower system, which allows for a greater degree of Federal storage project flexibility than has been the case under the highly regulated regime which normally takes into account the combined constraints of irrigation withdrawals, flood control, and hydropower operations. For the reference operation, the average spring flow target in the Snake River is increased to 110 kcfs over the period from April through June 20. This flow target was based on observed breakpoints on a curve fitted between a flow index and survival for both juvenile SR spring chinook salmon and steelhead (Williams *et al.* 2004). It also factored in the potential value to be gained from reducing the travel time of steelhead through the Snake River. Elevated levels of predation on steelhead by Caspian terns nesting on islands in the McNary pool have been observed in recent years. It is reasonable to assume that a faster downstream migration rate, together with the higher turbidity associated

with higher spring flows, would help reduce this predation. Similarly, the average spring flow objective at McNary Dam was increased to 285 kcfs to reduce and thereby improve steelhead travel time through the middle and lower reaches of the Columbia River.

To define a reference operation to maximize fish survival for the 1994-2003 study period, NOAA Fisheries Hydro staff worked with BPA staff on BPA's hydro-system regulation model (HYDSIM) to evaluate changes in mainstem Snake and Columbia river flows, spills, and storage reservoir elevations resulting from a reference operation under a full range of 50 different water years (1929-1978). This difficult and time-consuming modeling effort required numerous modeling changes and studies to obtain the best reference operation, the priorities of which were to achieve refill of Federal storage projects by June 30, meet summer flow objectives, meet flow objectives in other periods of the year, and reduce forced (involuntary) spill at mainstem dams to minimize excess total dissolved gas. Accordingly, average spring flows were obtained from the 50-year HYDSIM model output flows using a post-processing hydrologic analysis. The flows are shown in Table 1 (see Attachment 1 for a description of how we matched 1929-78 output flows to the 1994-2003 biological opinion study period).[1]

Based on 50-year reference operation modeling, the average spring flow targets from the 2000 Biological Opinion for the Snake and Columbia rivers were either met or exceeded 72% and 78% of the time, respectively. In the reference operation, refill by June 30 was achieved at Dworshak, Hungry Horse, Libby and Grand Coulee 80%, 50%, 70% and 100% of the time, respectively, in the 50-year record.

Development of Average Spring Flows for the Proposed Hydro Operation

For the proposed hydro operation, NOAA Fisheries staff used the description in the updated proposed action dated August 2004 from the federal Action Agencies and their 2004-2008 Annual Implementation Plan for the 2000 Biological Opinion. Our review of these documents suggests an operation that is similar to existing 2000 Biological Opinion operations. Accordingly, NOAA Fisheries staff used current 2000 Biological Opinion operations to replicate the proposed action operation and relied on the seasonal average flows obtained from BPA's HYDSIM modeling of existing biological opinion operations over the 1929-1978 period to define the proposed action flow levels. The principle differences between this proposed hydro operation and the one analyzed in the 2000 Biological Opinion are updated Kootenai River white sturgeon and bull trout flow requirements consistent with the USFWS 2000 FCRPS Biological Opinion and changes in the maximum voluntary spill rates at several mainstem dams to reflect an improved understanding of spill effects on total dissolved gas. Again, average spring flows were obtained from the 50-year HYDSIM model output flows, using a post-processing hydrologic analysis. The average spring flows are shown in Table 1 (see Attachment 1). The

[1] It is noteworthy that the range of water conditions experienced over the past 10 years in the Columbia Basin is representative of a full range of runoff conditions over the longer 50-year period.

average spring flow targets from the 2000 Biological Opinion for the Snake and Columbia rivers were either met or exceeded, based on 50-year modeling of the proposed hydro operation, 68% and 82% of the time, respectively. In the reference operation, the spring flow targets from the 2000 Biological Opinion for the Snake and Columbia rivers were met or exceeded, based on 50-year modeling of the reference operation, 72% and 78% of the time, respectively.

Table 1 –Average spring flows[2] (in kcfs) obtained from BPA hydrosystem modeling of both the proposed hydro action (P.A.) and reference operation (Ref.).

	Year	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
P.A.	L. Snake	56	94	125	145	105	113	80	54	85	73
P.A.	Columbia	162	244	316	402	258	311	246	156	256	195
Ref.	L. Snake	57	94	126	148	107	113	80	48	84	73
Ref.	Columbia	157	245	321	425	269	319	252	144	269	182

<u>Spring Voluntary Fish Spill Levels for the Proposed Hydro and Reference Operations</u>

For FCRPS project spill levels, NOAA Fisheries staff assumed the following spring spill rates for each project under the proposed hydro operation (Table 2). These levels are based on the Action Agencies' Updated Proposed Action (August 2004). Table 3 outlines the 24-hour spill levels that were defined for the reference operation.

<u>Spring Transportation Operations under the Proposed Hydro and Reference Operations</u>

Based on the Action Agencies' Updated Proposed Action (August 2004), spring transport operations under the proposed hydro operation were assumed to be the same as defined in the 2000 FCRPS Biological Opinion. Thus, for the proposed hydro operation, the flow threshold for eliminating spill at the three Snake River collector projects and going to a full collection and transport operation remains at the 85 kcfs seasonal average flow level.

The Updated Proposed Action (August 2004) spring transportation protocol for juvenile Snake River spring/summer chinook salmon and Snake River steelhead calls for the following actions:

- All fish collected at Snake River dams will be transported.
- Spill will be provided at Snake River collector dams when average spring (April 3 - June 20) flows are projected to exceed 85 kcfs. The provision of spill reduces the efficiency of juvenile fish collection and provides the safest route of passage for fish that migrate in-river.

[2] Seasonal average flows during April 3-June 20 spring period at Lower Granite Dam on the lower Snake River and average flows during April 10-June 30 spring period at McNary Dam on the Columbia River. Flows shown are rounded to the nearest kcfs.

Table 2 – Proposed Hydro Operation Spring Spill Levels and Spill Caps

FCRPS dam-by-dam spill levels in kcfs (unless otherwise indicated).					
Dam	**Spill Cap-Night**[3]	**Spill Cap-Day**	**Spill Min**	**PH Min.**	**PH Max.**
LWG[4]	20	20	-	9	118
LGS	45	0	-	9	118
LMN	40	40	-	9	123
IHR[5]	20	20	-	9	92
MCN	150	0	-	50	170
JDA	60% or 160[6]	0	25%	50	350
TDA	40%	40%	-	50	345
BON	120	75	50	30	264

Table 3 – Reference Spring Operation Spill Levels, Spill Caps, and Assumptions.

Spill assumptions:

1 Gas cap spill based on 120% allowable TDG based on 2002 and 2003 tailrace fixed gas monitor station readings
2 24-hour spill , unless noted
3 In-river fish passage priority
4 Voluntary spill
5 Adult passage factors considered

Project	Reference Operation Spill Levels	Gas Cap Spill
Lower Granite	20 kcfs with RSW	60 kcfs
Little Goose	40 kcfs	45 kcfs
Lower Monumental	40 kcfs	40 kcfs
Ice Harbor	45 kcfs with RSW	100 kcfs
McNary	Spill to gas cap	185 kcfs
John Day	60% of project discharge up to gas cap	160 kcfs
The Dalles	40% of project discharge up to gas cap	150 kcfs
Bonneville	Day spill 120 kcfs; night spill up to gas cap	150 kcfs

[3] Spill caps based on 120% allowable TDG in tailrace from fixed monitor station readings, unless otherwise noted (Lower Granite and Ice Harbor dams).
[4] Spill at Lower Granite is 20 kcfs total, which includes 7 kcfs through the RSW.
[5] Spill at Ice Harbor is 20 kcfs total, which includes 7 kcfs through the RSW.
[6] The John Day Dam spill cap is 60% of total river flow up to the gas cap of 160 kcfs. Then it becomes the gas cap.

- When average spring flow in the Snake River is projected to be less than 85 kcfs, no spill will be provided at Snake River collector projects, forcing fish to use powerhouse routes and thus maximizing collection and transportation of juvenile salmonids.

For spring transport operations in the reference operation, NOAA Fisheries proposes to reduce the flow threshold for eliminating spill at Snake River collector projects. The threshold would be reduced from 85 kcfs, as in the proposed action, to 70 kcfs seasonal average flow. Hence, a full collection and transport operation, along with the curtailment of spill at collector dams, would be triggered by a seasonal average flow projection of 70 kcfs or less. As a result of the use of PIT-tag technology, spring transport studies conducted from 1995 through 2001 have yielded much more comprehensive information about the effects of transportation. The findings of these studies are summarized and presented in Williams *et al.* (2004).

A summary of the NOAA Fisheries Hydro Division interpretation of the spring transport management implications drawn from Williams *et al.* (2004) follows (see Attachment 2, P. Wagner 6-18-04 memo):

- There appears to be little consistent benefit provided to wild spring chinook by transportation.

- There appears to be a benefit provided to hatchery spring chinook by the transportation program. That benefit is most significant after May 1.

- There appears to be a benefit provided to both wild and hatchery steelhead from the transportation program.

- The benefit from transportation for listed spring migrants increases through the spring. The benefit from transportation during the month of April appears to be negligible, becoming more significant after May 1.

<u>Development of Summer Flow Objectives for the Reference Operation</u>

For the reference operation, the summer flow objectives for the Snake River were established as follows: June 21 through July 31, 65 kcfs; August 1 through August 31, 60 kcfs; and September 1 through September 15, 50 kcfs. These values are based on known flow/survival information (Smith *et al.* 2003), run timing, and historical water availability. That is, compared to spring flows, water available for summer flow augmentation in the Snake basin is limited. To maximize the potential benefit from available water, the highest flow objective was set for the June 21 through July 31 timeframe, when the majority of fall chinook are migrating, with flows gradually decreasing after that time. This approach also conforms more closely with the natural hydrograph, which typically peaks in June and then recedes throughout the summer.

Similarly, based on average run timing for SR fall chinook in the lower Columbia River, summer flow objectives were established as follows: July 1 through July 31, 210 kcfs; August 1 through September 7, 200 kcfs. The reference operation is based on full use of an unconstrained Federal hydropower system, which allows for a greater degree of operational flexibility than has been the case under the highly regulated regime that normally takes into account the combined constraints posed by the nondiscretionary project purposes of irrigation withdrawals, flood control, and hydropower operations.

To define a reference operation for SR fall chinook over the 8-year study period (1995-2001 and 2003), NOAA Fisheries staff again worked with BPA staff on BPA's hydro-system regulation model (HYDSIM) to evaluate changes in mainstem Snake and Columbia river summer flows and spills resulting from a reference operation under a full range of 50 different water years (1929-1978). This effort required numerous modeling changes and studies in trying to obtain the best reference operation, the priorities of which were to achieve refill of Federal storage projects by June 30, meet summer flow objectives, meet flow objectives in other periods of the year, and reduce involuntary spill at mainstem dams to minimize excess total dissolved gas. Average summer flows were obtained from the 50-year HYDSIM model output flows, using a post-processing hydrologic analysis. The flows are shown in Table 4 (see Attachment 1 for a description of how we matched 1929-78 output summer period flows to the biological opinion study period).

The average summer flow targets at Lower Granite and McNary dams for the reference operation were either met or exceeded, based on HYDSIM's 50-year hydro operations simulation, about 10% and 78% of the time, respectively.[7] In the reference operation, refill of Federal storage projects by about June 30 was achieved at Dworshak, Hungry Horse, Libby, and Grand Coulee 80%, 50%, 70%, and 100% of the time in the 50-year record, respectively.[8]

<u>Development of Average Summer Flows for the Proposed Hydro Operation</u>

For the proposed hydro operation flow objectives, NOAA Fisheries staff used the operations identified in the Federal Action Agencies' updated proposed action dated August 2004, as well as their 2004-2008 Annual Implementation Plan for the 2000 Biological Opinion. These documents suggest a hydro operation with flow objectives that are similar to those specified in the 2000 FCRPS Biological Opinion. NOAA Fisheries staff used current 2000 Biological Opinion operations to replicate the proposed hydro operations, both in 2004 and 2010, and relied on the seasonal average flows obtained from BPA's HYDSIM modeling of existing biological opinion operations over the 1929-1978 period to define the proposed action flow levels. The principle differences between this proposed hydro operation and the one analyzed in the 2000

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[7] Seasonal average flow targets used for this comparison were the same as those identified in the 2000 Biological Opinion.

[8] For the refill analysis, refill means the project is within 1-foot of full pool on or about June 30.

Biological Opinion are updated Kootenai River white sturgeon and bull trout flow requirements consistent with the USFWS 2000 FCRPS Biological Opinion and changes in the maximum voluntary spill rates at several mainstem dams to reflect an improved understanding of spill effects on total dissolved gas. Again, average summer flows were obtained from the 50-year HYDSIM model output flows using a post-processing hydrologic analysis. The average summer flows are shown in Table 4 (see Attachment 1). The average summer flow objectives from the 2000 Biological Opinion for Lower Granite and McNary dams were either met or exceeded, based on the 50-year proposed hydro operations modeling, 10% and 36% of the time, respectively. In the proposed hydro operation, refill by the end of June or early July was achieved at Dworshak, Hungry Horse, Libby, and Grand Coulee 82%, 56%, 26%, and 100% of the time in the 50-year record, respectively.[9]

Table 4 – Simulated average summer flows[10] (in kcfs) obtained from BPA hydro-system modeling of both the proposed hydro action (P.A.) and reference operation (Ref.).

	Year	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2003**
P.A.	L. Snake	43	54	60	44	48	35	27	36
P.A.	L. Col.	139	188	196	136	182	131	115	129
Ref.	L. Snake	47	58	65	48	55	38	27	39
Ref.	L. Col.	179	213	220	178	210	177	166	175

Summer Voluntary Fish Spill Levels for the Proposed Hydro and Reference Operations

For FCRPS project spill levels, NOAA Fisheries staff assumed 2000 Biological Opinion summer spill rates for the proposed hydro operation (Table 5). Table 6 outlines the 24-hour spill levels that were defined for the reference operation.

Summer Transportation Operations under the Proposed Hydro and Reference Operations

It was assumed that summer transport operations under both the proposed hydro operation and the reference operation would be the same as defined in the 2000 FCRPS Biological Opinion, i.e., no spill at collector projects and all collected fish would be transported from Lower Granite, Little Goose, Lower Monumental, and McNary dams.

[9] For the proposed operation refill analysis, refill means the project is within 1-foot of full pool or upper (flood control) rule curve on June 30. At Libby, refill events that occurred in July were included.
[10] Seasonal average flows during June 21 – September 30 summer period at Lower Granite Dam on the lower Snake River, and average flows during July 1 – September 30 summer period at McNary Dam on the Columbia River.

Table 5 – Proposed Hydro Operation Summer Spill Levels and Spill Caps.

FCRPS dam-by-dam spill levels in kcfs unless otherwise indicated.					
Dam	**Spill Cap-Night[11]**	**Spill Cap-Day**	**Spill Min**	**PH Min.**	**PH Max.**
LWG	0	0	-	na	118
LGS	0	0	-	na	118
LMN	0	0	-	na	123
IHR[12]	20	20	-	9	92
MCN	0	0	-	na	170
JDA	30% or 160[13]	30% or 160	25%	50	350
TDA	40%	40%	-	50	345
BON	120	75	50	30	264

Table 6 – Reference Operation Summer Spill Levels, Spill Caps and Assumptions.

Spill assumptions:

1. Gas cap spill based on 120% allowable TDG based on 2002 and 2003 tailrace fixed gas monitor station readings
2. 24-hour spill , unless noted
3. Voluntary spill
4. Adult passage factors considered

Project	Reference Operation Spill Levels	Gas Cap Spill
Lower Granite	No spill	n/a
Little Goose	No spill	n/a
Lower Monumental	No spill	n/a
Ice Harbor	20 kcfs with RSW	100 kcfs
McNary	No spill	185 kcfs
John Day	60% of project discharge up to gas cap	160 kcfs
The Dalles	40% of project discharge up to gas cap	150 kcfs
Bonneville	Day spill 120 kcfs; night spill up to gas cap	150 kcfs

[11] Spill caps based on 120% allowable TDG in tailrace from fixed monitor station readings, unless otherwise noted (Ice Harbor Dam).
[12] Spill at Ice Harbor is 20 kcfs total with RSW operation.
[13] The John Day Dam spill cap is 60% of total river flow up to the gas cap of 160 kcfs, then it becomes the gas cap.

Thus, for both operations, the summer transportation protocol for juvenile Snake River fall chinook salmon calls for the following actions:

- All fish collected at Snake River dams and McNary Dam will be transported.
- Spill will not be provided during the summer period at the Snake River collector dams and McNary in order to maximize the number of fish collected and transported.
- Spill will be provided at non-collector dams, including Ice Harbor, John Day, The Dalles and Bonneville, on a 24-hour basis from approximately June 21 through August 31.

For the summer transport operations in the reference operation, NOAA Fisheries determined to continue the same transport operation as called for in the 2000 Biological Opinion. This is based on Williams *et al.* (2004), which states that "no empirical evidence exists to suggest that transportation either harms or helps fall chinook salmon." Thus, it is uncertain whether transport provides a benefit or a detriment for SR fall chinook. The lack of scientific information to inform the appropriate transportation strategy results in a determination based on a combination of policy and scientific considerations (personal communication, D. Robert Lohn, August 25, 2004).

A significant consideration is that for the past several years since the 2000 Biological Opinion, the region has experienced above-average adult returns of SR fall chinook under a strategy that maximizes transportation of juvenile SR fall chinook during the summer months. Without better information, a change to a strategy of leaving more fish in the river could either further improve or instead reduce the level of adult returns. The risk of a reduction in adult returns associated with leaving more fish in the river is less acceptable than the risk of failing to achieve even higher adult returns than the record numbers observed during the past four years.

Therefore, for the reference operation, NOAA Fisheries' transport strategy will be to use the same approach identified in the 2000 Biological Opinion, i.e., to maximize juvenile fish collection and transportation due to concerns about low in-river survival rates. However, given the absence of empirical information on the benefits of transportation for this stock, the Action Agencies' proposal to initiate an in-river survival and summer transport evaluation in the Snake River by 2007/2008 is an important component of this strategy.

Higher summer flows provided under the reference operation are intended to help move juvenile fish to the Snake River collector projects in a timely manner, as well as to improve in-river survival rates for those fish not transported (Williams *et al*. 2004). Even with the higher flows provided in the reference operation, average summer flows are often below the biological flow objectives (the Snake River flow objective is only met 10% of the time in the reference operation), and water temperatures can exceed the 20° C State of Washington water temperature standard in portions of the lower Snake River. Thus, under this transport strategy, fish spill continues to be curtailed at the four transport projects, and all collected fish are transported during the summer to try to improve overall juvenile fish survival. For those relatively few fish that are left in-river to migrate on their own, higher flows and 24-hour spill at each non-collector dam are provided in the reference operation to maximize in-river survival to below Bonneville Dam.

Summary Description of FCRPS Project Proposed Hydro and Reference Operations

Table 7 provides a summary description of the differences in operations and system configuration, i.e., structural changes, between the proposed hydro operation and the reference operation[14] for FCRPS projects. Specific operations for ESA-listed bull trout and Kootenai River white sturgeon at Libby and Hungry Horse, with a related effect at Grand Coulee,[15] are included in both the proposed hydro operation and the reference operation, because those operations have already undergone ESA Section 7 consultation between the USFWS and the Action Agencies in 2000 and are included in the USFWS 2000 FCRPS Biological Opinion.

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[14] The hypothetical reference operation serves an analytical purpose for the gap analysis but does not describe an operation that could actually be implemented, since the FCRPS projects must be operated to meet certain other authorized project purposes.

[15] Implementation of VARQ flood control operations at both Libby and Hungry Horse, which is required as part of the 2000 USFWS Biological Opinion for bull trout and sturgeon, results in a related minor change in flood control elevations at FDR Lake behind Grand Coulee Dam.

Table 7 – Summary Description of the Reference and Proposed Hydro Operations and Fish Passage Improvements at FCRPS Projects

FCRPS Project	Reference Operation	Proposed Hydro Operation
Libby	• Operate as a run-of-river project, e.g., operate at full pool and pass inflow unless winter/spring drafts are needed for salmon flow augmentation or to reduce TDG downstream at mainstem dams • Try to refill by about June 30 each year[16] • Draft as needed to meet salmon flow targets and remove summer draft limit. • Maintain minimum flows for ESA-listed bull trout • Provide tiered volumes for ESA-listed KR white sturgeon spawning/recruitment • Operate within hourly/daily ramp rates for bull trout • Provide even or gradually-declining flows during summer months (minimize double peak) • Negotiate with Canada annually to try to implement a storage exchange • Limit spill to avoid exceeding Montana State TDG standards of 110%	• Use VARQ flood control criteria • Use variable Dec. 31 flood control curve based on runoff forecast • Minimum flow = 4 kcfs • Maintain minimum flows for bull trout • Provide tiered volumes for listed KR white sturgeon spawning/recruitment • Operate within hourly/daily ramp rates for bull trout • Operate to achieve 75% chance of reaching URC elev. by April 10 • Refill by about June 30 each year • Draft to meet salmon flow objectives during July-August w/ draft limit of 2439 ft. by Aug. 31 • Provide even or gradually-declining flows during summer months (minimize double peak) • Negotiate with Canada annually to try to implement a storage exchange • Limit spill to avoid exceeding Montana State TDG standards of 110%
Hungry Horse	• Operate as a run-of-river project, e.g., operate at full pool and pass inflow unless winter/spring drafts are needed for salmon flow augmentation or to reduce TDG downstream at mainstem dams • Try to refill by June 30 each year • Draft as needed to meet salmon flow targets and remove summer draft limit • Maintain minimum flows for ESA-listed bull trout • Operate within hourly/daily ramp rates for bull trout • Provide even or gradually-declining flows during summer months (minimize double peak) • Limit spill to avoid exceeding Montana State TDG standards of 110%	• Use VARQ flood control • Min Q = 400-900 cfs at site, w/ sliding scale min Q of 3200-3500 cfs at Col. Falls • Maintain minimum flows for bull trout • Operate within hourly/daily ramp rates for bull trout • Operate to achieve 75% chance of reaching URC elev. by April 10 • Refill by June 30 each year • Draft to meet salmon flow objectives during July-August w/ draft limit of 3540 ft. by Aug. 31 • Provide even or gradually-declining flows during summer months (minimize double peak) • Limit spill to avoid exceeding Montana State TDG standards of 110%

[16] June 30 refill of FCRPS storage projects has priority over attempting to meet spring flow objectives.

FCRPS Project	Reference Operation	Proposed Hydro Operation
Albeni Falls	• Operate as a run-of-river project, e.g., operate at full pool and pass inflow unless winter/spring drafts are needed for salmon flow augmentation or to reduce TDG downstream at mainstem dams • Draft to elev. 2051 ft. by Nov. 30 annually • Try to refill by June 30 • Draft as needed to meet salmon flow targets	• Use standard flood control • Draft to elev. 2051 ft. by Nov. 30 annually
Grand Coulee	• Operate as a run-of-river project, e.g., operate at full pool and pass inflow unless winter/spring drafts are needed for salmon flow augmentation or to reduce TDG downstream at mainstem dams • Try to refill by June 30 each year • Draft as needed to meet salmon flow targets and remove summer draft limits • Eliminate irrigation withdrawal pumping into Banks Lake and remove associated return flows	• Use standard flood control. • Operate to achieve 85% chance of reaching URC elevation by April 10. • Refill by June 30 each year • Draft to meet salmon flow objectives during July-August w/ variable draft limit of 1278-1280 ft. by August 31 • Incl. irrigation withdrawal pumping into Banks Lake; operate Banks Lake up to 5 ft. from full pool during August to meet flow target
Chief Joseph	• Use available storage to assist in meeting salmon flow targets • Install spillway flow deflectors	• Operate as run-of-river project • Install spillway flow deflectors
Dworshak	• Operate as a run-of-river project, e.g., operate at full pool and pass inflow unless winter/spring drafts are needed for salmon flow augmentation or to reduce TDG downstream at mainstem dams • Try to refill by June 30 each year. Draft as needed to meet salmon flow targets and regulate outflow temps. to achieve water temperature standard at LWG • Maximum project discharge for salmon flow augmentation to be within State of Idaho TDG water quality standards (14 kcfs)	• Use standard flood control; shift system FC to GCL in below avg water years, if possible • Minimum flow = 1.3 kcfs • Refill by June 30 each year • Draft to meet salmon flow objectives during July-August w/ draft limit of 1520 ft. by Aug. 31 • Regulate outflow temps. to meet WQ temperature std. at LWG • Maximum project discharge for salmon flow augmentation to be within State of Idaho TDG water quality standards (14 kcfs)

FCRPS Project	Reference Operation	Proposed Hydro Operation
Lower Snake River dams (LWG to IHR)	• Operate at MOP elev. from April thru September • During the spring: spill 20 kcfs at Lower Granite; spill 40 kcfs at Little Goose and Lower Monumental; spill 45 kcfs at Ice Harbor[17] • During the summer: spill 20 kcfs at Ice Harbor; provide no spill at Lower Granite, Little Goose, and Lower Monumental[18] • Transport all fish collected at LWG, LGS, and LMN in accordance with transport protocol described earlier • Continue predator control • Operate RSWs with 24-hour spill at Lower Granite (spring only) and Ice Harbor dams	• Operate at MOP elev. from April 10 until small number of juvenile migrants are present, except at Lower Granite operate at MOP until TMT determines the Lower Granite forebay has cooled enough, generally after October 1 • During the spring: spill 20 kcfs at Ice Harbor and Lower Granite; spill to the gas cap at Little Goose and Lower Monumental[19] • During the summer: spill 20 kcfs at Ice Harbor; provide no spill at Lower Granite, Little Goose, and Lower Monumental[20] • Collect fish and transport at LWG, LGS and LMN; provide fish spill in years when flows >85 kcfs during spring months • Operate RSWs with 24-hour spill at Lower Granite. Little Goose, Lower Monumental (in spring only) and at Ice Harbor Dam (when flows are ≥85 kcfs)
Columbia River dams (MCN to BON)	• Operate JDA pool at MOP (elev. 257 ft.) April-Sept. • Spill 120 kcfs during the day and spill to gas cap at night at Bonneville; spill 40% at The Dalles; spill 60% at John Day April thru Sept. 7 • Spill to the gas cap at McNary during the spring, and provide no spill at McNary during the summer • Continue predator control • Operate corner collector at Bonneville Second P.H. April through Sept. 7	• Operate JDA pool at MIP from April 10 thru Sept. 30 • Spill 75 kcfs during the day and spill to the gas cap at night at Bonneville April through August • Spill 40% at The Dalles April through August • At John Day spill 60% at night during the spring (April-June) and 30% 24-hrs. during the summer (June-August) • At McNary, spill to the gas cap at night during the spring and provide no spill during the summer • Operate corner collector at Bonneville Second P.H. April through August • Operate RSWs with 24-hour spill at McNary (in spring only) and John Day dams

[17] Spill levels at mainstem Snake and lower Columbia River FCRPS projects are defined in Tables 2, 3, 5 and 6.
[18] See Table 6.
[19] See Table 2.
[20] See Table 5.

Description of the Proposed Hydro and Reference Operations for non-FCRPS Projects

No modification in current operations is assumed to be made for non-Federal hydropower projects. These projects are not a part of the FCRPS proposed action but their operational effects are included in the hydrosystem modeling analysis of both the reference operation and the proposed action operation. Thus, the operation of non-Federal projects is, in essence, a common denominator in comparing the proposed action to the reference operation. Project operations for the non-Federal dams in the Columbia River basin are summarized below.

Canadian projects: Operate all Canadian Columbia River Treaty projects to the appropriate Assured Operating Plan requirements. Operate Kootenai Lake to the current IJC order. Continue existing Treaty/Non-treaty non-power storage and flow shaping operations.

Reclamation tributary projects:

- Reclamation is completing supplemental consultations on the operation and maintenance of its authorized tributary projects, the effects of which occur within the range of the listed species. To provide complete coverage on the entire effect of these tributary projects, USBR chose to consult on the mainstem effects of the 19 Columbia River Basin projects as part of the FCRPS consultation. The hydrologic effects calculated at the mouth of the tributary for each individual tributary consultation are assumed to be the hydrologic effects on the mainstem Columbia River for this consultation. Those effects can be found in Table 1-2 on page C-7 of Appendix C of the *Draft Proposed Action for the FCRPS Biological Opinion Remand,* dated August 2004. A listing of the 19 USBR projects operating in the Columbia River Basin can be found in Table 1-1 on page C-4 of that same document.

- USBR projects in the upper Snake basin and the Idaho Power Company Hells Canyon Complex are not considered part of the environmental baseline for this analysis, because they are not within the FCRPS action area. There is currently a completed consultation on the upper Snake basin so this analysis will use inflows to Brownlee based on the *2001 Amended Biological Assessment for Bureau of Reclamation Operations and Maintenance in the Snake River above Brownlee Reservoir.* The 10 upper Snake River projects that are listed in Table 1.0-1 on page 1-2 of the NMFS 2000 FCRPS Biological Opinion have completed a Section 7(a)(2) consultation. The Lewiston Orchard project, also shown in Table 1.0-1, is undergoing separate consultation, and its effects are included in the 19 Columbia River projects mentioned previously.

Methods Used in Conducting the Gap Analysis

SR Spring/Summer Chinook and UCR and LCR Spring Chinook

Three major analytical steps were necessary under the NOAA Fisheries approach to complete a gap analysis using the SIMPAS model. The first step was to define and analyze a retrospective analysis of survivals over the 1994-2003 study period. This step is needed to determine if a relation between flow and survival existed during the study period and, if so, to define a functional relationship that could be applied to the reference and proposed hydro operation flow conditions. In this step, the SIMPAS model was calibrated to reflect the annual NWFSC empirical SR spring/summer chinook reach survival estimates using the actual flows, spills, and, to the extent possible, actual dam passage conditions and survival data applicable for each year.[21] The annual changes in various dam passage parameters for the yearling chinook retrospective analysis are specified in Tables 8 through 17. After calibrating the model with these annual reach survival data, the resultant pool survival estimates (empirical reach survival values without dam survival) were calculated by the model for use in the next step in the analysis.

[21] As part of our analytical approach for the retrospective analysis, we used actual seasonal average flow and project-specific spill levels that occurred in each year. Similarly, to reflect annual changes in dam survival, we used historical measured dam passage survival rates and fish passage efficiency data reflecting actual changes in passage conditions and/or installation of fish passage improvement facilities for each year and at each of the mainstem FCRPS dams.

Table 8. 1994 Retro Operation Passage Parameters for Snake River Spring/Summer Chinook[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	18.6	1.5	68%	57% [6]	93%	98%	98%	n/a
LGS	15.3	12.0	68%	57%[6]	92%	100%[5]	99%	n/a
LMN	10.6	0.9	83%	49%	86.5%[4]	95.6%[7]	95%	n/a
IHR	23.1	18.1	50%	54%	90%	94%[8]	95%[10]	n/a
MCN	29.8	6.3	68%	57%[6]	90%	95%[11]	90%[11]	n/a
JDA	11.5	3.1	80%	73%	90%	98%	99%[14]	n/a
TDA	41.0	0.4	50%	3%	84%[12]	90%[13]	n/a	96.5%[15]
BON-I[9]				39%	90%		90%	90%[16]
Spillway	96.8	70.5	50%			98%		
BON-II				48%	90%		90%[17]	n/a

References:

1. All parameters without specific references were taken from the 2000 BiOp, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 BiOp, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. Al. N. Am J. of Fish Mgnt. 2001.
5. Iwamoto et al. 1994.
6. FGE prior to ESBS Installation (average over several years of evaluation).
7. Average of 1994 LMN spillway survival estimates (.927 and .984) - Muir et al 1995.
8. Average of 2000, '02, '03 IHR spillway survival estimates - Eppard et al. 2002, 2003.
9. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
10. Best professional judgment given that the system passed fish through the sluiceway.
11. MCN bypass and spillway survivals are the average of 2002 and 2003 RT survival point estimates (Axel, G.A. et al. 2004a and 2004b).
12. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
13. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
14. Average of point estimates for route specific JDA JBS survival in 2002 and 2003 with low spill.
15. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates @ 40% spill.
16. Best professional judgement - assume no better than PH1 turbine survival.
17. Best professional judgement for PH2 JBS spring migrants given poor summer results and PH1 flow priority.

Table 9. 1995 Retro Operation Passage Parameters for Snake River Spring/Summer Chinook[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	19.0	3.2	68%	57% [6]	93%	98%	98%	n/a
LGS	29.2	10.1	68%	57%[6]	92%	100%[5]	99%	n/a
LMN	20.3	10.3	83%	49%	86.5%[4]	95.6%[8]	95%	n/a
IHR	34.5	35.5	50%	54%	90%	94%[9]	95%[10]	n/a
MCN	110.0	78.3	50%	57%[6]	90%	95%[11]	90%[11]	n/a
JDA	9.7	7.3	80%	73%	82%[12]	98%	95%[15]	n/a
TDA	124.2	124.2	50%	3%	84%[13]	90%[14]	n/a	96.5%[16]
BON-I [7]				39%	90%		90%	90%[17]
Spillway	110.5	73.0	50%			98%		
BON-II				48%	90%		90%[18]	n/a

References:

1. All parameters without specific references were taken from the 2000 BiOp, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 BiOp, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. Al. N. Am J. of Fish Mgnt. 2001.
5. Iwamoto et al. 1994.
6. FGE prior to ESBS Installation (average over several years of evaluation).
7. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
8. Average of 1994 LMN spillway survival estimates (.927 and .984) - Muir et al 1995.
9. Average of 2000, '01, '02, IHR spillway survival estimates - Eppard et al. 2002, 2003.
10. Best professional judgment given that the system passed fish through the sluiceway.
11. MCN bypass and spillway survivals are the average of 2002 and 2003 RT survival point estimates (Axel, G.A. et al. 2004a and 2004b).
12. Average of point estimates for route specific JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
13. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
14. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
15. Average of point estimates for route specific JDA JBS survival in 2002 and 2003 with 0/60 spill (91 and 100%).
16. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates @ 40% spill.
17. Best professional judgement - assume no better than PH1 turbine survival.
18. Best professional judgement for PH2 JBS spring migrants given poor summer results and PH1 flow priority.

Table 10. 1996 Retro Operation Passage Parameters for Snake River Spring/Summer Chinook[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	55.4	51.3	50%	75%	93%	98%	98%	n/a
LGS	60.4	42.7	50%	78%	92%	100%[5]	99%	n/a
LMN	55.1	44.4	50%	49%	86.5%[4]	95.6%[8]	95%	n/a
IHR	58.6	55.8	50%	54%	90%	94%[9]	98%	n/a
MCN	206.8	199.9	50%	57%[6]	90%	95%[10]	90%[10]	n/a
JDA	85.7	79.6	50%	73%	82%[11]	98%	95%[14]	n/a
TDA	205.7	205.7	50%	3%	84%[12]	90%[13]	n/a	96.5%[15]
BON-I [7]				39%	90%		90%	90%[16]
Spillway	189.1	168.3	50%			98%		
BON-II				48%	90%		90%[17]	n/a

References:

1. All parameters without specific references were taken from the 2000 BiOp, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 BiOp, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. Al. N. Am J. of Fish Mgnt. 2001.
5. Iwamoto et al. 1994.
6. FGE prior to ESBS Installation (average over several years of evaluation).
7. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
8. Average of 1994 LMN spillway survival estimates (.927 and .984) - Muir et al 1995.
9. Average of 2000, '01, '02, IHR spillway survival estimates - Eppard et al. 2002, 2003.
10. MCN bypass and spillway survivals are the average of 2002 and 2003 RT survival point estimates (Axel, G.A. et al. 2004a and 2004b).
11. Average of point estimates for route specific JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
12. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
13. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
14. Average of point estimates for route specific JDA JBS survival in 2002 and 2003 with 0/60 spill (91 and 100%).
15. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates @ 40% spill.
16. Best professional judgement - assume no better than PH1 turbine survival.
17. Best judgement for PH2 JBS spring migrants given poor summer results and PH1 flow priority.

Table 11. 1997 Retro Operation Passage Parameters for Snake River Spring/Summer Chinook[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	60.9	47.8	50%	75%	93%	98%	98%	n/a
LGS	61.0	50.9	50%	78%	92%	100%[5]	99%	n/a
LMN	66.5	52.6	50%	49%	86.5%[4]	95.6%[6]	95%	n/a
IHR	90.3	83.7	50%	54%	90%	94%[8]	98%	n/a
MCN	266.5	263.0	50%	83%	90%	95%[9]	90%[9]	n/a
JDA	142.4	141.3	50%	73%	82%[10]	98%	95%[13]	n/a
TDA	267.3	267.3	50%	3%	84%[11]	90%[12]	n/a	96.5%[14]
BON-I [7]				39%	90%		90%	90%[15]
Spillway	234.7	226.2	50%			98%		
BON-II				48%	90%		90%[16]	n/a

References:

1. All parameters without specific references were taken from the 2000 BiOp, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 BiOp, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. Al. N. Am J. of Fish Mgnt. 2001.
5. Iwamoto et al. 1994.
6. Average of 1994 LMN spillway survival estimates (.927 and .984) - Muir et al 1995.
7. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
8. Average of 2000, '01, '02, IHR spillway survival estimates - Eppard et al. 2002, 2003.
9. MCN bypass and spillway survivals are the average of 2002 and 2003 RT survival point estimates (Axel, G.A. et al. 2004a and 2004b).
10. Average of point estimates for route specific JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
11. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
12. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
13. Average of point estimates for route specific JDA JBS survival in 2002 and 2003 with 0/60 spill (91 and 100%).
14. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates @ 40% spill.
15. Best professional judgement - assume no better than PH1 turbine survival.
16. Best judgement for PH2 JBS spring migrants given poor summer results and PH1 flow priority.

Table 12. 1998 Retro Operation Passage Parameters for Snake River Spring/Summer Chinook[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	37.2	30.4	50%	75%	93%	98%	98%	n/a
LGS	49.8	23.6	50%	78%	92%	100%[5]	99%	n/a
LMN	41.8	23.1	50%	49%	86.5%[4]	95.6%[6]	95%	n/a
IHR	80.5	52.3	50%	54%	90%	94%[8]	98%	n/a
MCN	139.3	93.5	50%	83%	90%	95%[9]	90%[9]	n/a
JDA	121.8	57.1	50%	73%	82%[10]	98%	95%[13]	n/a
TDA	126.1	126.1	50%	3%	84%[11]	90%[12]	n/a	96.5%[14]
BON-I [7]				39%	90%		90%	90%[15]
Spillway	129.1	91.0	50%			98%		
BON-II				48%	90%		90%[16]	n/a

References:

1. All parameters without specific references were taken from the 2000 BiOp, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 BiOp, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. Al. N. Am J. of Fish Mgnt. 2001.
5. Iwamoto et al. 1994.
6. Average of 1994 LMN spillway survival estimates (.927 and .984) - Muir et al 1995.
7. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
8. Average of 2000, '01, '02, IHR spillway survival estimates - Eppard et al. 2002, 2003.
9. MCN bypass and spillway survivals are the average of 2002 and 2003 RT survival point estimates (Axel, G.A. et al. 2004a and 2004b).
10. Average of point estimates for route specific JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
11. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
12. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
13. Average of point estimates for route specific JDA JBS survival in 2002 and 2003 with 0/60 spill (91 and 100%).
14. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates @ 40% spill.
15. Best professional judgement - assume no better than PH1 turbine survival.
16. Best judgement for PH2 JBS spring migrants given poor summer results and PH1 flow priority.

Table 13. 1999 Retro Operation Passage Parameters for Snake River Spring/Summer Chinook[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	63.4	24.1	68%	75%	93%	98%	98%	n/a
LGS	43.4	13.2	68%	78%	92%	100%[5]	99%	n/a
LMN	36	12.8	83%	49%	86.5%[4]	95.6%[6]	95%	n/a
IHR	91.1	53	50%	54%	90%	94%[8]	98%	n/a
MCN	140.2	128.1	50%	83%	90%	95%[9]	90%[9]	n/a
JDA	100.5	59.1	50%	73%	82%[10]	98%	95%[13]	n/a
TDA	129.3	129.3	50%	3%	84%[11]	90%[12]	n/a	96.5%[14]
BON-I [7]				39%	90%		90%	90%[15]
Spillway	119.7	93.2	50%			98%		
BON-II				48%	90%		98%	n/a

References:

1. All parameters without specific references were taken from the 2000 BiOp, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 BiOp, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. Al. N. Am J. of Fish Mgnt. 2001.
5. Iwamoto et al. 1994.
6. Average of 1994 LMN spillway survival estimates (.927 and .984) - Muir et al 1995.
7. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
8. Average of 2000, '01, '02, IHR spillway survival estimates - Eppard et al. 2002, 2003.
9. MCN bypass and spillway survivals are the average of 2002 and 2003 RT survival point estimates (Axel, G.A. et al. 2004a and 2004b).
10. Average of point estimates for route specific JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
11. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
12. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
13. Average of point estimates for route specific JDA JBS survival in 2002 and 2003 with 0/60 spill (91 and 100%).
14. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates @ 40% spill.
15. Best professional judgement - assume no better than PH1 turbine survival.

Table 14. 2000 Retro Operation Passage Parameters for Snake River Spring/Summer Chinook[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	33.2	16.2	68%	75%	93%	98%	98%	n/a
LGS	39.6	5.1	68%	78%	92%	100%[5]	99%	n/a
LMN	35.6	27.5	50%	49%	86.5%[4]	95.6%[6]	95%	n/a
IHR	81.6	45.6	50%	54%	90%	98%[8]	98%	n/a
MCN	123.7	70	50%	83%	90%	95%[9]	90%[9]	n/a
JDA	114.2	44.6	50%	73%	82%[10]	98%	95%[13]	n/a
TDA	93	93	50%	3%	84%[11]	90%[12]	n/a	96.5%[14]
BON-I [7]				39%	90%		90%	90%[15]
Spillway	98.7	85.1	50%			98%		
BON-II				48%	90%		98%	n/a

References:

1. All parameters without specific references were taken from the 2000 BiOp, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 BiOp, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. Al. N. Am J. of Fish Mgnt. 2001.
5. Iwamoto et al. 1994.
6. Average of 1994 LMN spillway survival estimates (.927 and .984) - Muir et al. 1995.
7. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
8. IHR spillway survival based on 2000 PIT study (.978) - Eppard et al. 2002.
9. MCN bypass and spillway survivals are the average of 2002 and 2003 RT survival point estimates (Axel, G.A. et al. 2004a and 2004b).
10. Average of point estimates for route specific JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
11. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
12. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
13. Average of point estimates for route specific JDA JBS survival in 2002 and 2003 with 0/60 spill (91 and 100%).
14. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates @ 40% spill.
15. Best professional judgement - assume no better than PH1 turbine survival.

Table 15. 2001 Retro Operation Passage Parameters for Snake River Spring/Summer Chinook[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	0	0	68%	89%[4]	93%	98%	98%	n/a
LGS	0	0	68%	78%	92%	100%[6]	99%	n/a
LMN	0	2	83%	49%	86.5%[5]	95.6%[8]	95%	n/a
IHR	4	0.2	68%	68%[18]	90%	89%[9]	99%[18]	n/a
MCN	4	0.3	68%	83%	90%	95%[10]	90%[10]	n/a
JDA	9.9	0.6	80%	73%	82%[11]	98%	93%[14]	n/a
TDA	15.4	15.4	50%	3%	84%[12]	90%[13]	n/a	96.5%[15]
BON-I [7]				39%	92%[16]		90%	92%[17]
Spillway	18.4	17.9	50%			98%		
BON-II				48%	90%		98%	n/a

References:

1. All parameters without specific references were taken from the 2000 BiOp, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 BiOp, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Plumb, J.M. et al. 2002.
5. Muir, et. Al. N. Am J. of Fish Mgnt. 2001.
6. Iwamoto et al. 1994.
7. Bonneville Powerhouse priority was PH2 from 2001 through 2003.
8. Average of 1994 LMN spillway survival estimates (.927 and .984) - Muir et al. 1995.
9. IHR spillway survival based on 2002 PIT study (.89) - Eppard et al. 2002.
10. MCN bypass and spillway survivals are the average of 2002 and 2003 RT survival point estimates (Axel, G.A. et al. 2004a and 2004b).
11. Average of point estimates for route specific JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
12. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
13. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
14. 2001 R/T survival estimate for JDA JBS.
15. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates @ 40% spill.
16. Best professional judgement - improved ph1 turbine survival due to install of MGR units.
17. Best professional judgement - assume no better than PH1 turbine survival.
18. Axel et al. 2001.

Table 16. 2002 Retro Operation Passage Parameters for Snake River Spring/Summer Chinook[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	39.7	23.3	50%	75%	93%	95%[4]	98%	n/a
LGS	38.5	17.4	68%	78%	92%	100%[6]	99%	n/a
LMN	0.7	1	83%	49%	86.5%[5]	95.6%[8]	95%	n/a
IHR	72.3	43.2	50%	54%	90%	89%[9]	98%	n/a
MCN	153.2	85.6	50%	83%	90%	98%	93%[10]	n/a
JDA	115	59.2	50%	73%	82%[11]	98%	95%[14]	n/a
TDA	98.9	98.9	50%	3%	84%[12]	90%[13]	n/a	96.5%[15]
BON-I [7]				39%	92%[16]		90%	92%[17]
Spillway	135.1	115.1	50%			98%		
BON-II				48%	90%		98%	n/a

References:

1. All parameters without specific references were taken from the 2000 BiOp, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 BiOp, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Plumb, J.M. et al. LGR RSW evaluations, 2003.
5. Muir, et. Al. N. Am J. of Fish Mgnt. 2001.
6. Iwamoto et al. 1994.
7. Bonneville Powerhouse priority was PH2 from 2001 through 2003.
8. Average of 1994 LMN spillway survival estimates (.927 and .984) - Muir et al. 1995.
9. IHR spillway survival based on 2002 PIT study (.892) - Eppard et al. 2002.
10. MCN bypass survival estimate from 2002 R/T survival study (Axel, G.A. et al. 2004a and 2004b).
11. Average of point estimates for route specific JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
12. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
13. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
14. Average of point estimates for route specific JDA JBS survival in 2002 and 2003 with 0/60 spill (91 and 100%).
15. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates @ 40% spill.
16. Best professional judgement - improved ph1 turbine survival due to install of MGR units.
17. Best professional judgement - assume no better than PH1 turbine survival.

Table 17. 2003 Retro Operation Passage Parameters for Snake River Spring/Summer Chinook[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival	RSW Survival
LGR	39	18.2	50%	82%[4]	93%	95%[4]	98%	n/a	98%[4]
LGS	37.7	9.5	68%	78%	92%	100%[5]	99%	n/a	
LMN	29.2	30.5	50%	49%	86.5%[6]	90%[7]	95%	n/a	
IHR	59.8	45.4	50%	54%	89%[8]	95%[9]	98%	n/a	
MCN	115.1	42	50%	89%[10]	90%	93%[10]	86.5%[10]	n/a	
JDA	109.1	12.6	80%	73%	82%[11]	98%	95%[12]	n/a	
TDA	84.6	84.6	50%	0%	84%[13]	90%[14]	n/a	96.5%[15]	
BON-I[16]				39%	92%[17]		90%	92%[18]	
Spillway	132.4	105.9	50%			98%			
BON-II				48%	90%		98%	n/a	

References:

1. All parameters without specific references were taken from the 2000 BiOp, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 BiOp, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Plumb, J.M. et al. LGR RSW evaluations, 2003.
5. Iwamoto et al. 1994.
6. Muir, et. Al. N. Am J. of Fish Mgnt. 2001.
7. Hockersmith, E.E. et al. LMN spillway survival in 2003.
8. Absolon, R. F. et al. IHR chinook salmon survival in 2003.
9. Eppard, et al. Survival of yearling chinook at IHR in 2003.
10. MCN bypass survival estimate from 2003 R/T survival study (Axel, G.A. et al. 2004a and 2004b).
11. Average of point estimates for route specific JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
12. Average of point estimates for route specific JDA JBS survival in 2002 and 2003 with 0/60 spill (91 and 100%).
13. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
14. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
15. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates @ 40% spill.
16. Bonneville Powerhouse priority was PH2 from 2001 through 2003.
17. Best professional judgement - improved ph1 turbine survival due to install of MGR units.
18. Best professional judgement - assume no better than PH1 turbine survival.

Table 18 shows the SR spring chinook individual pool survival estimates for each Lower Snake and Lower Columbia pool and dam reach for 1994 through 2003, as estimated using the SIMPAS model. The observed spring flows used for each major reach (Lower Snake [LSN] and Lower Columbia [LCO]) are listed at the bottom of the table. The more recent 1999 to 2003 pool survival estimates are based on empirical reach survival data for each reach, except the IHR, MCN, TDA, and BON reaches. Reach survivals for these four reaches were calculated based on the square root of a longer empirical reach that included two projects, i.e., LMN to MCN and JDA to BON. That is, equal survival was assumed through each pool (e.g., Sandford and Smith 2002). The 1994 to1998 data include some survival rates that were extrapolated from the upstream sampled reaches on a per-mile basis for the JDA (or TDA) through BON pools (as in the 2000 FCRPS Biological Opinion, Appendix D). Because there are four years of survival estimates through all eight FCRPS projects, the per-mile survival expansion method could be compared with empirical survival estimates in these years. The expansion method tended to overestimate reach survival by about 1-3%, so correction factors were applied to all expanded reach survivals. The reaches start at the head of Lower Granite Pool and end at the tailrace of Bonneville Dam, and each project reach begins in the tailrace of the upstream dam and ends at the tailrace of the downstream dam.

Table 18. Per pool reach survivals by year, with **bolded values** based on empirical data:

	1994	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
LWG	**0.9664**	**0.9293**	**1.0033**	**0.9391**	**0.9507**	**0.9660**	**0.9537**	**0.9860**	**0.9782**	**1.0191**
LGS	**0.8516**	**0.8951**	**0.9397**	**0.9551**	**1.0004**	**0.9636**	**0.9513**	**0.9696**	**0.9622**	**0.9588**
LMN	**0.9062**	**0.9679**	**0.9761**	**0.9418**	**0.8951**	**0.9703**	**0.9259**	**0.8880**	**1.0224**	**0.9575**
IHR	0.9028	**0.9635**	**0.8997**	**0.9227**	**0.9857**	**0.9792**	**1.0083**	**0.8921**	**0.9405**	**0.9773**
MCN	0.8782	**0.9623**	**0.8937**	**0.9162**	**0.9834**	**0.9774**	**0.9904**	**0.8707**	**0.9406**	**0.9781**
JDA	0.7691	0.8531	0.8498	0.8365	**0.8471**	**0.8795**	**0.9245**	**0.7909**	**0.9337**	**0.9193**
TDA	0.9083	0.9385	0.9374	0.9327	0.9444	**0.9902**	**0.9056**	**0.8703**	**1.0036**	**0.9903**
BON	0.8511	0.9048	0.9027	0.8943	0.9154	**0.9570**	**0.8762**	**0.8746**	**0.9716**	**0.9576**
Observed seasonal average flows for each reach:										
LSN	58	97	138	158	112	116	84	43	80	89
LCO	186	249	360	441	285	303	254	120	277	242

The second step in the analytical process was to determine if a relationship between flow and survival for each pool or for an entire reach existed and, if so, to describe it in the form of a functional relationship. Hydro Division staff regressed the lower Snake River and the lower Columbia reach survivals (single pool survivals multiplied together to produce two 4-pool-reach survivals) from Table 8 on seasonal average flows and a flow-survival relationship was developed (Attachment 3).

The final step was to apply the reach survival relationship to the seasonal average flows obtained from the hydrosystem modeling for both the proposed action and the reference operation. Using the developed flow-survival relationship, juvenile spring chinook reach survivals were calculated for both the reference operation flows and the proposed action flows for the lower Snake and lower Columbia reaches. The 4^{th} root of the reach survivals was then calculated to obtain average single pool survivals for each reach. Finally, the single pool survivals for the reference operation were then divided by the single pool survivals of the proposed action operation to obtain an adjustment factor for use in estimating the reference operation pool survivals in the SIMPAS model for the gap analysis.

In addition to changes in flows and spills between the reference and proposed action operations, certain dam passage parameters also changed between the two operations. For example, spill efficiency and diel passage parameters changed under different spill conditions or when changing from 12-hour spill in proposed hydro operation to 24-hour spill in the reference operation. The various dam passage parameters used in the survival gap analyses related to yearling chinook salmon for the reference operation and the 2004 and 2010 proposed hydro operation are shown on Tables 19 through 21.

For the gap analysis for UCR and LCR spring chinook salmon, we assumed the juvenile survival rates for those species would be equivalent to the McNary to Bonneville dam survival rates of SR spring/summer chinook salmon, including the flow-survival relationship.

SR, UCR, MCR, and LCR Steelhead

As with SR spring chinook, the same three analytical steps were taken to complete a gap analysis for SR steelhead using the SIMPAS model. The first step was to define and analyze a retrospective analysis of survivals over the 1994-2003 study period. This step is needed to determine if a relation between flow and survival existed during this time period and, if so, to define a functional relationship that could be applied to the reference and proposed action flow conditions. In this step, the SIMPAS model was set up to reflect the annual NWFSC empirical SR steelhead reach survival estimates using the actual flows, spills, and, to the extent possible, actual dam passage conditions and survival data applicable for each year. The annual changes in various dam passage parameters for the steelhead retrospective analysis are specified in Tables 22 through 31. After calibrating the model to these annual data, the resulting pool survival estimates (empirical reach survival values without dam survival) were calculated by the model for use in the next step in the analysis.

Table 19. Proposed 2004 Operation Passage Parameters for Snake River Spring/Summer Chinook[1]

Project	Diel Passage[2]	FGE	SLPE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival	RSW Survival
LGR	50/68%	82%[3]	n/a	93%	93%[3]	98%	n/a	98%[3]
LGS	50/68%	78%	n/a	92%	100%[4]	99%	n/a	
LMN	50/83%	49%	n/a	86.5%[5]	95.6%[6]	95%	n/a	
IHR	50/68%	54%	n/a	89%[7]	94%[8]	98%	n/a	98%[3]
MCN	50/68%	89%[9]	n/a	90%	95%[9]	90%[9]	n/a	
JDA	50/80%	73%	n/a	82%[10]	98%	95%[11]	n/a	
TDA	50%	n/a	equ[19]	84%[12]	97%[13]	n/a	96.5%[14]	
BON-I		n/a	equ[19]	92%[16]		n/a	92%[17]	
Spillway	50%				98%			
BON-II[15]		48%	46%[18]	90%		98%	98%[20]	

References:

1. All parameters without specific references were taken from the 2000 BiOp, Appendix page D-13.
2. Diels for very low spills are based on 2000 BiOp, Appendix page D-13. Diel is 50% for significant 24 hour spills.
3. Spill and RSW survival from 2003 LGR RT studies, Plumb, J.M. et al. 2003 (Spill- 0.93, RSW- 0.98).
4. 1993 spring chinook PIT study, Iwamoto et al. 1994.
5. Muir, et. Al. N. Am J. of Fish Mgnt. 2001.
6. LMN spill survival - average of '94 survival estimates (.927, .984). Muir et al. 1995
7. Absolon, R. F. et al. IHR chinook salmon survival in 2003.
8. Average of 2000, '01, '02, IHR spillway survival estimates - Eppard et al. 2002, 2003.
9. MCN bypass and spillway survivals are the average of 2002 and 2003 RT survival point estimates (Axel, G.A. et al. 2004a and 2004b).
10. Average of point estimates for route specific JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
11. Average of point estimates for route specific JDA JBS survival in 2002 and 2003 with 0/60 spill (91 and 100%).
12. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
13. Best professional judgement given installation of spillway divider wall in 2003.
14. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates @ 40% spill.
15. Bonneville Powerhouse priority is PH2.
16. Best professional judgement - improved ph1 turbine survival due to install of MGR units.
17. Best professional judgement - assume no better than PH1 turbine survival.
18. Best professional judgement based on limited 1999 sluiceway studies.
19. The TDA and BON sluiceway efficiencies are calculated from equations based on the data listed below.
20. BON sluiceway survival based on best professional judgement.

Table 20. Reference Operation Passage Parameters for Snake River Spring/Summer Chinook[1]

Project	Diel Passage[2]	FGE	SLPE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival	RSW Survival
LGR	50/68%	82%[3]	n/a	93%	93%[3]	98%	n/a	98%[3]
LGS	50/68%	78%	n/a	92%	100%[4]	99%	n/a	
LMN	50/83%	49%	n/a	86.5%[5]	95.6%[6]	95%	n/a	
IHR	50/68%	54%	n/a	89%[7]	94%[8]	98%	n/a	98%[3]
MCN	50/68%	89%[9]	n/a	90%	95%[9]	90%[9]	n/a	
JDA	50/80%	73%	n/a	82%[10]	98%	95%[11]	n/a	
TDA	50%	n/a	equ[19]	84%[12]	97%[13]	n/a	96.5%[14]	
BON-I[15]		n/a	equ[19]	92%[16]		n/a	92%[17]	
Spillway	50%				98%			
BON-II		48%	46%[18]	90%		98%	98%[20]	

References:

1. All parameters without specific references were taken from the 2000 BiOp, Appendix page D-13.
2. Diels for very low or night only spills are based on 2000 BiOp, Appendix page D-13. Diel was 50% for significant 24 hour spills.
3. Spill and RSW survival from 2003 LGR RT studies, Plumb, J.M. et al. 2003 (Spill- 0.93, RSW- 0.98).
4. Spring chinook PIT study, Iwamoto et al. 1994.
5. Muir, et. Al. N. Am J. of Fish Mgnt. 2001.
6. LMN spill survival - average of '94 survival estimates (.927, .984). Muir et al. 1995
7. Absolon, R. F. et al. IHR chinook salmon survival in 2003.
8. Average of 2000, '01, '02, IHR spillway survival estimates - Eppard et al. 2002, 2003.
9. MCN bypass and spillway survivals are the average of 2002 and 2003 RT survival point estimates (Axel, G.A. et al. 2004a and 2004b).
10. Average of point estimates for route specific JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
11. Average of point estimates for route specific JDA JBS survival in 2002 and 2003 with 0/60 spill (91 and 100%).
12. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
13. Best professional judgement given installation of spillway divider wall in 2003.
14. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates @ 40% spill.
15. Bonneville Powerhouse priority is PH2.
16. Best professional judgement - improved ph1 turbine survival due to install of MGR units.
17. Best professional judgement - assume no better than PH1 turbine survival.
18. Best professional judgement based on limited 1999 sluiceway studies.
19. The TDA and BON sluiceway efficiencies are calculated from equations based on the data listed below.
20. BON sluiceway survival based on best professional judgement.

Table 21. Proposed 2010 Operation Passage Parameters for Snake River Spring/Summer Chinook[1]

Project	Diel Passage	FGE	SLPE	Turbine Survival[2]	Spillway Survival	Bypass Survival	Sluiceway Survival	RSW Survival[4]
LGR	50/68%	82%	n/a	94%	93%	98%	n/a	98%
LGS	50/68%	78%	n/a	94%	100%	99%	n/a	98%
LMN	50/83%	49%	n/a	89%	98%[3]	95%	n/a	98%
IHR	50/68%	54%	n/a	91%	98%[5]	98%	n/a	98%
MCN	50/68%	89%	n/a	92%	96%[6]	93%[7]	n/a	98%
JDA	50/80%	73%	n/a	85%	98%	97%[8]	n/a	
TDA	50%	n/a	equ	84%	98%[9]	n/a	98%[10]	
BON-I		n/a	equ	92%		n/a	98%[10]	
Spillway	50%				98%			
BON-II		60%[11]	40%[12]	90%		98%	98%	

References:

1. All parameters without specific references are the same as the 2004 Proposed Operation.
2. Future turbine survivals were increased 1 to 2%based on improved turbine operations (and design in some cases).
3. LMN spillway survival increase 2.5% due to RSW, deflector mods and improved tailrease egress.
4. RSW survivals and efficiencies are based on LGR studies, assumed MCN operated at same % RSW flows as LGR.
5. Spillway survival increase of 4% due to combination of RSW, bulk spill, divider wall and deflector mods.
6. MCN spillway survival increased 1% due to improved egress conditions.
7. MCN bypass survival increaed 2% due to outfall relocation and improved egress.
8. JDA bypass survival increased 2% due to imporved egress.
9. TDA spill survival, 1% increase due to spill basin improvments and 1% due to egress improvments.
10. Sluiceway survival increased 1.5 and 6% for TDA and BON, respectively, due to relocation of outfalls.
11. BON PH2 FGE increased 12% due to FGE improvement program.
12. Sluice chute guidance decreased 6% based on preliminary 2004 sluice chute studies.

Table 22. 1994 Retro Operation Passage Parameters for Snake River Steelhead[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	18.6	1.5	76%	57% [6]	93%	98%	98%	n/a
LGS	15.3	12.0	76%	57%[6]	92%	100%[5]	95%	n/a
LMN	10.6	0.9	83%	82%	86.5%[4]	95.6%[7]	93%	n/a
IHR	23.1	18.1	50%	93%	90%	94%[8]	95%[10]	n/a
MCN	29.8	6.3	76%	57%[6]	90%	95%[11]	90%[11]	n/a
JDA	11.5	3.1	83%	85%	90%	93%[18]	92%[14]	n/a
TDA	41.0	0.4	50%	3%	84%[12]	90%[13]	n/a	96.5%[15]
BON-I[9]				41%	90%		90%	90%[16]
Spillway	96.8	70.5	50%			98%		
BON-II				48%	90%		90%[17]	n/a

References:

1. All parameters without specific references were taken from the 2000 BiOp, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 BiOp, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. al. N. Am J. of Fish Mgnt. 2001.
5. Iwamoto et al. 1994.
6. FGE prior to ESBS Installation (average over several years of evaluation)
7. Average of 1994 LMN spillway yearling chinook survival estimates (.927 and .984) - Muir et al 1995.
8. Average of 2000, '02, '03 IHR spillway yrlg chinook survival estimates - Eppard et al. 2002, 2003.
9. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
10. Best professional judgment given that the system passed fish through the sluiceway.
11. MCN JBS and spill survivals are the average of 2002 and 2003 RT yrlg chinook survival point estimates (Axel, G.A. et al. 2004a and 2004b).
12. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
13. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
14. Point estimate for JDA JBS RT steelhead survival in 2001 with low spill.
15. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates for spring migrants @ 40% spill.
16. Best professional judgement - assume no better than PH1 turbine survival.
17. Best professional judgement for PH2 JBS spring migrants given poor summer results and PH1 flow priority.
18. Point estimate for steelhead route specific spill survival with lower spill levels in 2002.

Table 23. 1995 Retro Operation Passage Parameters for Snake River Steelhead[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	19.0	3.2	76%	57% [6]	93%	98%	98%	n/a
LGS	29.2	10.1	76%	57%[6]	92%	100%[5]	95%	n/a
LMN	20.3	10.3	83%	82%	86.5%[4]	95.6%[8]	93%	n/a
IHR	34.5	35.5	50%	93%	90%	94%[9]	95%[10]	n/a
MCN	110.0	78.3	50%	57%[6]	90%	95%[11]	90%[11]	n/a
JDA	9.7	7.3	83%	85%	82%[12]	93%[19]	95%[15]	n/a
TDA	124.2	124.2	50%	3%	84%[13]	90%[14]	n/a	96.5%[16]
BON-I [7]				41%	90%		90%	90%[17]
Spillway	110.5	73.0	50%			98%		
BON-II				48%	90%		90%[18]	n/a

References:

1. All parameters without specific references were taken from the 2000 BiOp, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 BiOp, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. al. N. Am J. of Fish Mgnt. 2001.
5. Iwamoto et al. 1994.
6. FGE prior to ESBS Installation (average over several years of evaluation)
7. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
8. Average of 1994 LMN spillway yearling chinook survival estimates (.927 and .984) - Muir et al 1995.
9. Average of 2000, '02, '03 IHR spillway yrlg chinook survival estimates - Eppard et al. 2002, 2003.
10. Best professional judgment given that the system passed fish through the sluiceway.
11. MCN JBS and spill survivals are the average of 2002 and 2003 RT yrlg chinook survival point estimates (Axel, G.A. et al. 2004a and 2004b).
12. Average of point estimates for route specific yearling chinook JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
13. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
14. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
15. Average of point estimates for route specific JDA JBS survival in 2002 and 2003 with 0/60 spill (91 and 100%).
16. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates for spring migrants @ 40% spill.
17. Best professional judgement - assume no better than PH1 turbine survival.
18. Best professional judgement for PH2 JBS spring migrants given poor summer results and PH1 flow priority.
19. Point estimate for steelhead route specific spill survival with lower spill levels in 2002.

Table 24. 1996 Retro Operation Passage Parameters for Snake River Steelhead[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	55.4	51.3	50%	81%	93%	98%	98%	n/a
LGS	60.4	42.7	50%	81%	92%	100%[5]	95%	n/a
LMN	55.1	44.4	50%	82%	86.5%[4]	95.6%[8]	93%	n/a
IHR	58.6	55.8	50%	93%	90%	94%[9]	98%	n/a
MCN	206.8	199.9	50%	57%[6]	90%	95%[10]	90%[10]	n/a
JDA	85.7	79.6	50%	85%	82%[11]	96%[18]	95%[14]	n/a
TDA	205.7	205.7	50%	3%	84%[12]	90%[13]	n/a	96.5%[15]
BON-I [7]				41%	90%		90%	90%[16]
Spillway	189.1	168.3	50%			98%		
BON-II				48%	90%		90%[17]	n/a

References:

1. All parameters without specific references were taken from the 2000 BiOp, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 BiOp, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. al. N. Am J. of Fish Mgnt. 2001.
5. Iwamoto et al. 1994.
6. FGE prior to ESBS Installation (average over several years of evaluation)
7. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
8. Average of 1994 LMN spillway yearling chinook survival estimates (.927 and .984) - Muir et al 1995.
9. Average of 2000, '02, '03 IHR spillway yrlg chinook survival estimates - Eppard et al. 2002, 2003.
10. MCN JBS and spill survivals are the average of 2002 and 2003 RT yrlg chinook survival point estimates (Axel, G.A. et al. 2004a and 2004b).
11. Average of point estimates for route specific yearling chinook JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
12. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
13. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
14. Average of point estimates for route specific JDA JBS survival in 2002 and 2003 with 0/60 spill (91 and 100%).
15. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates for spring migrants @ 40% spill.
16. Best professional judgement - assume no better than PH1 turbine survival.
17. Best judgement for PH2 JBS spring migrants given poor summer results and PH1 flow priority.
18. Point estimate for steelhead route specific spill survival with 60% spill level in 2002.

Table 25. 1997 Retro Operation Passage Parameters for Snake River Steelhead[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	60.9	47.8	50%	81%	93%	98%	98%	n/a
LGS	61.0	50.9	50%	81%	92%	100%[5]	95%	n/a
LMN	66.5	52.6	50%	82%	86.5%[4]	95.6%[6]	93%	n/a
IHR	90.3	83.7	50%	93%	90%	94%[8]	98%	n/a
MCN	266.5	263.0	50%	89%	90%	95%[9]	90%[9]	n/a
JDA	142.4	141.3	50%	85%	82%[10]	98%	95%[13]	n/a
TDA	267.3	267.3	50%	3%	84%[11]	90%[12]	n/a	96.5%[14]
BON-I [7]				41%	90%		90%	90%[15]
Spillway	234.7	226.2	50%			98%		
BON-II				48%	90%		90%[16]	n/a

References:

1. All parameters without specific references were taken from the 2000 BiOp, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 BiOp, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. al. N. Am J. of Fish Mgnt. 2001.
5. Iwamoto et al. 1994.
6. Average of 1994 LMN spillway yearling chinook survival estimates (.927 and .984) - Muir et al 1995.
7. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
8. Average of 2000, '02, '03 IHR spillway yrlg chinook survival estimates - Eppard et al. 2002, 2003.
9. MCN JBS and spill survivals are the average of 2002 and 2003 RT yrlg chinook survival point estimates (Axel, G.A. et al. 2004a and 2004b).
10. Average of point estimates for route specific yearling chinook JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
11. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
12. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
13. Average of point estimates for route specific JDA JBS survival in 2002 and 2003 with 0/60 spill (91 and 100%).
14. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates for spring migrants @ 40% spill.
15. Best professional judgement - assume no better than PH1 turbine survival.
16. Best judgement for PH2 JBS spring migrants given poor summer results and PH1 flow priority.

Table 26. 1998 Retro Operation Passage Parameters for Snake River Steelhead[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	37.2	30.4	50%	81%	93%	98%	98%	n/a
LGS	49.8	23.6	50%	81%	92%	100%[5]	95%	n/a
LMN	41.8	23.1	50%	82%	86.5%[4]	95.6%[6]	93%	n/a
IHR	80.5	52.3	50%	93%	90%	94%[8]	98%	n/a
MCN	139.3	93.5	50%	89%	90%	95%[9]	90%[9]	n/a
JDA	121.8	57.1	50%	85%	82%[10]	98%	95%[13]	n/a
TDA	126.1	126.1	50%	3%	84%[11]	90%[12]	n/a	96.5%[14]
BON-I[7]				41%	90%		90%	90%[15]
Spillway	129.1	91.0	50%			98%		
BON-II				48%	90%		90%[16]	n/a

References:

1. All parameters without specific references were taken from the 2000 BiOp, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 BiOp, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. al. N. Am J. of Fish Mgnt. 2001.
5. Iwamoto et al. 1994.
6. Average of 1994 LMN spillway yearling chinook survival estimates (.927 and .984) - Muir et al 1995.
7. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
8. Average of 2000, '02, '03 IHR spillway yrlg chinook survival estimates - Eppard et al. 2002, 2003.
9. MCN JBS and spill survivals are the average of 2002 and 2003 RT yrlg chinook survival point estimates (Axel, G.A. et al. 2004a and 2004b).
10. Average of point estimates for route specific yearling chinook JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
11. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
12. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
13. Average of point estimates for route specific JDA JBS survival in 2002 and 2003 with 0/60 spill (91 and 100%).
14. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates for spring migrants @ 40% spill.
15. Best professional judgement - assume no better than PH1 turbine survival.
16. Best judgement for PH2 JBS spring migrants given poor summer results and PH1 flow priority.

Table 27. 1999 Retro Operation Passage Parameters for Snake River Steelhead[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	63.4	24.1	76%	81%	93%	98%	98%	n/a
LGS	43.4	13.2	76%	81%	92%	100%[5]	95%	n/a
LMN	36	12.8	83%	82%	86.5%[4]	95.6%[6]	93%	n/a
IHR	91.1	53	50%	93%	90%	94%[8]	98%	n/a
MCN	140.2	128.1	50%	89%	90%	95%[9]	90%[9]	n/a
JDA	100.5	59.1	50%	85%	82%[10]	98%	95%[13]	n/a
TDA	129.3	129.3	50%	3%	84%[11]	90%[12]	n/a	96.5%[14]
BON-I [7]				41%	90%		90%	90%[15]
Spillway	119.7	93.2	50%			98%		
BON-II				48%	90%		98%	n/a

References:

1. All parameters without specific references were taken from the 2000 BiOp, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 BiOp, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. al. N. Am J. of Fish Mgnt. 2001.
5. Iwamoto et al. 1994.
6. Average of 1994 LMN spillway yearling chinook survival estimates (.927 and .984) - Muir et al 1995.
7. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
8. Average of 2000, '02, '03 IHR spillway yrlg chinook survival estimates - Eppard et al. 2002, 2003.
9. MCN JBS and spill survivals are the average of 2002 and 2003 RT yrlg chinook survival point estimates (Axel, G.A. et al. 2004a and 2004b).
10. Average of point estimates for route specific yearling chinook JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
11. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
12. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
13. Average of point estimates for route specific JDA JBS survival in 2002 and 2003 with 0/60 spill (91 and 100%).
14. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates for spring migrants @ 40% spill.
15. Best professional judgement - assume no better than PH1 turbine survival.

Table 28. 2000 Retro Operation Passage Parameters for Snake River Steelhead[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	33.2	16.2	76%	81%	93%	98%	98%	n/a
LGS	39.6	5.1	76%	81%	92%	100%[5]	95%	n/a
LMN	35.6	27.5	50%	82%	86.5%[4]	95.6%[6]	93%	n/a
IHR	81.6	45.6	50%	93%	90%	98%[8]	98%	n/a
MCN	123.7	70	50%	89%	90%	95%[9]	90%[9]	n/a
JDA	114.2	44.6	50%	85%	82%[10]	98%	95%[13]	n/a
TDA	93	93	50%	3%	84%[11]	90%[12]	n/a	96.5%[14]
BON-I [7]				41%	90%		90%	90%[15]
Spillway	98.7	85.1	50%			98%		
BON-II				48%	90%		98%	n/a

References:

1. All parameters without specific references were taken from the 2000 BiOp, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 BiOp, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. al. N. Am J. of Fish Mgnt. 2001.
5. Iwamoto et al. 1994.
6. Average of 1994 LMN spillway yearling chinook survival estimates (.927 and .984) - Muir et al 1995.
7. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
8. IHR spillway survival based on 2000 PIT yearling chinook study (.978) - Eppard et al. 2002.
9. MCN JBS and spill survivals are the average of 2002 and 2003 RT yrlg chinook survival point estimates (Axel, G.A. et al. 2004a and 2004b).
10. Average of point estimates for route specific yearling chinook JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
11. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
12. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
13. Average of point estimates for route specific JDA JBS survival in 2002 and 2003 with 0/60 spill (91 and 100%).
14. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates for spring migrants @ 40% spill.
15. Best professional judgement - assume no better than PH1 turbine survival.

Table 29. 2001 Retro Operation Passage Parameters for Snake River Steelhead[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	0	0	76%	89%[4]	93%	98%	98%	n/a
LGS	0	0	76%	81%	92%	100%[6]	95%	n/a
LMN	0	2	83%	82%	86.5%[5]	95.6%[8]	93%	n/a
IHR	4	0.2	50%	93%	90%	89%[9]	99%[18]	n/a
MCN	4	0.3	76%	89%	90%	95%[10]	90%[10]	n/a
JDA	9.9	0.6	83%	85%	82%[11]	98%	92%[14]	n/a
TDA	15.4	15.4	50%	3%	84%[12]	90%[13]	n/a	96.5%[15]
BON-I [7]				41%	92%[16]		90%	92%[17]
Spillway	18.4	17.9	50%			98%		
BON-II				48%	90%		98%	n/a

References:

1. All parameters without specific references were taken from the 2000 BiOp, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 BiOp, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Plumb, J.M. et al. 2002.
5. Muir, et. al. N. Am J. of Fish Mgnt. 2001.
6. Iwamoto et al. 1994.
7. Bonneville Powerhouse priority was PH2 from 2001 through 2003.
8. Average of 1994 LMN spillway yearling chinook survival estimates (.927 and .984) - Muir et al 1995.
9. IHR spillway survival based on 2002 PIT yearling chinook study (.89) - Eppard et al. 2002.
10. MCN JBS and spill survivals are the average of 2002 and 2003 RT yrlg chinook survival point estimates (Axel, G.A. et al. 2004a and 2004b).
11. Average of point estimates for route specific yearling chinook JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
12. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
13. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
14. Point estimate for JDA JBS RT steelhead survival in 2001 with low spill.
15. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates for spring migrants @ 40% spill.
16. Best professional judgement - improved ph1 turbine survival due to install of MGR units.
17. Best professional judgement - assume no better than PH1 turbine survival.
18. Axel et al. 2001.

Table 30. 2002 Retro Operation Passage Parameters for Snake River Steelhead[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	39.7	23.3	50%	81%	93%	95%[4]	98%	n/a
LGS	38.5	17.4	76%	81%	92%	100%[6]	95%	n/a
LMN	0.7	1	83%	82%	86.5%[5]	95.6%[8]	93%	n/a
IHR	72.3	43.2	50%	93%	90%	89%[9]	98%	n/a
MCN	153.2	85.6	50%	89%	90%	98%	93%[10]	n/a
JDA	115	59.2	50%	85%	82%[11]	98%	95%[14]	n/a
TDA	98.9	98.9	50%	3%	84%[12]	90%[13]	n/a	96.5%[15]
BON-I [7]				41%	92%[16]		90%	92%[17]
Spillway	135.1	115.1	50%			98%		
BON-II				48%	90%		98%	n/a

References:

1. All parameters without specific references were taken from the 2000 BiOp, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 BiOp, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Plumb, J.M. et al. LGR RSW evaluations, 2003.
5. Muir, et. Al. N. Am J. of Fish Mgnt. 2001.
6. Iwamoto et al. 1994.
7. Bonneville Powerhouse priority was PH2 from 2001 through 2003.
8. Average of 1994 LMN spillway yearling chinook survival estimates (.927 and .984) - Muir et al 1995.
9. IHR spillway survival based on 2002 PIT yearling chinook study (.89) - Eppard et al. 2002.
10. MCN bypass survival estimate from 2002 R/T spring chinook survival study (Axel, G.A. et al. 2004a and 2004b).
11. Average of point estimates for route specific yearling chinook JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
12. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
13. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
14. Average of point estimates for route specific JDA JBS yrlg chinook survival in 2002 and 2003 with 0/60 spill (91 and 100%).
15. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates for spring migrants @ 40% spill.
16. Best professional judgement - improved ph1 turbine survival due to install of MGR units.
17. Best professional judgement - assume no better than PH1 turbine survival.

Table 31. 2003 Retro Operation Passage Parameters for Snake River Steelhead[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival	RSW Survival
LGR	39	18.2	50%	81%	93%	95%[4]	98%	n/a	98%[4]
LGS	37.7	9.5	76%	81%	92%	100%[5]	95%	n/a	
LMN	29.2	30.5	50%	82%	86.5%[6]	90%[7]	93%	n/a	
IHR	59.8	45.4	50%	93%	89%[8]	95%[9]	98%	n/a	
MCN	115.1	42	50%	89%	90%	93%[10]	86.5%[10]	n/a	
JDA	109.1	12.6	83%	85%	82%[11]	98%	95%[12]	n/a	
TDA	84.6	84.6	50%	3%	84%[13]	90%[14]	n/a	96.5%[15]	
BON-I[16]				41%	92%[17]		90%	92%[18]	
Spillway	132.4	105.9	50%			98%			
BON-II				48%	90%		98%	n/a	

References:

1. All parameters without specific references were taken from the 2000 BiOp, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 BiOp, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Plumb, J.M. et al. LGR RSW evaluations, 2003.
5. Iwamoto et al. 1994.
6. Muir, et. Al. N. Am J. of Fish Mgnt. 2001.
7. Hockersmith, E.E. et al. LMN spillway yearling chinook survival in 2003.
8. Absolon, R. F. et al. IHR chinook salmon survival in 2003.
9. Eppard, et al. Survival of yearling chinook at IHR in 2003.
10. MCN bypass survival estimate from 2003 R/T spring chinook survival study (Axel, G.A. et al. 2004a and 2004b).
11. Average of point estimates for route specific yearling chinook JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
12. Average of point estimates for route specific JDA JBS yrlg chinook survival in 2002 and 2003 with 0/60 spill (91 and 100%).
13. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
14. Average of 1997, '98 and '99 PIT TDA spillway survival estimates for spring migrants.
15. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates for spring migrants @ 40% spill.
16. Bonneville Powerhouse priority was PH2 from 2001 through 2003.
17. Best professional judgement - improved ph1 turbine survival due to install of MGR units.
18. Best professional judgement - assume no better than PH1 turbine survival.

Table 32 shows the SR steelhead individual pool survival estimates for each lower Snake and lower Columbia pool and dam reach for 1994 through 2003, as estimated using the SIMPAS model. The observed spring flows used for each major reach (lower Snake [LSN] and lower Columbia [LCO]) are listed at the bottom of the table. The more recent 1999 to 2003 pool survival estimates are based on empirical reach survival data for each reach, except the IHR, MCN, TDA, and BON reaches. Reach survivals for these four reaches were calculated based on the square root of a longer empirical reach that included two projects, i.e., LMN to MCN and JDA to BON. That is, equal survival was assumed through each pool (e.g., Sandford and Smith 2002). The 1994 to1998 data include some survival rates that were extrapolated from the upstream sampled reaches on a per-mile basis for the JDA (or TDA) through BON pools (as described in the 2000 Biological Opinion, Appendix D). Because there are four years of survival estimates through all eight FCRPS projects, per-mile survival expansions could be compared with empirical survival estimates in those years. The expansion method appeared to miscalculate reach survival by about 1- 4%, so correction factors were applied to all expanded reach survivals. The reaches start at the head of Lower Granite Pool and end at the tailrace of Bonneville Dam, and each project reach extends from the tailrace of the upstream dam to the tailrace of the downstream dam.

Table 32. Per pool reach survivals by year, with **bolded values** based on empirical data:

	1994	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
LWG	0.9125	**0.9781**	**0.9570**	**0.9880**	**0.9475**	**0.9301**	**0.9881**	**0.9348**	**0.9345**	**0.9600**
LGS	**0.8754**	**0.9346**	**0.9589**	**0.9909**	**0.9523**	**0.9524**	**0.9244**	**0.8482**	**0.9027**	**0.9754**
LMN	**0.9465**	**1.0000**	**0.9839**	**0.9473**	**0.9349**	**0.9661**	**0.9498**	**0.7621**	**0.9478**	**0.9448**
IHR	1.0000	**0.9601**	**0.9198**	**0.9417**	**0.9191**	**0.9397**	**0.9433**	**0.5533**	**0.8959**	**0.8881**
MCN	0.9981	**0.9611**	**0.9175**	**0.9345**	**0.9144**	**0.9348**	**0.9403**	**0.5601**	**0.8271**	**0.8628**
JDA	0.9558	0.9094	0.8692	0.8835	**0.8538**	**0.9460**	**0.8742**	**0.3478**	**0.8673**	**0.9032**
TDA	0.8931	0.9466	0.9332	0.9380	**1.0000**	**0.8918**	**0.9143**	**0.9829**	**0.8237**	**0.8358**
BON	0.8411	0.9897	0.9637	0.9730	**1.0000**	**0.8747**	**0.9206**	**0.9371**	**0.8254**	**0.8375**
Observed seasonal average flows for each reach:										
LSN	58	97	138	158	112	116	84	43	80	89
LCO	186	249	360	441	285	303	254	120	277	242

The second step in the analytical process was to determine if a relationship between flow and survival for each pool or for an entire reach existed and, if so, to describe it in the form of a functional relationship. Hydro Division staff regressed the lower Snake River and the lower Columbia reach survivals (single pool survivals multiplied together to produce two 4-pool-reach survivals) from Table 32 on seasonal average flows and a flow-survival relationship was developed (Attachment 3).

The final step was to apply the reach survival relationship to the seasonal average flows obtained from BPA's hydro-system modeling for both the proposed action and the reference operation.

Using the developed flow-survival relationship, juvenile steelhead reach survivals were calculated for both the reference operation flows and the proposed hydro operation flows for the lower Snake and lower Columbia reaches. The 4^{th} root of the reach survivals was then calculated to obtain average single pool survivals for each reach. Finally, the single pool survivals for the reference operation were divided by the single pool survivals of the proposed hydro operation to obtain an adjustment factor for use in estimating the reference operation pool survivals in the SIMPAS model for the gap analysis.

In addition to changes in flows and spills between the reference and proposed hydro operations, certain dam passage parameters also changed between the two operations. For example, spill efficiency and diel passage parameters changed under different spill conditions or when changing from 12-hour spill in proposed hydro operation to 24-hour spill in the reference operation. The various dam passage parameters used in the survival gap analyses related to steelhead for the reference operation and the 2004 and 2010 proposed hydro operation are shown on Tables 33 through 35.

For the gap analysis for UCR, MCR, and LCR steelhead, we assumed the juvenile survival rates for those species would be equivalent to the respective McNary to Bonneville Dam survival rates of SR steelhead, including the flow-survival relationship.

<u>SR and LCR Fall Chinook</u>

AS with SR spring chinook and SR steelhead, the same three analytical steps were necessary to complete a gap analysis for SR fall chinook using the SIMPAS model. A retrospective analysis of survivals over the 1995-2003 study period (not including 2002, due to lack of available healthy research fish) was defined and analyzed in the first step. This step is needed to determine if a relation between flow and survival existed during the study period and, if so, to define a functional relationship that could be applied to the reference and proposed action flow conditions. In this step, the SIMPAS model was set up to reflect the annual empirical SR fall chinook reach survival estimates using the actual flows, spills, and, to the extent possible, actual dam passage conditions and survival data applicable for each year. The annual changes in various dam passage parameters for the fall chinook retrospective analysis are specified in Tables 36 through 43. After setting up the model with these annual data, the resulting pool survival estimates (empirical reach survival values without dam survival) were calculated by the model for use in the next step in the analysis.

Table 33. Proposed 2004 Operation Passage Parameters for Snake River Steelhead[1]

Project	Diel Passage[2]	FGE	SLPE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival	RSW Survival
LGR	50/76%	81%	n/a	93%	93%[3]	98%	n/a	98%[3]
LGS	50/76%	81%	n/a	92%	98.5%[4]	95%	n/a	
LMN	50/83%	82%	n/a	86.5%[5]	95.6%[6]	93%	n/a	
IHR	50/76%	93%	n/a	89%[7]	94%[8]	98%	n/a	98%[3]
MCN	50/76%	89%	n/a	90%	95%[9]	90%[9]	n/a	
JDA	50/83%	85%	n/a	82%[10]	98%	95%[11]	n/a	
TDA	50%	n/a	equ[19]	84%[12]	97%[13]	n/a	96.5%[14]	
BON-I[15]		n/a	equ[19]	92%[16]		n/a	92%[17]	
Spillway	50%				98%			
BON-II		48%	62%[18]	90%		98%	98%[20]	

References:

1. All parameters without specific references were taken from the 2000 BiOp, Appendix page D-13.
2. Diels for very low or night only spills are based on 2000 BiOp, Appendix page D-13. Diel was 50% for significant 24 hour spills.
3. Spill and RSW survival from 2003 LGR RT yrlg chinook studies, Plumb, J.M. et al. 2003 (Spill- 0.93, RSW- 0.98).
4. 1997 PIT steehead study at LGS (average of .97 and 1.0) - Muir et al. 1998.
5. Muir, et. Al. N. Am J. of Fish Mgnt. 2001.
6. LMN spill survival - average of '94 spring chinook survival estimates (.927, .984). Muir et al. 1995.
7. Absolon, R. F. et al. IHR chinook salmon survival in 2003.
8. Average of 2000, '01, '02, IHR spillway survival estimates - Eppard et al. 2002, 2003.
9. MCN bypass and spillway survivals are the average of 2002 and 2003 RT survival point estimates (Axel, G.A. et al. 2004a and 2004b).
10. Average of point estimates for route specific yearling chinook JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
11. Average of point estimates for route specific JDA JBS yrlg chinook survival in 2002 and 2003 with 0/60 spill (91 and 100%).
12. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
13. Best professional judgement given installation of spillway divider wall in 2003.
14. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates for spring migrants @ 40% spill.
15. Bonneville Powerhouse priority is PH2.
16. Best professional judgement - improved ph1 turbine survival due to install of MGR units.
17. Best professional judgement - assume no better than PH1 turbine survival.
18. Best professional judgement based on limited 1999 sluiceway studies.
19. The TDA and BON sluiceway efficiencies are calculated from equations based on the data listed below.
20. BON sluiceway survival based on best professional judgement.

Table 34. Reference Operation Passage Parameters for Snake River Steelhead[1]

Project	Diel Passage[2]	FGE	SLPE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival	RSW Survival
LGR	50/76%	81%	n/a	93%	93%[3]	98%	n/a	98%[3]
LGS	50/76%	81%	n/a	92%	98.5%[4]	95%	n/a	
LMN	50/83%	82%	n/a	86.5%[5]	95.6%[6]	93%	n/a	
IHR	50/76%	93%	n/a	89%[7]	94%[8]	98%	n/a	98%[3]
MCN	50/76%	89%	n/a	90%	95%[9]	90%[9]	n/a	
JDA	50/83%	85%	n/a	82%[10]	98%	95%[11]	n/a	
TDA	50%	n/a	equ[19]	84%[12]	97%[13]	n/a	96.5%[14]	
BON-I[15]		n/a	equ[19]	92%[16]		n/a	92%[17]	
Spillway	50%				98%			
BON-II		48%	62%[18]	90%		98%	98%[20]	

References:

1. All parameters without specific references were taken from the 2000 BiOp, Appendix page D-13.
2. Diels for very low or night only spills are based on 2000 BiOp, Appendix page D-13. Diel was 50% for significant 24 hour spills.
3. Spill and RSW survival from 2003 LGR RT yrlg chinook studies, Plumb, J.M. et al. 2003 (Spill- 0.93, RSW- 0.98).
4. 1997 PIT steehead study at LGS (average of .97 and 1.0) - Muir et al. 1998.
5. Muir, et. Al. N. Am J. of Fish Mgnt. 2001.
6. LMN spill survival - average of '94 spring chinook survival estimates (.927, .984). Muir et al. 1995.
7. Absolon, R. F. et al. IHR chinook salmon survival in 2003.
8. Average of 2000, '01, '02, IHR spillway survival estimates - Eppard et al. 2002, 2003.
9. MCN bypass and spillway survivals are the average of 2002 and 2003 RT survival point estimates (Axel, G.A. et al. 2004a and 2004b).
10. Average of point estimates for route specific yearling chinook JDA turbine survival in 2002 and 2003 with 0/60 spill (78 and 82%).
11. Average of point estimates for route specific JDA JBS yrlg chinook survival in 2002 and 2003 with 0/60 spill (91 and 100%).
12. This is the average of 2000 R/T and PIT spring migrant TDA turbine survival estimates.
13. Best professional judgement given installation of spillway divider wall in 2003.
14. TDA sluiceway survival is the average of 2000 PIT and R/T point estimates for spring migrants @ 40% spill.
15. Bonneville Powerhouse priority is PH2.
16. Best professional judgement - improved ph1 turbine survival due to install of MGR units.
17. Best professional judgement - assume no better than PH1 turbine survival.
18. Best professional judgement based on limited 1999 sluiceway studies.
19. The TDA and BON sluiceway efficiencies are calculated from equations based on the data listed below.
20. BON sluiceway survival based on best professional judgement.

Table 35. Proposed 2010 Operation Passage Parameters for Snake River Steelhead[1]

Project	Diel Passage	FGE	SLPE	Turbine Survival[2]	Spillway Survival	Bypass Survival	Sluiceway Survival	RSW Survival[4]
LGR	50/76%	81%	n/a	94%	93%	98%	n/a	98%
LGS	50/76%	81%	n/a	94%	98.5%	95%	n/a	98%
LMN	50/83%	82%	n/a	89%	98%[3]	93%	n/a	98%
IHR	50/76%	93%	n/a	91%	98%[5]	98%	n/a	98%
MCN	50/76%	89%	n/a	92%	96%[6]	93%[7]	n/a	98%
JDA	50/83%	85%	n/a	85%	98%	97%[8]	n/a	
TDA	50%	n/a	equ	84%	98%[9]	n/a	98%[10]	
BON-I		n/a	equ	92%		n/a	98%[10]	
Spillway	50%				98%			
BON-II		60%[11]	70%[12]	90%		98%	98%	

References:

1. All parameters without specific references are the same as the 2004 Proposed Operation.
2. Future turbine survivals were increased 1 to 2% based on improved turbine operations (and design in some cases).
3. LMN spillway survival increase 2.5% due to RSW, deflector mods and improved tailrease egress.
4. RSW survivals and efficiencies are based on LGR studies, assumed MCN operated at same % RSW flows as LGR.
5. Spillway survival increase of 4% due to combination of RSW, bulk spill, divider wall and deflector mods.
6. MCN spillway survival increased 1% due to improved egress conditions.
7. MCN bypass survival increased 2% due to outfall relocation and improved egress.
8. JDA bypass survival increased 2% due to imporved egress.
9. TDA spill survival, 1% increase due to spill basin improvments and 1% due to egress improvments.
10. Sluiceway survival increased 1.5 and 6% for TDA and BON, respectively, due to relocation of outfalls.
11. BON PH2 FGE increased 12% due to FGE improvement program.
12. Sluice chute guidance increased 8% based on preliminary 2004 sluice chute studies.

Table 36. 1995 Retro Operation Passage Parameters for Snake River Fall Chinook[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	0.9	0.1	68%	53%	90%	98%	98%	
LGS	2.1	0.7	68%	53%	90%	98%	98%	
LMN	2.4	0.2	83%	49%	86.5%[4]	98%	98%	
IHR	25.2	25.2	50%	0%	89%[5]	98%	n/a	93%[7]
MCN	7.2	6.5	68%	45%[6]	82%[8]	95%[9]	90%[9]	
JDA	9.7	1.2	80%	32%	72%[10]	98%	92%[11]	
TDA	99.0	99.0	50%	3%	84%[12]	92%[13]	n/a	92.5%[14]
BON-I [15]				9%	90%		82%	82%[16]
Spillway	118.6	74.2	50%			98%		
BON-II				28%	94%		82%[17]	

References:

1. All parameters without specific references were taken from the 2000 BiOp, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 BiOp, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. Al. N. Am J. of Fish Mgnt. 2001 (yearling chinook).
5. IHR turbine survival based on 2003 summer PIT evaluation (Absolon et al. 2004).
6. FGE prior to ESBS Installation (average over several years of evaluation).
7. IHR sluiceway survival - best professional judgement based on TDA sluiceway survival.
8. MCN turbine survival based on 2003 RT summer study results (Perry et al. 2003).
9. MCN bypass and spillway survivals are the average of 2002 and 2003 RT spring survival point estimates - Axel, G.A. et al.
10. Turbine survival for JDA based on 2003 RT summer study results (Counihan et al. 2003 draft).
11. JBS survival for JDA based on 2003 RT summer study results (Counihan et al. 2003 draft).
12. Summer PIT results for turibne and sluiceway passage at TDA in 2000 (Absolon et al. 2002).
13. TDA spill survival based on NMFS 2000 summary of 1997-2000 PIT survival study results.
14. TDA spill survival based on NMFS 2000 summary of 1997-2000 PIT survival study results (average of 1998 and 2000 results).
15. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
16. Best professional judgement - assume no better than PH1 turbine survival.
17. Based on coded wire tag studies in late 1980's (Ledgerwood et al. date?)

Table 37. 1996 Retro Operation Passage Parameters for Snake River Fall Chinook[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	7.0	2.6	68%	53%	90%	98%	98%	
LGS	8.2	3.5	68%	53%	90%	98%	98%	
LMN	8.2	4.9	83%	49%	86.5%[4]	98%	98%	
IHR	25.4	24.4	50%	54%	89%[5]	98%	100%[6]	
MCN	64.2	67.5	50%	62%	82%[7]	95%[8]	90%[8]	
JDA	66.4	10.6	80%	32%	72%[9]	96%[10]	92%[11]	
TDA	117.1	117.1	50%	3%	84%[12]	92%[13]	n/a	92.5%[14]
BON-I [15]				9%	90%		82%	82%[16]
Spillway	111.3	79.0	50%			98%		
BON-II				28%	94%		82%[17]	

References:

1. All parameters without specific references were taken from the 2000 BiOp, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 BiOp, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. Al. N. Am J. of Fish Mgnt. 2001 (yearling chinook).
5. IHR turbine survival based on 2003 summer PIT evaluation (Absolon et al. 2004).
6. IHR bypass survival based on 2003 summer PIT evaluation (Absolon et al. 2004).
7. MCN turbine survival based on 2003 RT summer study results (Perry et al. 2003).
8. MCN bypass and spillway survivals are the average of 2002 and 2003 RT spring survival point estimates - Axel, G.A. et al.
9. Turbine survival for JDA based on 2003 RT summer study results (Counihan et al. 2003 draft).
10. JDA spill survival is based on 2002 and 2003 RT study resluts (Counihan et al. 2002, 2003 drafts).
11. JBS survival for JDA based on 2003 RT summer study results (Counihan et al. 2003 draft).
12. Summer PIT results for turibne and sluiceway passage at TDA in 2000 (Absolon et al. 2002).
13. TDA spill survival based on NMFS 2000 summary of 1997-2000 PIT survival study results.
14. TDA spill survival based on NMFS 2000 summary of 1997-2000 PIT survival study results (average of 1998 and 2000 results).
15. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
16. Best professional judgement - assume no better than PH1 turbine survival.
17. Based on coded wire tag studies in late 1980's (Ledgerwood et al. date?)

Table 38. 1997 Retro Operation Passage Parameters for Snake River Fall Chinook[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	5.1	4.1	68%	53%	90%	98%	98%	
LGS	4.7	2.5	68%	53%	90%	98%	98%	
LMN	4.6	3.2	83%	49%	86.5%[4]	98%	98%	
IHR	40.4	40.4	50%	54%	89%[5]	98%	100%[6]	
MCN	70.0	84.5	50%	62%	82%[7]	95%[8]	90%[8]	
JDA	75.4	20.7	50%	32%	72%[9]	96%[10]	92%[11]	
TDA	146.8	146.8	50%	3%	84%[12]	92%[13]	n/a	92.5%[14]
BON-I[15]				9%	90%		82%	82%[16]
Spillway	122.8	91.1	50%			98%		
BON-II				28%	94%		82%[17]	

References:

1. All parameters without specific references were taken from the 2000 BiOp, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 BiOp, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. Al. N. Am J. of Fish Mgnt. 2001 (yearling chinook).
5. IHR turbine survival based on 2003 summer PIT evaluation (Absolon et al. 2004).
6. IHR bypass survival based on 2003 summer PIT evaluation (Absolon et al. 2004).
7. MCN turbine survival based on 2003 RT summer study results (Perry et al. 2003).
8. MCN bypass and spillway survivals are the average of 2002 and 2003 RT spring survival point estimates - Axel, G.A. et al.
9. Turbine survival for JDA based on 2003 RT summer study results (Counihan et al. 2003 draft).
10. JDA spill survival is based on 2002 and 2003 RT study resluts (Counihan et al. 2002, 2003 drafts).
11. JBS survival for JDA based on 2003 RT summer study results (Counihan et al. 2003 draft).
12. Summer PIT results for turibne and sluiceway passage at TDA in 2000 (Absolon et al. 2002).
13. TDA spill survival based on NMFS 2000 summary of 1997-2000 PIT survival study results.
14. TDA spill survival based on NMFS 2000 summary of 1997-2000 PIT survival study results (average of 1998 and 2000 results).
15. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
16. Best professional judgement - assume no better than PH1 turbine survival.
17. Based on coded wire tag studies in late 1980's (Ledgerwood et al. date?)

Table 39. 1998 Retro Operation Passage Parameters for Snake River Fall Chinook[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	1.5	1.4	68%	53%	90%	98%	98%	
LGS	0.0	0.0	68%	53%	90%	98%	98%	
LMN	0.0	0.0	83%	49%	86.5%[4]	98%	98%	
IHR	41.6	41.6	50%	54%	89%[5]	88.5%[7]	100%[6]	
MCN	16.1	21.7	68%	62%	82%[8]	95%[9]	90%[9]	
JDA	94.0	7.9	80%	32%	72%[10]	96%[11]	92%[12]	
TDA	78.3	78.3	50%	3%	84%[13]	92%[14]	n/a	92.5%[15]
BON-I [16]				9%	90%		82%	82%[17]
Spillway	116.8	76.2	50%			98%		
BON-II				28%	94%		82%[18]	

References:

1. All parameters without specific references were taken from the 2000 BiOp, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 BiOp, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. Al. N. Am J. of Fish Mgnt. 2001 (yearling chinook).
5. IHR turbine survival based on 2003 summer PIT evaluation (Absolon et al. 2004).
6. IHR bypass survival based on 2003 summer PIT evaluation (Absolon et al. 2004).
7. IHR spill survival based on Eppard 2000 PIT study.
8. MCN turbine survival based on 2003 RT summer study results (Perry et al. 2003).
9. MCN bypass and spillway survivals are the average of 2002 and 2003 RT spring survival point estimates - Axel, G.A. et al.
10. Turbine survival for JDA based on 2003 RT summer study results (Counihan et al. 2003 draft).
11. JDA spill survival is based on 2002 and 2003 RT study resluts (Counihan et al. 2002, 2003 drafts).
12. JBS survival for JDA based on 2003 RT summer study results (Counihan et al. 2003 draft).
13. Summer PIT results for turibne and sluiceway passage at TDA in 2000 (Absolon et al. 2002).
14. TDA spill survival based on NMFS 2000 summary of 1997-2000 PIT survival study results.
15. TDA spill survival based on NMFS 2000 summary of 1997-2000 PIT survival study results (average of 1998 and 2000 results).
16. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
17. Best professional judgement - assume no better than PH1 turbine survival.
18. Based on coded wire tag studies in late 1980's (Ledgerwood et al. date?)

Table 40. 1999 Retro Operation Passage Parameters for Snake River Fall Chinook[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	4.8	5.2	68%	53%	90%	98%	98%	
LGS	1.3	1.1	68%	53%	90%	98%	98%	
LMN	1.3	1.2	83%	49%	86.5%[4]	98%	98%	
IHR	44.1	44.1	50%	54%	89%[5]	88.5%[7]	100%[6]	
MCN	76.6	80.1	50%	62%	82%[8]	95%[9]	90%[9]	
JDA	116.8	18.4	80%	32%	72%[10]	96%[11]	92%[12]	
TDA	127.0	127.0	50%	3%	84%[13]	92%[14]	n/a	92.5%[15]
BON-I [16]				9%	90%		82%	82%[17]
Spillway	109.3	76.8	50%			98%		
BON-II				28%	94%		98%	

References:

1. All parameters without specific references were taken from the 2000 BiOp, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 BiOp, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. Al. N. Am J. of Fish Mgnt. 2001 (yearling chinook).
5. IHR turbine survival based on 2003 summer PIT evaluation (Absolon et al. 2004).
6. IHR bypass survival based on 2003 summer PIT evaluation (Absolon et al. 2004)
7. IHR spill survival based on Eppard 2000 PIT study.
8. MCN turbine survival based on 2003 RT summer study results (Perry et al. 2003).
9. MCN bypass and spillway survivals are the average of 2002 and 2003 RT spring survival point estimates - Axel, G.A. et al.
10. Turbine survival for JDA based on 2003 RT summer study results (Counihan et al. 2003 draft).
11. JDA spill survival is based on 2002 and 2003 RT study resluts (Counihan et al. 2002, 2003 drafts).
12. JBS survival for JDA based on 2003 RT summer study results (Counihan et al. 2003 draft).
13. Summer PIT results for turibne and sluiceway passage at TDA in 2000 (Absolon et al. 2002).
14. TDA spill survival based on NMFS 2000 summary of 1997-2000 PIT survival study results.
15. TDA spill survival based on NMFS 2000 summary of 1997-2000 PIT survival study results (average of 1998 and 2000 results).
16. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
17. Best professional judgement - assume no better than PH1 turbine survival.

Table 41. 2000 Retro Operation Passage Parameters for Snake River Fall Chinook[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	0.0	0.0	68%	53%	90%	98%	98%	
LGS	0.0	0.0	68%	53%	90%	98%	98%	
LMN	0.0	0.0	83%	49%	86.5%[4]	98%	98%	
IHR	30.1	30.1	50%	54%	89%[5]	88.5%[7]	100%[6]	
MCN	4.0	7.5	68%	62%	82%[8]	95%[9]	90%[9]	
JDA	83.9	27.6	80%	32%	72%[10]	96%[11]	92%[12]	
TDA	59.5	59.5	50%	3%	84%[13]	92%[14]	n/a	92.5%[15]
BON-I [16]				9%	90%		82%	82%[17]
Spillway	101.3	87.0	50%			98%		
BON-II				28%	94%		98%	

References:

1. All parameters without specific references were taken from the 2000 BiOp, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 BiOp, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. Al. N. Am J. of Fish Mgnt. 2001 (yearling chinook).
5. IHR turbine survival based on 2003 summer PIT evaluation (Absolon et al. 2004).
6. IHR bypass survival based on 2003 summer PIT evaluation (Absolon et al. 2004).
7. IHR spill survival based on Eppard 2000 PIT study.
8. MCN turbine survival based on 2003 RT summer study results (Perry et al. 2003).
9. MCN bypass and spillway survivals are the average of 2002 and 2003 RT spring survival point estimates - Axel, G.A. et al.
10. Turbine survival for JDA based on 2003 RT summer study results (Counihan et al. 2003 draft).
11. JDA spill survival is based on 2002 and 2003 RT study resluts (Counihan et al. 2002, 2003 drafts).
12. JBS survival for JDA based on 2003 RT summer study results (Counihan et al. 2003 draft).
13. Summer PIT results for turibne and sluiceway passage at TDA in 2000 (Absolon et al. 2002).
14. TDA spill survival based on NMFS 2000 summary of 1997-2000 PIT survival study results.
15. TDA spill survival based on NMFS 2000 summary of 1997-2000 PIT survival study results (average of 1998 and 2000 results).
16. Bonneville Powerhouse priority was PH1 from 1994 through 2000.
17. Best professional judgement - assume no better than PH1 turbine survival.

Table 42. 2001 Retro Operation Passage Parameters for Snake River Fall Chinook[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival
LGR	0.0	0.0	68%	53%	90%	98%	98%	
LGS	0.0	0.0	68%	53%	90%	98%	98%	
LMN	0.0	0.0	83%	49%	86.5%[4]	98%	98%	
IHR	0.0	0.0	68%	54%	89%[5]	88.5%[7]	100%[6]	
MCN	0.0	0.0	68%	62%	82%[8]	95%[9]	90%[9]	
JDA	0.0	0.0	80%	32%	72%[10]	96%[11]	87%[12]	
TDA	18.6	18.6	50%	3%	84%[13]	92%[14]	n/a	92.5%[15]
BON-I [16]				9%	90%		82%	82%[17]
Spillway	24.9	18.9	50%			98%		
BON-II				28%	94%		98%	

References:

1. All parameters without specific references were taken from the 2000 BiOp, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 BiOp, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. Al. N. Am J. of Fish Mgnt. 2001 (yearling chinook).
5. IHR turbine survival based on 2003 summer PIT evaluation (Absolon et al. 2004).
6. IHR bypass survival based on 2003 summer PIT evaluation (Absolon et al. 2004).
7. IHR spill survival based on Eppard 2000 PIT study.
8. MCN turbine survival based on 2003 RT summer study results (Perry et al. 2003).
9. MCN bypass and spillway survivals are the average of 2002 and 2003 RT spring survival point estimates - Axel, G.A. et al.
10. Turbine survival for JDA based on 2003 RT summer study results (Counihan et al. 2003 draft).
11. JDA spill survival is based on 2002 and 2003 RT study resluts (Counihan et al. 2002, 2003 drafts).
12. JBS survival for JDA based on 2001 RT summer study results (Counihan, 2001 AFEP Presentation).
13. Summer PIT results for turibne and sluiceway passage at TDA in 2000 (Absolon et al. 2002).
14. TDA spill survival based on NMFS 2000 summary of 1997-2000 PIT survival study results.
15. TDA spill survival based on NMFS 2000 summary of 1997-2000 PIT survival study results (average of 1998 and 2000 results).
16. Bonneville Powerhouse priority was PH2 from 2001 through 2003.
17. Best professional judgement - assume no better than PH1 turbine survival.

Table 43. 2003 Retro Operation Passage Parameters for Snake River Fall Chinook[1]

Project	Night Spill Amount (kcfs)[2]	Day Spill Amount (kcfs)[2]	Diel Passage[3]	FGE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival	RSW Survival
LGR	0.0	0.0	68%	53%	90%	93%[19]	98%		98%[18]
LGS	0.0	0.0	68%	53%	90%	98%	98%		
LMN	0.0	0.0	83%	49%	86.5%[4]	96%[20]	98%		
IHR	14.4	14.4	50%	54%	89%[5]	96%[7]	100%[6]		
MCN	0.0	0.0	68%	62%	82%[8]	95%[9]	90%[9]		
JDA	60.0	9.2	80%	32%	72%[10]	96%[11]	92%[12]		
TDA	51.0	51.0	50%	3%	84%[13]	92%[14]	n/a	92.5%[15]	
BON-I [16]				0%	90%		82%	82%[17]	
Spillway	106.0	75.0	50%			98%			
BON-II				28%	94%		98%		

References:

1. All parameters without specific references were taken from the 2000 BiOp, Appendix page D-13.
2. Spill amounts are average for the season for each year and are based on Corps data.
3. Diels for very low or night only spills are based on 2000 BiOp, Appendix page D-13. Diel was 50% for significant 24 hour spills.
4. Muir, et. Al. N. Am J. of Fish Mgnt. 2001 (yearling chinook).
5. IHR turbine survival based on 2003 summer PIT evaluation (Absolon et al. 2004).
6. IHR bypass survival based on 2003 summer PIT evaluation (Absolon et al. 2004)
7. IHR spill survival based on 2003 summer PIT evaluation (Absolon et al. 2004).
8. MCN turbine survival based on 2003 RT summer study results (Perry et al. 2003).
9. MCN bypass and spillway survivals are the average of 2002 and 2003 RT spring survival point estimates - Axel, G.A. et al.
10. Turbine survival for JDA based on 2003 RT summer study results (Counihan et al. 2003 draft)
11. JDA spill survival is based on 2002 and 2003 RT study resluts (Counihan et al. 2002, 2003 drafts).
12. JBS survival for JDA based on 2003 RT summer study results (Counihan et al. 2003 draft)
13. Summer PIT results for turibne and sluiceway passage at TDA in 2000 (Absolon et al. 2002).
14. TDA spill survival based on NMFS 2000 summary of 1997-2000 PIT survival study results.
15. TDA spill survival based on NMFS 2000 summary of 1997-2000 PIT survival study results (average of 1998 and 2000 results).
16. Bonneville Powerhouse priority was PH2 from 2001 through 2003.
17. Best professional judgement - assume no better than PH1 turbine survival.
18. Spill and RSW survival from 2003 LGR RT studies, Plumb, J.M. et al. 2003 (Spill- 0.93, RSW- 0.98).
19. Spill and RSW survival from 2003 LGR RT studies, Plumb, J.M. et al. 2003 (Spill- 0.93, RSW- 0.98).
20. LMN spill survival based on 2003 RT Studies (ref?).

Table 44 shows the SR fall chinook individual pool survival estimates for each Lower Snake and Lower Columbia pool and dam reach for 1995 through 2001 and 2003, as estimated using the SIMPAS model. The observed summer flows used for each major reach (lower Snake [LSN] and lower Columbia [LCO]) are listed at the bottom of the table. The reaches start at the head of Lower Granite Pool and end at the tailrace of Bonneville Dam, and each project reach extends from the tailrace of the upstream dam to the tailrace of the downstream dam. Pool survival estimates for LWG, LGS, and LMN are based on empirical reach survival data for each reach. Between 1997 and 2003, IHR and MCN reach survivals were calculated based on the square root of a longer empirical reach that included LMN to MCN. That is, equal survival was assumed through each pool (e.g., Sandford and Smith 2002). The 1995 and 1996, IHR and MCN pool survivals were extrapolated from the upstream sampled reaches on a per-mile basis. Because there are six years of empirical estimates for these two reaches, the extrapolated pool survivals based on the per-mile expansions could be compared with empirical survival estimates from these years. The expansion method tended to underestimate pool survival, so correction factors were applied to these extrapolated pool survivals. All years include additional pool survival rates that were extrapolated from the upstream sampled reaches on a per-mile basis (as described in the 2000 Biological Opinion, Appendix D). These included the JDA, TDA, and BON pools. No correction factors were possible for these pools, since there are no corresponding empirical reach survival estimates.

Table 44. Per reach pool survivals by year, with **bolded values** based on empirical data:

	1995	1996	1997	1998	1999	2000	2001	2003
LWG	**0.7083**	**0.5040**	**0.3729**	**0.5964**	**0.7451**	**0.5062**	**0.2228**	**0.5497**
LGS	**0.9127**	**0.9378**	**0.5951**	**0.8232**	**0.7449**	**0.8221**	**0.8106**	**0.8818**
LMN	**0.8468**	**0.8388**	**0.6870**	**0.9971**	**0.8978**	**0.8238**	**0.7598**	**0.8889**
IHR	0.9849	0.9933	**0.8891**	**0.9634**	**0.9458**	**0.9780**	**0.7704**	**0.8919**
MCN	1.0562	1.0681	**0.9540**	**0.9708**	**0.9223**	**0.9961**	**0.8411**	**0.9825**
JDA	0.7418	0.7571	0.5606	0.8655	0.7449	0.7967	0.6053	0.8144
TDA	0.9101	0.9160	0.8331	0.9554	0.9113	0.9308	0.8536	0.9373
BON	0.8383	0.8485	0.7106	0.9183	0.8404	0.8744	0.7435	0.8859
Observed seasonal average flows for each reach:								
LSN	97	138	158	112	116	84	43	89
LCO	249	360	441	285	303	254	120	242

The second step in the analytical process for SR fall chinook was to determine if a relationship between flow and survival for each pool or for an entire reach existed and, if so, to describe it in the form of a functional relationship. Hydro Division staff regressed the lower Snake River and the lower Columbia reach survivals (single pool survivals multiplied together to produce two 4-pool-reach survivals) from Table 44 on seasonal average flows and a flow-survival relationship was developed (Attachment 3).

The final step in the process was to apply the reach survival relationship to the seasonal average flows obtained from BPA's hydro-system modeling for both the proposed hydro operation and the reference operation. Using the developed flow-survival relationships, juvenile reach survivals were calculated for both the reference operation flows and the proposed hydro operation flows for the lower Snake and lower Columbia reaches. The 4^{th} root of the reach survivals was then calculated to obtain average single pool survivals for each reach. Finally, the single pool survivals for the reference operation were then divided by the single pool survivals of the proposed action operation to obtain a pool adjustment factor for use in estimating the reference operation pool survivals in the SIMPAS model for the gap analysis.

In addition to changes in flows and spills between the reference and proposed hydro operations, certain dam passage parameters also changed between the two operations. For example, spill efficiency and diel passage parameters changed under different spill conditions, particularly when changing from 12-hour spill at a project in the proposed hydro operation to 24-hour spill in the reference operation. The various dam passage parameters used in the survival gap analyses related to fall chinook salmon for the reference operation and the 2004 and 2010 proposed hydro operation are shown on Tables 45 through 47.

For the gap analysis for LCR fall chinook, Hydro Division staff assumed the juvenile survival rates for that species would be equivalent to the respective McNary to Bonneville dam survival rates of SR fall chinook, including the flow-survival relationship.

Table 45. Proposed 2004 Operation Passage Parameters for Snake River Fall Chinook[1]

Project	Diel Passage[2]	FGE	SLPE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival	RSW Survival
LGR	50/68%	53%	n/a	90%	93%[3]	98%	n/a	98%[3]
LGS	50/68%	53%	n/a	90%	98%	98%	n/a	
LMN	50/83%	49%	n/a	86.5%[4]	95.6%[7]	98%	n/a	
IHR	50/68%	54%	n/a	89%[5]	96%5	98%	n/a	98%[3]
MCN	50/68%	62%	n/a	82%[6]	95%[8]	90%[8]	n/a	
JDA	50/80%	32%	n/a	72%[9]	98%[10]	92%[9]	n/a	
TDA	50%	n/a	equ[17]	84%[11]	97%[12]	n/a	96%[11]	
BON-I		n/a	equ[17]	92%[14]		n/a	92%[15]	
Spillway	50%				98%			
BON-II[13]		28%	47%[16]	94%		98%	98%[18]	

References:

1. All parameters without specific references were taken from the 2000 BiOp, Appendix page D-13.
2. Diels for very low or night only spills are based on 2000 BiOp, Appendix page D-13. Diel was 50% for significant 24 hour spills.
3. Spill and RSW survival from 2003 LGR RT studies, Plumb, J.M. et al. 2003 (Spill- 0.93, RSW- 0.98).
4. Muir, et. Al. N. Am J. of Fish Mgnt. 2001. Spring Chinook - best available data.
5. Absolon et al, 2003, PIT subyearling chinook turbine and spill survival at IHR.
6. Peery et al 2003, draft report, RT subyearling chinook turbine survival at MCN.
7. LMN spill survival - average of '94 survival estimates (.927, .984). Muir et al. 1995
8. MCN bypass and spillway survivals are the average of 2002 and 2003 RT survival point estimates - Axel, G.A. et al.
9. Route specifc 30/30 route specific JBS and turbine survival from summer RT studies at JDA in 2003.
10. Average 30/30 route specific spill survival from summer RT studies at JDA in 2002 and 2003.
11. Summer PIT results for turibne and sluiceway passage at TDA in 2000 - Absolon et al. 2002.
12. Best professional judgement given installation of spillway divider wall in 2003.
13. Bonneville Powerhouse priority is PH2.
14. Best professional judgement - improved ph1 turbine survival due to install of MGR units.
15. Best professional judgement - assume no better than PH1 turbine survival.
16. Best professional judgement based on limited 1999 sluiceway studies.
17. The TDA and BON sluiceway efficiencies are calculated from equations based on the data listed below.
18. BON sluiceway survival based on best professional judgement.

Table 46. Reference Operation Passage Parameters for Snake River Fall Chinook[1]

Project	Diel Passage[2]	FGE	SLPE	Turbine Survival	Spillway Survival	Bypass Survival	Sluiceway Survival	RSW Survival
LGR	50/68%	53%	n/a	90%	93%[3]	98%	n/a	98%[3]
LGS	50/68%	53%	n/a	90%	98%	98%	n/a	
LMN	50/83%	49%	n/a	86.5%[4]	95.6%[7]	98%	n/a	
IHR	50/68%	54%	n/a	89%[5]	96%[5]	98%	n/a	98%[3]
MCN	50/68%	62%	n/a	82%[6]	95%[8]	90%[8]	n/a	
JDA	50/80%	32%	n/a	72%[9]	98%[10]	92%[9]	n/a	
TDA	50%	n/a	equ[17]	84%[11]	97%[12]	n/a	96%[11]	
BON-I		n/a	equ[17]	92%[14]		82%	92%[15]	
Spillway	50%				98%			
BON-II[13]		28%	47%[16]	94%		98%	98%[18]	

References:

1. All parameters without specific references were taken from the 2000 BiOp, Appendix page D-13.
2. Diels for very low or night only spills are based on 2000 BiOp, Appendix page D-13. Diel was 50% for significant 24 hour spills.
3. Spill and RSW survival from 2003 LGR RT studies, Plumb, J.M. et al. 2003 (Spill- 0.93, RSW- 0.98).
4. Muir, et. al. N. Am J. of Fish Mgnt. 2001. Spring Chinook - best available data.
5. Absolon et al, 2003, PIT subyearling chinook turbine and spill survival at IHR.
6. Peery et al 2003, draft report, RT subyearling chinook turbine survival at MCN.
7. LMN spill survival - average of '94 survival estimates (.927, .984). Muir et al. 1995
8. MCN bypass and spillway survivals are the average of 2002 and 2003 RT survival point estimates - Axel, G.A. et al.
9. Route specifc 30/30 route specific JBS and turbine survival from summer RT studies at JDA in 2003.
10. Average 30/30 route specific spill survival from summer RT studies at JDA in 2002 and 2003.
11. Summer PIT results for turibne and sluiceway passage at TDA in 2000 - Absolon et al. 2002.
12. Best professional judgement given installation of spillway divider wall in 2003.
13. Bonneville Powerhouse priority is PH2.
14. Best professional judgement - improved ph1 turbine survival due to install of MGR units.
15. Best professional judgement - assume no better than PH1 turbine survival.
16. Best professional judgement based on limited 1999 sluiceway studies.
17. The TDA and BON sluiceway efficiencies are calculated from equations based on the data listed below.
18. BON sluiceway survival based on best professional judgement.

Table 47. Proposed 2010 Operation Passage Parameters for Snake River Fall Chinook[1]

Project	Diel Passage	FGE	SLPE	Turbine Survival[2]	Spillway Survival	Bypass Survival	Sluiceway Survival	RSW Survival
LGR	50/68%	53%	n/a	91%	93%	98%	n/a	98%
LGS	50/68%	53%	n/a	91%	98%	98%	n/a	
LMN	50/83%	49%	n/a	87.5%	95.6%	98%	n/a	
IHR	50/68%	54%	n/a	91%	98%[3]	98%	n/a	98%
MCN	50/68%	62%	n/a	84%	96%[4]	92%[5]	n/a	
JDA	50/80%	32%	n/a	85%[6]	98%	96%[7]	n/a	
TDA	50%	n/a	equ	84%	98%[8]	n/a	98%[9]	
BON-I		n/a	equ	92%		n/a	96%[9]	
Spillway	50%				98%			
BON-II		40%[10]	47%	94%		98%	98%	

References:

1. All parameters without specific references are the same as the 2004 Proposed Operation.
2. Turbine survivals increased 1 to 2% at LGR through MCN due to improved turbine operations (and design in some cases).
3. Spillway survival increase of 2% due to combination of RSW, bulk spill, divider wall and deflector mods.
4. MCN spillway survival increased 1% due to improved egress conditions.
5. MCN bypass survival increaed 2% due to outfall relocation and improved egress.
6. JDA turbine survival increased 13% due to combination of improved operation and guidewall.
7. JDA bypass survival increased 4% due to imporved egress.
8. TDA spill survival, 1% increase due to spill basin improvments and 1% due to egress improvments.
9. Sluiceway survival increased 2 and 4% for TDA and BON, respectively, due to relocation of outfalls.
10. BON PH2 FGE increased 12% due to FGE improvement program.

Results of the Gap Analyses

For the following gap analyses, NOAA Fisheries used the estimated SIMPAS survival rates for the various listed stocks of spring/summer chinook salmon, steelhead, and fall chinook salmon resulting from the respective reference operations and compared them to the survivals associated with the Action Agencies' proposed hydro operations. The difference in survival identified by this analysis is expected to represent the effects to the listed species that may be attributable to the existence of the projects (dams and reservoirs) compared to the proposed operation of the projects. Two different gap analyses were conducted, one to measure the near-term (2004) survival gap, and the other to measure the long-term (2010) survival gap.

SR Spring/Summer Chinook

The previous discussion was provided to explain and illustrate the analytical approach that was used to define the gap in survival through the FCRPS between a reference operation and the proposed hydro operation. The SIMPAS modeling results shown below in Tables 48 and 49 for SR spring/summer chinook provide an indication of the relative difference, or "gap," in hydro survival between the two operations. This relative difference in survival is calculated for each year in the 10-year study period by subtracting the reference operation system survival from the proposed action system survival and dividing the difference by the reference operation system survival.

Under the reference operation for SR spring/summer chinook, estimated juvenile system survivals ranged from 48% to nearly 54% during the 1994-2003 study period, with a mean survival rate of nearly 52% (Table 48). In-river survivals ranged from about 36% to almost 60%, with a mean value of over 51% during the same 10-year period.

For the near-term (2004) proposed hydro operation, estimated juvenile system survivals for this listed stock ranged from just under 47% to over 53% during the 1994-2003 study period, with a mean value of 51%, and in-river survivals ranged from 33% to 58%, with a mean of over 47% during the 10-year period (Table 48). For the long-term proposed hydro operation, estimated juvenile system survivals for this listed stock ranged from just under 48% to over 55% during the 1994-2003 study period, with a mean value of 52%, and in-river survivals ranged from 36% to over 63%, with a mean of over 51% during the 10-year period (Table 49).

For SR spring/summer chinook, the estimated relative gap in the near-term (2004) over the 10-year study period for total system survival (including differential delayed survival associated with transportation) between the proposed action and the reference operation is -1.5%[22] and

[22] The estimated relative gap for total system survival between the proposed hydro operation and the reference operation was calculated using a relative difference of the mean survival rates (proposed minus reference/reference) over the 10-year study period (1994-2003).

ranges from -0.1% to -3.7% (Figure 1). Table 48 shows the estimated relative gap for in-river survival through the FCRPS between the proposed hydro operation and the reference operation is -7.4% and ranges from -2.6% to -9.5%. The estimated survival multiplier, or relative difference in survival between the reference operation and the proposed hydro operation for system survival with D, is 1.02[23] and ranges from 1.00 to 1.04. The estimated survival multiplier for in-river survival is 1.08, with a range from 1.03 up to 1.10.

The estimated relative gap for SR spring chinook in the long term (2010) over the 10-year study period for total system survival (including differential delayed survival associated with transportation) between the proposed action and the reference operation is +0.3% and ranges from -0.8% to +2.6% (Figure 2). The estimated relative gap for in-river survival through the FCRPS between the proposed hydro operation and the reference operation is about +0.5% and ranges from -1.9% to +6.7% (Table 149). The estimated survival multiplier, or relative difference in survival between the reference operation and the proposed hydro operation for system survival with D, indicates that no survival improvement is needed with a range of improvement up to 1.01. The estimated survival multiplier for in-river survival also indicates that no survival improvement is need with a range up to 1.02.

UCR Spring Chinook

Under the reference operation for UCR spring chinook, estimated juvenile in-river survival rates through the lower Columbia River ranged from about 52% up to nearly 80% during the 1994-2003 study period, with a mean value of almost 69% (Table 48). For the near-term (2004) proposed hydro operation, the estimated juvenile in-river survivals for UCR spring chinook ranged from 48% up to nearly 75% during the 1994-2003 study period, with a mean value of 64% (Table 48). For the long-term (2010) proposed hydro operation, Table 49 shows the estimated juvenile in-river survivals for UCR spring chinook range from over 51% up to 79% during the 1994-2003 study period, with a mean value of nearly 68%.

The estimated relative gap between the proposed hydro operation and the reference operation in the near term (2004) for UCR spring chinook in-river survival through four Columbia River FCRPS dams and reservoirs over the 10-year study period is -6.6%, and ranges from -2.8% up to -9% (Figure 3). The estimated survival multiplier for UCR spring chinook, or the relative difference in survival between the reference operation and the proposed action operation for in-river survival through the lower Columbia River projects, is 1.07, ranging from 1.03 up to 1.10 (Table 48).

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[23] The estimated survival multiplier is a measure of the amount of survival improvement needed in another life stage for this listed species to make up the system survival gap. A geometric mean was used to calculate the relative difference (reference/proposed) in survival between the reference and proposed hydro operations, which dampens out the effects of both extreme high and low survival differences.

For UCR spring chinook, the estimated relative gap between the proposed hydro operation and the reference operation in the long term (2010) for in-river survival through four Columbia River FCRPS dams and reservoirs is -1.2% and ranges from -3.4% to +2.8% (Figure 4). The estimated long-term survival multiplier for UCR spring chinook, or the relative difference in survival between the reference operation and the proposed action operation for in-river survival through the lower Columbia River projects, is 1.01, ranging from no survival improvement needed up to 1.04 (Table 49).

LCR Spring Chinook

For LCR spring chinook in the reference operation, the estimated juvenile in-river survival rates through Bonneville pool and dam on the lower Columbia River ranged from over 83% up to nearly 95% during the 1994-2003 study period, with a mean value of over 89% (Table 48). For the near-term (2004) proposed hydro operation, Table 48 shows the estimated juvenile in-river survivals for LCR spring chinook ranged from under 84% up to 93% during the 1994-2003 study period, with a mean value of about 89%. For the long-term (2010) proposed hydro operation, estimated juvenile in-river survivals for LCR spring chinook ranged from about 84% up to over 93% during the 1994-2003 study period, with a mean value of over 89% (Table 49).

For LCR spring chinook, the estimated relative gap between the proposed hydro operation and the reference operation in the near term (2004) for in-river survival over the 10-year study period through Bonneville Dam is -0.9%, and ranges from -3.2% up to +0.1%. The estimated survival multiplier in the near term for LCR spring chinook, or the relative difference in survival between the reference operation and the proposed hydro operation for in-river survival through Bonneville Dam on the lower Columbia River, is 1.01, ranging from no survival improvement needed up to 1.03 (Table 48).

The estimated relative gap in the long term for in-river survival over the 10-year study period through Bonneville Dam between the proposed hydro operation and the reference operation is -.5% and ranges from -2.0% up to +0.3%. Table 49 shows the estimated survival multiplier for LCR spring chinook, or the relative difference in survival between the reference operation and the proposed hydro operation for in-river survival through Bonneville Dam on the lower Columbia River, is 1.00, ranging from no survival improvement needed to 1.02.

Table 48. Summary of Estimated Survival Rates for Yearling Chinook Salmon from 2004 Hydro Gap Analysis

Gap Analysis - Yearling Chinook Summary Page	Study Years										
	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Mean
Proposed Hydro Operation											
SR Sp Chinook System Survival with Wild D	52.4%	46.7%	52.4%	53.5%	49.6%	49.9%	51.2%	52.9%	49.5%	52.8%	51.1%
SR Sp Chin In river Survival (without Transport)	48.7%	44.7%	54.2%	58.1%	47.3%	50.0%	46.5%	33.2%	49.3%	44.9%	47.7%
Total % Transported	95.2%	60.8%	74.7%	72.4%	67.9%	69.0%	93.0%	96.5%	60.2%	96.0%	78.6%
UCR Sp Chinook In river Survival (4 projects)	67.5%	61.5%	72.5%	74.8%	62.5%	65.6%	60.7%	48.3%	66.9%	60.0%	64.0%
LCR Sp Chinook In river Survival (1 project)	90.9%	87.4%	91.7%	93.0%	88.5%	90.5%	84.3%	83.6%	90.7%	87.2%	88.8%
Reference Operation											**Mean**
SR Sp Chinook System Survival with Wild D	52.5%	48.1%	54.1%	53.9%	50.6%	50.8%	51.5%	52.9%	51.4%	52.9%	51.9%
SR Sp Chin In river Survival (without Transport)	53.8%	48.1%	59.7%	59.6%	50.9%	52.7%	51.3%	35.8%	53.3%	49.4%	51.5%
Total % Transported	95.2%	55.2%	70.7%	70.2%	62.7%	64.3%	89.9%	96.5%	52.3%	92.5%	75.0%
UCR Sp Chinook In river Survival (4 projects)	74.1%	65.9%	79.6%	76.9%	67.0%	68.7%	65.3%	52.1%	72.0%	64.1%	68.6%
LCR Sp Chinook In river Survival (1 project)	91.3%	88.1%	94.8%	93.2%	89.3%	91.3%	85.1%	83.5%	91.5%	87.3%	89.5%
Absolute Difference (Reference-Proposed)											**Difference in means**
SR Sp Chinook System Survival with Wild D	0.1%	1.3%	1.7%	0.4%	1.0%	0.9%	0.2%	0.0%	1.9%	0.1%	0.8%
SR Sp Chin In river Survival (without Transport)	5.1%	3.5%	5.5%	1.6%	3.6%	2.6%	4.8%	2.7%	4.0%	4.5%	3.8%
Total % Transported	0.0%	-5.6%	-4.0%	-2.2%	-5.2%	-4.7%	-3.1%	0.0%	-7.9%	-3.5%	-3.6%
UCR Sp Chinook In river Survival (4 projects)	6.6%	4.4%	7.1%	2.1%	4.4%	3.2%	4.5%	3.7%	5.1%	4.1%	4.5%
LCR Sp Chinook In river Survival (1 project)	0.4%	0.7%	3.1%	0.2%	0.8%	0.8%	0.8%	-0.1%	0.8%	0.1%	0.8%
Relative Difference (Reference/Proposed)											**Geomean**
SR Sp Chinook System Survival with Wild D	1.00	1.03	1.03	1.01	1.02	1.02	1.00	1.00	1.04	1.00	1.02
SR Sp Chin In river Survival (without Transport)	1.10	1.08	1.10	1.03	1.08	1.05	1.10	1.08	1.08	1.10	1.08
UCR Sp Chinook In river Survival (4 projects)	1.10	1.07	1.10	1.03	1.07	1.05	1.07	1.08	1.08	1.07	1.07
LCR Sp Chinook In river Survival (1 project)	1.00	1.01	1.03	1.00	1.01	1.01	1.01	1.00	1.01	1.00	1.01
Relative Difference (Proposed-Reference/Reference)											**Difference in means**
SR Sp Chinook System Survival with Wild D	-0.2%	-2.8%	-3.1%	-0.8%	-1.9%	-1.8%	-0.4%	-0.1%	-3.7%	-0.3%	-1.5%
SR Sp Chin In river Survival (without Transport)	-9.4%	-7.2%	-9.2%	-2.6%	-7.0%	-5.0%	-9.4%	-7.4%	-7.5%	-9.1%	-7.3%
UCR Sp Chinook In river Survival (4 projects)	-8.9%	-6.7%	-8.9%	-2.8%	-6.6%	-4.6%	-6.9%	-7.2%	-7.1%	-6.4%	-6.6%
LCR Sp Chinook In river Survival (1 project)	-0.4%	-0.8%	-3.3%	-0.2%	-0.9%	-0.9%	-0.9%	0.1%	-0.9%	-0.1%	-0.8%

Table 49. Summary of Estimated Survival Rates for Yearling Chinook Salmon from 2010 Hydro Gap Analysis

Gap Analysis - Yearling Chinook Summary Page					**Study Years**						
	1994	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**Mean**
2010 Proposed Hydro Operation											
SR Sp Chinook System Survival with Wild D	52.6%	47.9%	54.5%	55.3%	50.5%	51.0%	51.4%	53.1%	51.0%	53.0%	52.0%
SR Sp Chin In river Survival (without Transport)	53.0%	48.0%	59.5%	63.6%	50.8%	53.9%	50.4%	36.2%	53.0%	48.6%	51.7%
Total % Transported	95.3%	57.7%	62.7%	69.2%	65.2%	66.9%	93.2%	96.7%	56.3%	96.1%	75.9%
UCR Sp Chinook In river Survival (4 projects)	71.6%	64.9%	77.1%	79.1%	65.8%	69.2%	64.1%	51.4%	70.7%	63.3%	67.7%
LCR Sp Chinook In river Survival (1 project)	91.0%	87.7%	92.9%	93.5%	88.7%	91.0%	84.6%	83.7%	91.0%	87.3%	89.1%
Reference Operation											**Mean**
SR Sp Chinook System Survival with Wild D	52.5%	48.1%	54.1%	53.9%	50.6%	50.8%	51.5%	52.9%	51.4%	52.9%	51.9%
SR Sp Chin In river Survival (without Transport)	53.8%	48.1%	59.7%	59.6%	50.9%	52.7%	51.3%	35.8%	53.3%	49.4%	51.5%
Total % Transported	95.2%	55.2%	70.7%	70.2%	62.7%	64.3%	89.9%	96.5%	52.3%	92.5%	75.0%
UCR Sp Chinook In river Survival (4 projects)	74.1%	65.9%	79.6%	76.9%	67.0%	68.7%	65.3%	52.1%	72.0%	64.1%	68.6%
LCR Sp Chinook In river Survival (1 project)	91.3%	88.1%	94.8%	93.2%	89.3%	91.3%	85.1%	83.5%	91.5%	87.3%	89.5%
Absolute Difference (Reference-Proposed)											**Difference in means**
SR Sp Chinook System Survival with Wild D	-0.1%	0.2%	-0.4%	-1.4%	0.1%	-0.2%	0.0%	-0.1%	0.4%	-0.1%	-0.2%
SR Sp Chin In river Survival (without Transport)	0.8%	0.1%	0.2%	-4.0%	0.1%	-1.2%	1.0%	-0.3%	0.3%	0.7%	-0.2%
Total % Transported	-0.1%	-2.6%	8.0%	0.9%	-2.5%	-2.6%	-3.3%	-0.2%	-4.0%	-3.6%	-1.0%
UCR Sp Chinook In river Survival (4 projects)	2.5%	1.0%	2.4%	-2.2%	1.2%	-0.5%	1.2%	0.7%	1.3%	0.8%	0.9%
LCR Sp Chinook In river Survival (1 project)	0.3%	0.4%	1.9%	-0.3%	0.6%	0.3%	0.5%	-0.2%	0.5%	0.0%	0.4%
Relative Difference (Reference/Proposed)											**Geomean**
SR Sp Chinook System Survival with Wild D	1.00	1.00	0.99	0.97	1.00	1.00	1.00	1.00	1.01	1.00	1.00
SR Sp Chin In river Survival (without Transport)	1.01	1.00	1.00	0.94	1.00	0.98	1.02	0.99	1.00	1.02	1.00
UCR Sp Chinook In river Survival (4 projects)	1.04	1.02	1.03	0.97	1.02	0.99	1.02	1.01	1.02	1.01	1.01
LCR Sp Chinook In river Survival (1 project)	1.00	1.00	1.02	1.00	1.01	1.00	1.01	1.00	1.01	1.00	1.00
Relative Difference (Proposed-Reference/Reference)											**Difference in means**
SR Sp Chinook System Survival with Wild D	0.2%	-0.4%	0.7%	2.6%	-0.2%	0.3%	-0.1%	0.2%	-0.8%	0.1%	0.3%
SR Sp Chin In river Survival (without Transport)	-1.4%	-0.1%	-0.3%	6.7%	-0.2%	2.4%	-1.9%	0.9%	-0.5%	-1.5%	0.5%
UCR Sp Chinook In river Survival (4 projects)	-3.4%	-1.6%	-3.1%	2.8%	-1.7%	0.7%	-1.9%	-1.3%	-1.8%	-1.3%	-1.2%
LCR Sp Chinook In river Survival (1 project)	-0.3%	-0.5%	-2.0%	0.3%	-0.7%	-0.3%	-0.6%	0.2%	-0.5%	0.0%	-0.4%

SR Steelhead

Similar to the SR spring chinook survival gap analysis, the estimated SIMPAS survival rates for SR steelhead resulting from the reference operation were compared to the survivals associated with the Action Agencies' proposed hydro operations for 2004 and 2010. The difference in survival identified by this gap analysis is expected to represent the effects to the listed species that may be attributable to the existence of the projects (dams and reservoirs) compared to the proposed operation of the projects.

The SIMPAS modeling results shown below in Tables 50 and 51 provide an indication of the relative difference in hydro survival between the two proposed operations and the reference operation. This relative difference in survival is calculated for each year in the 10-year study period by subtracting the reference operation system survival from the respective proposed action system survival and dividing the difference by the reference operation system survival.

Under the reference operation for SR steelhead, Table 50 shows the estimated juvenile system survivals with D ranged from 44% to 55% during the 1994-2003 study period, with a mean value of about 50%. In-river survivals ranged from 12% to almost 45%, with a mean of about 33% over the study period.

For the near-term (2004) proposed hydro operation, estimated juvenile system survivals with D for this listed stock ranged from over 43% up to 55% during the 1994-2003 study period, with a mean value of about 50%, and in-river survivals ranged from 10% to about 41% with a mean of about 30% over the study period (Table 50).

Thus, for SR steelhead, the estimated relative gap between the 2004 proposed hydro operation and the reference operation over the 10-year study period for system survival in the near term (including differential delayed survival associated with transportation) is -0.2% and ranges from -1.8% to +1.2% (Figure 5). The estimated relative gap for in-river survival through the FCRPS between the 2004 proposed hydro operation and the reference operation is -8.4% and ranges from -1% to -29%. The estimated survival multiplier, or relative difference in survival between the reference operation and the 2004 proposed hydro operation for system survival with D, is 1.00, and ranges from no survival improvement needed to 1.02. The estimated survival multiplier for in-river survival is over 1.12, with a range from 1.01 up to 1.41 (Table 50).

For the long-term (2010) proposed hydro operation, estimated juvenile system survivals with D for this listed stock ranged from over 43% up to 55% during the 1994-2003 study period, with a mean value of about 50%, and in-river survivals ranged from 10% to 45% with a mean of nearly 33% over the study period (Table 51).

Thus, the estimated long-term relative gap between the 2010 proposed hydro operation and the reference operation in system survival with D over the 10-year study period is a +0.7% and ranges between -1.6% and +1.7% (Figure 6). The estimated long-term relative gap for in-river survival through the FCRPS between the 2010 proposed hydro operation and the reference operation is -0.7% and ranges from -24% to +9%. The estimated survival multiplier, or relative difference in survival between the reference operation and the 2010 proposed hydro operation for system survival with D, indicates that no survival improvement is needed with a range of improvement up to 1.02. The estimated survival multiplier for in-river survival is 1.04, ranging from no survival improvement needed up to 1.31% (Table 51).

UCR Steelhead

Under the reference operation for UCR steelhead (and for MCR steelhead that migrate through all four lower Columbia River dams), the estimated juvenile in-river survivals through the lower Columbia River ranged from about 28% to over 63% during the 1994-2003 study period, with a mean value of about 50% (Table 50). For the near-term (2004) proposed hydro operation, the estimated juvenile system survivals for this listed stock ranged from nearly 22% up to about 58% during the study period, with a mean value of nearly 54% (Table 50).

For UCR steelhead (and for MCR steelhead that migrate through all four lower Columbia River dams), the estimated relative survival gap between the proposed action and the reference operation in the near term (2004) over the study period through all four Columbia River FCRPS dams and reservoirs is -8.6%, and ranges from -1% to -25% (Figure 7). The estimated survival multiplier for UCR steelhead, or the relative difference in survival between the reference operation and the 2004 proposed hydro operation for in-river survival through the lower Columbia River projects, is 1.12%, ranging from 1.01 up to 1.34 (Table 50).

For the long-term (2010) proposed hydro operation, Table 51 shows the estimated juvenile system survivals for this listed stock range from 23% up to nearly 61% during the study period, with a mean value of over 48%.

Thus, for UCR steelhead (and for MCR steelhead that migrate through all four lower Columbia River dams), the estimated relative gap between the proposed hydro operation and the reference operation in the long term (2010) for in-river survival through four Columbia River FCRPS dams and reservoirs closes to -3.1%, and ranges from -20.5% to +5.1% (Figure 8). The estimated long-term survival multiplier for UCR steelhead, or the relative difference in survival between the reference operation and the proposed action operation for in-river survival through the lower Columbia River projects, is 1.05, ranging from no survival improvement needed up to 1.26 (Table 51).

MCR Steelhead (passing from John Day reservoir through Bonneville Dam)
For MCR steelhead passing through the John Day pool to Bonneville Dam in the reference operation (three projects), the estimated juvenile in-river survival rates through the lower Columbia River ranged from about 40% up to over 73% during the 1994-2003 study period, with a mean value of 59% (Table 50). For the near-term (2004) proposed hydro operation, Table 50 shows the estimated juvenile in-river survivals for MCR steelhead (JDA to BON) ranging from about 30% to nearly 68% during the study period, with a mean value of almost 54%. For the long-term (2010) proposed hydro operation, estimated juvenile in-river survivals for MCR steelhead ranged from about 30% up to over 69% during the study period, with a mean value of over 48% (Table 51).

For MCR steelhead, the estimated relative in-river survival gap between the proposed hydro operation and the reference operation in the near term (2004) over the 10-year study period is -8.8%, and ranges from -24.7% to -1.1%. The estimated survival multiplier in the near-term for MCR steelhead, or the relative difference in survival between the reference operation and the proposed 2004 hydro operation for in-river survival through the lower Columbia River is 1.11, ranging from 1.01 up to 1.33 (Table 50).

The estimated relative gap between the proposed 2010 hydro operation and the reference operation in the long term for in-river survival over the 10-year study period is -6.2%, ranging from -23% up to +2.1%. Table 51 shows the estimated survival multiplier for MCR steelhead (JDA to BON), or the relative difference in survival between the reference operation and the proposed action operation for in-river survival through the lower Columbia River, is 1.08, ranging from no survival improvement needed to 1.30.

MCR Steelhead (passing from John Day Dam through Bonneville Dam)
For MCR steelhead passing from John Day Dam to Bonneville Dam in the reference operation (three projects), the estimated juvenile in-river survival rates through the lower Columbia River ranged from about 42% up to over 84% during the 1994-2003 study period, with a mean value of over 67% (Table 50). For the near-term (2004) proposed hydro operation, Table 13 shows the estimated juvenile in-river survivals for MCR steelhead (JDA Dam to BON) to range from about 42% to over 88% during the study period, with a mean value of 67%. For the long-term (2010) proposed hydro operation, estimated juvenile in-river survivals for MCR steelhead (JDA Dam to BON) ranged from about 43% up to over 90% during the study period, with a mean value of 69% (Table 51).

For MCR steelhead, the estimated relative in-river survival gap between the proposed hydro operation and the reference operation in the near term (2004) over the 10-year study period is -0.5% and ranges from -2.6% to +4.5%. The estimated survival multiplier in the near term for MCR steelhead, or the relative difference in survival between the reference operation and the proposed 2004 hydro operation for in-river survival through the lower Columbia River, is 1.00, ranging from no survival improvement needed up to 1.03 (Table 50).

The estimated relative gap between the proposed 2010 hydro operation and the reference operation in the long term for in-river survival over the 10-year study period is +2.2%, ranging from +0.1% up to +7.1%. Table 51 indicates that, in the long term, no survival multiplier for MCR steelhead (JDA Dam to BON) is needed.

<u>MCR Steelhead (passing from The Dalles reservoir through Bonneville Dam)</u>
For MCR steelhead passing from The Dalles to Bonneville Dam in the reference operation, the estimated juvenile in-river survival rates through two projects on the lower Columbia River ranged from about 44% up to about 88% during the 1994-2003 study period, with a mean value of over 70% (Table 13). For the near-term (2004) proposed hydro operation, Table 13 shows the estimated juvenile in-river survivals for MCR steelhead (TDA to BON) range from about 44% to over 92% during the study period, with a mean value of about 70%. For the long-term (2010) proposed hydro operation, estimated juvenile in-river survivals for MCR steelhead (TDA to BON) ranged from over 44% up to almost 94% during the study period, with a mean value of over 71% (Table 51).

For MCR steelhead, Table 50 shows the estimated relative in-river survival gap between the proposed hydro operation and the reference operation in the near term (2004) over the 10-year study period is essentially 0%, ranging from -2% to +5%. The estimated survival multiplier in the near term for MCR steelhead, or the relative difference in survival between the reference operation and the proposed 2004 hydro operation for in-river survival through the lower Columbia River, is 1.00, ranging from no survival improvement needed up to 1.02 (Table 50).

The estimated relative gap in the long term for in-river survival over the 10-year study period between the proposed 2010 hydro operation and the reference operation is +1.6%, ranging from -0.4% up to +6.5%. Table 51 indicates that, in the long term, no survival multiplier for MCR steelhead (JDA Dam to BON) is needed, with a range of improvement up to 1.00.

<u>LCR Steelhead (passing through Bonneville Dam)</u>
For LCR steelhead passing Bonneville Dam in the reference operation, the estimated juvenile in-river survival rates ranged from about 64% up to about 95% during the 1994-2003 study period, with a mean value of 84% (Table 50). For the near-term (2004) proposed hydro operation, Table 13 shows the estimated juvenile in-river survivals for LCR steelhead range from 64% to over 97% during the study period, with a mean value of just under 84%. For the long-term (2010) proposed hydro operation, estimated juvenile in-river survivals for LCR steelhead ranged from 64% up to almost 98% during the study period, with a mean value of over 84% (Table 51).

For LCR steelhead, Table 50 shows the estimated relative in-river survival gap between the proposed hydro operation and the reference operation in the near term (2004) over the 10-year study period is -0.3%, ranging from -1.2% to +2.3%. The estimated survival multiplier in the near-term for LCR steelhead, or the relative difference in survival between the reference operation and the proposed 2004 hydro operation for in-river survival through Bonneville Dam, is 1.00, ranging from no survival improvement needed up to 1.01 (Table 50).

The estimated relative gap in the long term for in-river survival of LCR steelhead over the 10-year study period between the proposed 2010 hydro operation and the reference operation is essentially zero, ranging from -0.8% up to +2.6%. Table 51 also indicates that, in the long term, no survival multiplier for LCR steelhead is needed, with a range up to 1.01.

Table 50. Summary of Estimated Survival Rates for Steelhead from 2004 Hydro Gap Analysis

Gap Analysis - Steelhead Summary Page					Study Years						
	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Mean
Proposed Hydro Operation											
SR Stlhd System Survival with Wild D	43.3%	45.3%	50.8%	51.1%	49.9%	49.1%	54.5%	55.2%	45.5%	52.3%	49.7%
SR Stlhd In river Survival (without Transport)	9.8%	30.8%	40.8%	38.9%	40.9%	40.1%	34.7%	9.6%	34.2%	23.6%	30.3%
Total % Transported	75.7%	64.0%	75.6%	76.8%	70.2%	70.6%	95.2%	96.7%	60.6%	91.5%	77.7%
UCR Stlhd In river Survival (4 projects)	21.7%	44.1%	56.1%	53.6%	57.7%	56.1%	50.3%	22.8%	54.8%	38.6%	45.6%
MCR Stlhd In river Survival (JDA to BON)	29.8%	51.0%	63.8%	60.2%	67.6%	61.8%	57.0%	36.1%	63.3%	48.0%	53.9%
MCR Stlhd In river Survival (JDA Dam to BON)	42.0%	63.9%	72.9%	69.8%	81.4%	64.6%	66.6%	88.3%	67.0%	54.8%	67.1%
MCR Stlhd In river Survival (TDA to BON)	43.9%	66.8%	76.3%	73.8%	85.2%	67.6%	69.7%	92.3%	70.1%	57.3%	70.3%
LCR Stlhd In river Survival (BON)	64.0%	83.2%	88.8%	87.5%	92.3%	82.2%	83.5%	97.3%	83.7%	75.7%	83.8%
Reference Operation											**Mean**
SR Stlhd System Survival with Wild D	44.0%	45.7%	50.8%	50.8%	50.6%	49.1%	54.2%	55.3%	45.7%	51.7%	49.8%
SR Stlhd In river Survival (without Transport)	13.9%	34.2%	42.1%	39.3%	44.7%	41.3%	39.8%	12.1%	37.2%	26.7%	33.1%
Total % Transported	77.1%	60.7%	73.4%	75.1%	67.4%	67.9%	92.5%	96.8%	55.3%	88.7%	75.5%
UCR Stlhd In river Survival (4 projects)	28.9%	49.2%	57.9%	54.2%	63.3%	58.2%	56.4%	28.3%	60.1%	42.3%	49.9%
MCR Stlhd In river Survival (JDA to BON)	39.5%	56.3%	65.7%	60.9%	73.5%	63.8%	63.0%	45.7%	68.6%	53.4%	59.0%
MCR Stlhd In river Survival (JDA Dam to BON)	42.1%	64.8%	73.8%	70.4%	83.6%	65.4%	68.2%	84.4%	68.6%	53.4%	67.5%
MCR Stlhd In river Survival (TDA to BON)	43.8%	67.5%	77.1%	73.8%	87.0%	68.2%	71.0%	88.0%	71.4%	55.6%	70.3%
LCR Stlhd In river Survival (BON)	64.0%	83.8%	89.6%	87.7%	93.5%	82.9%	84.5%	95.1%	84.7%	74.7%	84.1%
Relative Difference (Reference/Proposed)											**Geomean**
SR Stlhd System Survival with Wild D	1.02	1.01	1.00	0.99	1.01	1.00	1.00	1.00	1.00	0.99	1.00
SR Stlhd In river Survival (without Transport)	1.41	1.11	1.03	1.01	1.09	1.03	1.15	1.25	1.09	1.13	1.13
UCR Stlhd In river Survival (4 projects)	1.34	1.11	1.03	1.01	1.10	1.04	1.12	1.24	1.10	1.10	1.11
MCR Stlhd In river Survival (JDA to BON)	1.33	1.10	1.03	1.01	1.09	1.03	1.11	1.27	1.08	1.11	1.11
MCR Stlhd In river Survival (JDA Dam to BON)	1.00	1.02	1.01	1.01	1.03	1.01	1.02	0.96	1.02	0.97	1.01
MCR Stlhd In river Survival (TDA to BON)	1.00	1.01	1.01	1.00	1.02	1.01	1.02	0.95	1.02	0.97	1.00
LCR Stlhd In river Survival (BON)	1.00	1.01	1.01	1.00	1.01	1.01	1.01	0.98	1.01	0.99	1.00
Relative Difference (Proposed-Reference/Reference)											**Difference in means**
SR Stlhd System Survival with Wild D	-1.8%	-1.0%	-0.1%	0.6%	-1.3%	0.0%	0.4%	-0.1%	-0.4%	1.3%	-0.2%
SR Stlhd In river Survival (without Transport)	-29.2%	-10.0%	-3.1%	-1.0%	-8.3%	-3.0%	-12.8%	-20.1%	-8.2%	-11.7%	-8.4%
UCR Stlhd In river Survival (4 projects)	-25.2%	-10.3%	-3.1%	-1.1%	-8.8%	-3.5%	-10.7%	-19.5%	-8.8%	-8.9%	-8.6%
MCR Stlhd In river Survival (JDA to BON)	-24.7%	-9.3%	-3.0%	-1.1%	-7.9%	-3.1%	-9.5%	-21.0%	-7.7%	-10.1%	-8.8%
MCR Stlhd In river Survival (JDA Dam to BON)	-0.2%	-1.5%	-1.2%	-0.8%	-2.5%	-1.2%	-2.3%	4.5%	-2.4%	2.6%	-0.5%
MCR Stlhd In river Survival (TDA to BON)	0.3%	-1.0%	-1.0%	0.0%	-2.0%	-1.0%	-1.8%	5.0%	-1.9%	3.1%	0.0%
LCR Stlhd In river Survival (BON)	0.0%	-0.7%	-0.9%	-0.2%	-1.3%	-0.8%	-1.2%	2.3%	-1.2%	1.3%	-0.3%

Table 51. Summary of Estimated Survival Rates for Steelhead from 2010 Hydro Gap Analysis

Gap Analysis - Steelhead Summary Page	Study Years										
	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Mean
2010 Proposed Hydro Operation											
SR Stlhd System Survival with Wild D	43.3%	46.0%	50.9%	51.7%	50.7%	49.8%	54.6%	55.3%	46.4%	52.5%	50.1%
SR Stlhd In river Survival (without Transport)	10.6%	33.3%	45.1%	42.9%	44.0%	43.3%	37.2%	10.4%	36.9%	25.3%	32.9%
Total % Transported	75.9%	63.8%	66.4%	74.5%	70.2%	70.8%	95.4%	96.9%	59.9%	91.7%	76.6%
UCR Stlhd In river Survival (4 projects)	23.0%	46.7%	59.9%	57.0%	60.9%	59.5%	53.2%	24.3%	58.1%	40.8%	48.3%
MCR Stlhd In river Survival (JDA to BON)	30.4%	52.4%	66.1%	62.2%	69.4%	63.6%	58.5%	37.0%	65.0%	49.3%	55.4%
MCR Stlhd In river Survival (JDA Dam to BON)	42.9%	65.4%	75.6%	72.0%	83.7%	66.3%	68.3%	90.4%	68.8%	56.2%	69.0%
MCR Stlhd In river Survival (TDA to BON)	44.4%	67.7%	78.2%	75.0%	86.6%	68.6%	70.7%	93.6%	71.2%	58.1%	71.4%
LCR Stlhd In river Survival (BON)	64.1%	83.5%	90.1%	88.1%	92.8%	82.7%	83.9%	97.6%	84.1%	76.0%	84.3%
Reference Operation											**Mean**
SR Stlhd System Survival with Wild D	44.0%	45.7%	50.8%	50.8%	50.6%	49.1%	54.2%	55.3%	45.7%	51.7%	49.8%
SR Stlhd In river Survival (without Transport)	13.9%	34.2%	42.1%	39.3%	44.7%	41.3%	39.8%	12.1%	37.2%	26.7%	33.1%
Total % Transported	77.1%	60.7%	73.4%	75.1%	67.4%	67.9%	92.5%	96.8%	55.3%	88.7%	75.5%
UCR Stlhd In river Survival (4 projects)	28.9%	49.2%	57.9%	54.2%	63.3%	58.2%	56.4%	28.3%	60.1%	42.3%	49.9%
MCR Stlhd In river Survival (JDA to BON)	39.5%	56.3%	65.7%	60.9%	73.5%	63.8%	63.0%	45.7%	68.6%	53.4%	59.0%
MCR Stlhd In river Survival (JDA Dam to BON)	42.1%	64.8%	73.8%	70.4%	83.6%	65.4%	68.2%	84.4%	68.6%	53.4%	67.5%
MCR Stlhd In river Survival (2 projects)	43.8%	67.5%	77.1%	73.8%	87.0%	68.2%	71.0%	87.9%	71.4%	55.6%	70.3%
LCR Stlhd In river Survival (1 project)	64.0%	83.8%	89.6%	87.7%	93.5%	82.9%	84.5%	95.1%	84.7%	74.7%	84.1%
Relative Difference (Reference/Proposed											
SR Stlhd System Survival with Wild D	1.02	0.99	1.00	0.98	1.00	0.98	0.99	1.00	0.99	0.98	0.99
SR Stlhd In river Survival (without Transport)	1.31	1.03	0.93	0.92	1.01	0.95	1.07	1.16	1.01	1.06	1.04
UCR Stlhd In river Survival (4 projects)	1.26	1.05	0.97	0.95	1.04	0.98	1.06	1.17	1.04	1.04	1.05
MCR Stlhd In river Survival (JDA to BON)	1.30	1.07	0.99	0.98	1.06	1.00	1.08	1.24	1.06	1.08	1.08
MCR Stlhd In river Survival (JDA Dam to BON)	0.98	0.99	0.98	0.98	1.00	0.99	1.00	0.93	1.00	0.95	0.98
MCR Stlhd In river Survival (TDA to BON)	0.99	1.00	0.99	0.98	1.00	0.99	1.00	0.94	1.00	0.96	0.98
LCR Stlhd In river Survival (BON)	1.00	1.00	0.99	1.00	1.01	1.00	1.01	0.97	1.01	0.98	1.00
Relative Difference (Proposed-Reference/Reference)											**Difference in means**
SR Stlhd System Survival with Wild D	-1.6%	0.6%	0.2%	1.7%	0.3%	1.6%	0.7%	0.2%	1.4%	1.5%	0.7%
SR Stlhd In river Survival (without Transport)	-23.8%	-2.8%	7.3%	9.0%	-1.4%	4.7%	-6.5%	-13.8%	-0.7%	-5.3%	-0.7%
UCR Stlhd In river Survival (4 projects)	-20.5%	-5.0%	3.5%	5.1%	-3.8%	2.3%	-5.6%	-14.3%	-3.4%	-3.6%	-3.1%
MCR Stlhd In river Survival (JDA to BON)	-23.0%	-6.9%	0.5%	2.1%	-5.5%	-0.4%	-7.2%	-19.1%	-5.2%	-7.7%	-6.2%
MCR Stlhd In river Survival (JDA Dam to BON)	2.0%	1.0%	2.4%	2.4%	0.1%	1.5%	0.2%	7.1%	0.2%	5.2%	2.2%
MCR Stlhd In river Survival (TDA to BON)	1.5%	0.4%	1.5%	1.6%	-0.4%	0.6%	-0.4%	6.5%	-0.4%	4.6%	1.6%
LCR Stlhd In river Survival (BON)	0.2%	-0.4%	0.6%	0.5%	-0.7%	-0.2%	-0.7%	2.6%	-0.7%	1.7%	0.3%

SR Fall Chinook

The estimated SIMPAS in-river survival rates for SR fall chinook resulting from the reference operation were compared to the in-river survival rates associated with the Action Agencies' proposed action operation. Due to the lack of empirical evidence about the effects of transportation for this listed stock, no estimates of transported fish survivals were calculated. Thus, the difference in survival identified in this gap analysis is the expected difference in in-river survival rates, representing the effects to the listed species that may be attributable to the existence of the projects (dams and reservoirs) compared to both the near-term and long-term proposed hydro operations of the projects.

The SIMPAS modeling results shown below in Tables 52 and 53 provide an indication of the relative difference, or "gap," in in-river passage survival between the operations. These relative differences in survival are calculated for each year in the eight-year study period by subtracting the reference operation in-river survival rates from the near-term and long-term proposed hydro operation survival rates and dividing the difference by the reference operation in-river survival.

Under the reference operation for SR fall chinook, Table 52 shows that estimated juvenile in-river survivals ranged from nearly 10% to over 24% during the 1995-2001 and 2003 study period, with a mean value of about 16.5%. For the proposed 2004 hydro operation, estimated juvenile in-river survivals for this listed stock ranged from 9% to almost 23% during the 8-year study period, with a mean value of over 14% (Table 52).

For SR fall chinook, the estimated relative gap between the 2004 proposed action and the reference operation over the eight-year study period for in-river survival through the FCRPS is -12.7%, and ranges from -5.8% to -22%. The estimated survival multiplier, or relative difference in in-river survival between the reference operation and the 2004 proposed hydro operation, is 1.16 and ranges from 1.06 to 1.28.

Under the proposed long-term (2010) hydro operation, the estimated juvenile in-river survival rates for this listed stock ranged from just under 10% to almost 25% during the eight-year study period, with a mean value of over 15.6% (Table 53).

For SR fall chinook, the estimated relative gap between the proposed action and the reference operation over the study period for in-river survival through the FCRPS long term (2010) is -5.4%, and ranges from -15.3% to +2.4%. The estimated survival multiplier, or relative difference in in-river survival between the reference operation and the long-term (2010) proposed hydro operation, is 1.07 and ranges from no improvement in survival needed to 1.18.

LCR Fall Chinook

Under the reference operation for LCR fall chinook passing Bonneville Dam, Table 15 shows that estimated juvenile in-river survivals ranged from about 79% to almost 98% during the 1995-2001 and 2003 study period, with a mean value of over 87%. For the proposed 2004 hydro operation, estimated juvenile in-river survivals for this listed stock ranged from about 77% to over 97% during the eight-year study period, with a mean value of about 86% (Table 52).

For LCR fall chinook, Table 15 shows the estimated relative gap over the eight-year study period for in-river survival through the FCRPS between the 2004 proposed action and the reference operation is -1.5% and ranges from -0.2% to -2.5%. The estimated survival multiplier, or relative difference in in-river survival between the reference operation and the 2004 proposed hydro operation, is 1.02 and ranges from 1.00 to 1.03% (Table 52).

Under the proposed long-term (2010) hydro operation, the estimated juvenile in-river survival rates for this listed stock ranged from over 77% to over 97% during the 8-year study period, with a mean value of 86% (Table 53).

For LCR fall chinook passing Bonneville Dam, Table 16 indicates the estimated relative gap between the long-term (2010) proposed action and the reference operation over the study period for in-river survival through the FCRPS is -1.4% and ranges from -0.1% to +2.4%. The estimated survival multiplier, or relative difference in in-river survival between the reference operation and the long-term (2010) proposed hydro operation is 1.01 and ranges from roughly no improvement in survival needed to 1.03 (Table 53).

Table 15 – Summary of Estimated Survival Rates for Fall Chinook from 2004 Hydro Gap Analysis

Gap Analysis - Subyearling Chinook Summary Page

	Study Years										
	1994	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**Mean**
Proposed Hydro Operation											
SR Fall Chinook In river Survival (without Transport)		11.5%	20.7%	22.9%	11.4%	15.4%	11.5%	9.1%		12.8%	14.4%
Total % Transported		55.7%	45.7%	41.2%	48.3%	58.1%	43.2%	21.7%		46.4%	45.0%
LCR Fall Chinook In river Survival (1 project)		77.3%	89.6%	97.2%	78.9%	84.2%	81.7%	96.7%		81.6%	85.9%
Reference Operation											**Mean**
SR Fall Chinook In river Survival (without Transport)		13.3%	23.1%	24.3%	13.5%	17.3%	14.8%	9.9%		15.9%	16.5%
Total % Transported		55.8%	45.2%	40.9%	48.4%	57.7%	44.4%	21.2%		47.8%	45.2%
LCR Fall Chinook In river Survival (1 project)		78.9%	90.4%	97.4%	80.6%	85.0%	83.7%	97.6%		83.7%	87.2%
Absolute Difference (Reference-Proposed)											**Difference in means**
SR Fall Chinook In river Survival (without Transport)		1.8%	2.3%	1.4%	2.1%	1.9%	3.3%	0.8%		3.1%	2.1%
Total % Transported		0.1%	-0.5%	-0.3%	0.1%	-0.4%	1.2%	-0.5%		1.4%	0.1%
LCR Fall Chinook In river Survival (1 project)		1.6%	0.8%	0.2%	1.7%	0.8%	2.0%	0.9%		2.1%	1.3%
Relative Difference (Reference/Proposed)											**Geomean**
SR Fall Chinook In river Survival (without Transport)		1.16	1.11	1.06	1.19	1.13	1.28	1.09		1.24	1.16
LCR Fall Chinook In river Survival (1 project)		1.02	1.01	1.00	1.02	1.01	1.02	1.01		1.03	1.02
Relative Difference (Proposed-Reference/Reference)											**Difference in means**
SR Fall Chinook In river Survival (without Transport)		-13.7%	-10.1%	-5.8%	-15.6%	-11.2%	-22.1%	-8.2%		-19.4%	-12.7%
LCR Fall Chinook In river Survival (1 project)		-2.0%	-0.9%	-0.2%	-2.1%	-0.9%	-2.4%	-0.9%		-2.5%	-1.4%

Table 16 – Summary of Estimated Survival Rates for Fall Chinook from 2010 Hydro Gap Analysis

Gap Analysis - Subyearling Chinook Summary Page

	Study Years										
	1994	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**Mean**
2010 Proposed Hydro Operation											
SR Fall Chinook In river Survival (without Transport)		12.5%	22.6%	24.9%	12.4%	16.7%	12.5%	9.8%		13.4%	15.6%
Total % Transported		56.0%	46.0%	41.5%	48.6%	58.4%	43.5%	21.8%		46.7%	45.3%
LCR Fall Chinook In river Survival (1 project)		77.4%	89.7%	97.3%	79.0%	84.3%	81.7%	96.8%		81.7%	86.0%
Reference Operation											**Mean**
SR Fall Chinook In river Survival (without Transport)		13.3%	23.1%	24.3%	13.5%	17.3%	14.8%	9.9%		15.9%	16.5%
Total % Transported		55.8%	45.2%	40.9%	48.4%	57.7%	44.4%	21.2%		47.8%	45.2%
LCR Fall Chinook In river Survival (1 project)		78.9%	90.4%	97.4%	80.6%	85.0%	83.7%	97.6%		83.7%	87.2%
Absolute Difference (Reference-Proposed)											**Difference in means**
SR Fall Chinook In river Survival (without Transport)		0.8%	0.5%	-0.6%	1.1%	0.6%	2.3%	0.0%		2.5%	0.9%
Total % Transported		-0.2%	-0.8%	-0.6%	-0.2%	-0.7%	1.0%	-0.7%		1.1%	-0.1%
LCR Fall Chinook In river Survival (1 project)		1.5%	0.7%	0.1%	1.6%	0.7%	2.0%	0.8%		2.0%	1.2%
Relative Difference (Reference/Proposed)											**Geomean**
SR Fall Chinook In river Survival (without Transport)		1.06	1.02	0.98	1.09	1.04	1.18	1.00		1.18	1.07
LCR Fall Chinook In river Survival (1 project)		1.02	1.01	1.00	1.02	1.01	1.02	1.01		1.02	1.01
Relative Difference (Proposed-Reference/Reference)											**Difference in means**
SR Fall Chinook In river Survival (without Transport)		-6.1%	-2.2%	2.4%	-8.2%	-3.4%	-15.3%	-0.2%		-15.5%	-5.4%
LCR Fall Chinook In river Survival (1 project)		-1.9%	-0.8%	-0.1%	-2.0%	-0.8%	-2.4%	-0.8%		-2.4%	-1.3%

Adult Passage Survival Rates under the Proposed Action and Reference Operation

No reduction in adult fish passage survival through the mainstem FCRPS projects is expected for SR spring/summer chinook and UCR spring chinook salmon, SR and UCR steelhead, and SR fall chinook salmon as a result of discretionary hydro operations under the proposed action or under the reference operation (Attachment 4).

Figure 1 – Relative System Survival Gap for Snake River Yearling Chinook Salmon

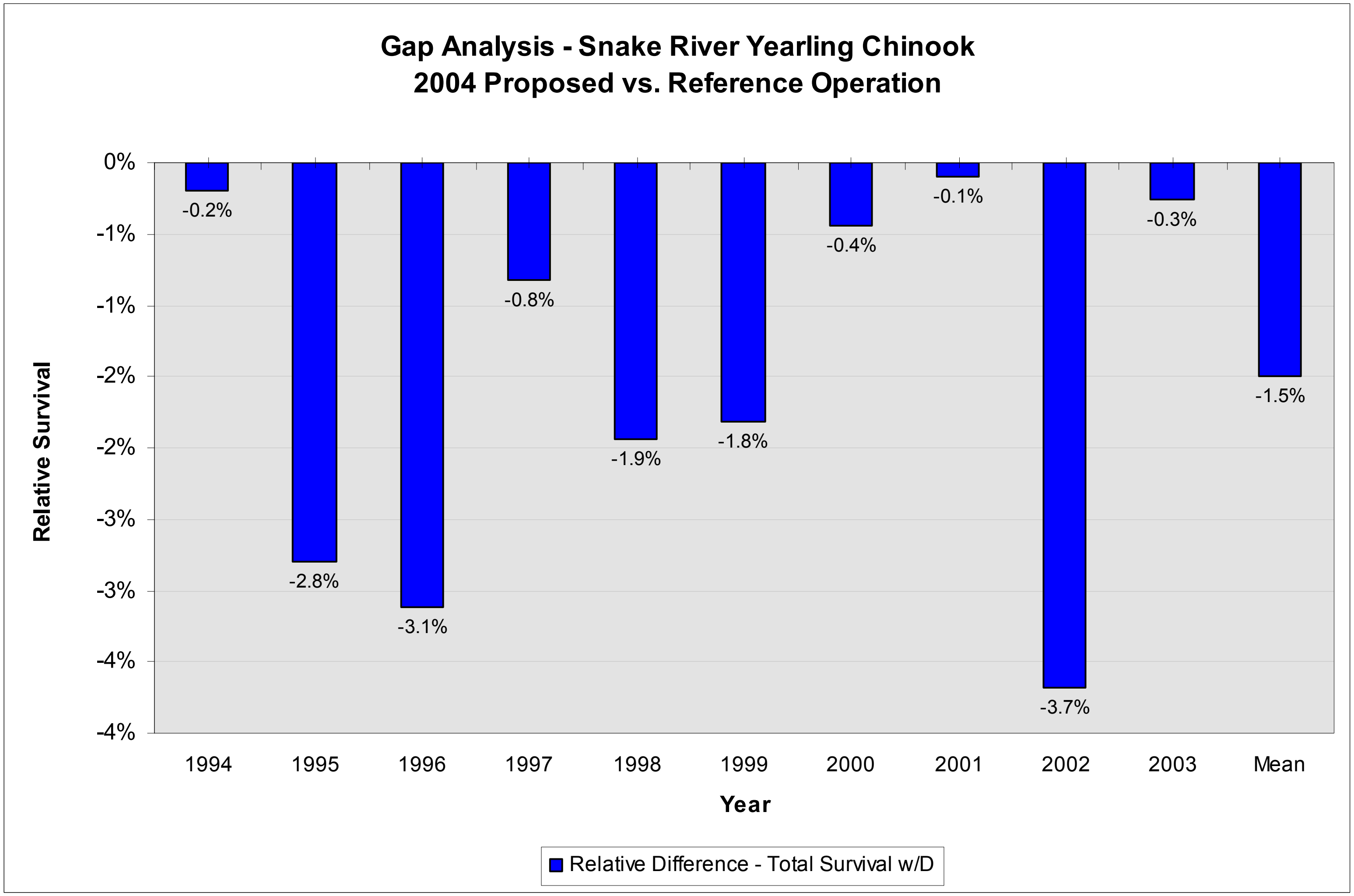


Figure 2 – Relative In-River Survival Gap for Upper Columbia River Yearling Chinook Salmon

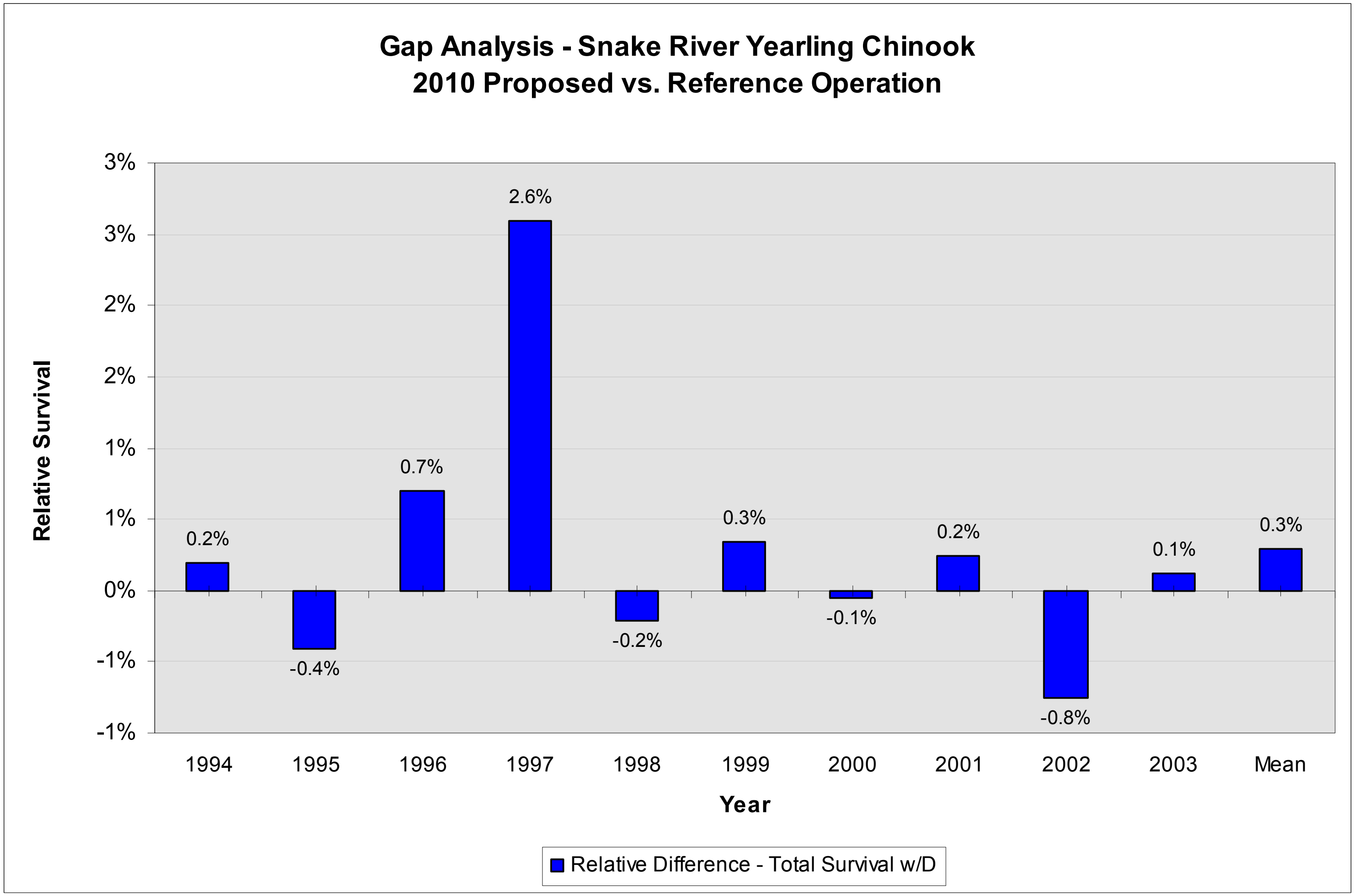


Figure 3.

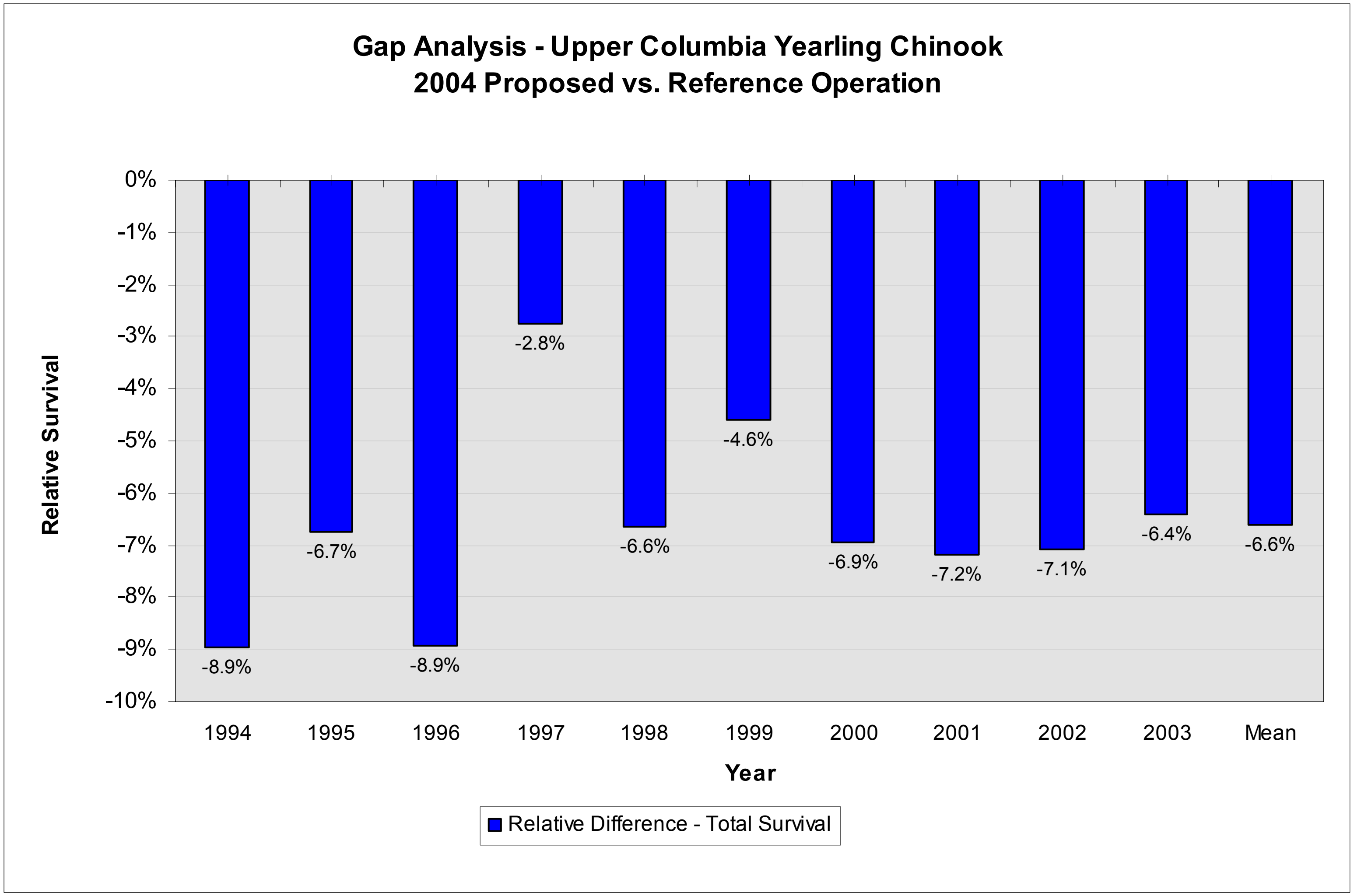

Gap Analysis - Upper Columbia Yearling Chinook
2004 Proposed vs. Reference Operation
0%
-1%
-2%
-3%
-4%
-5%
-6%
-7%
-8%
-9%
-10%
Relative Survival
-8.9%
-6.7%
-8.9%
-2.8%
-6.6%
-4.6%
-6.9%
-7.2%
-7.1%
-6.4%
-6.6%
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
Mean
Year
Relative Difference - Total Survival

Figure 4.

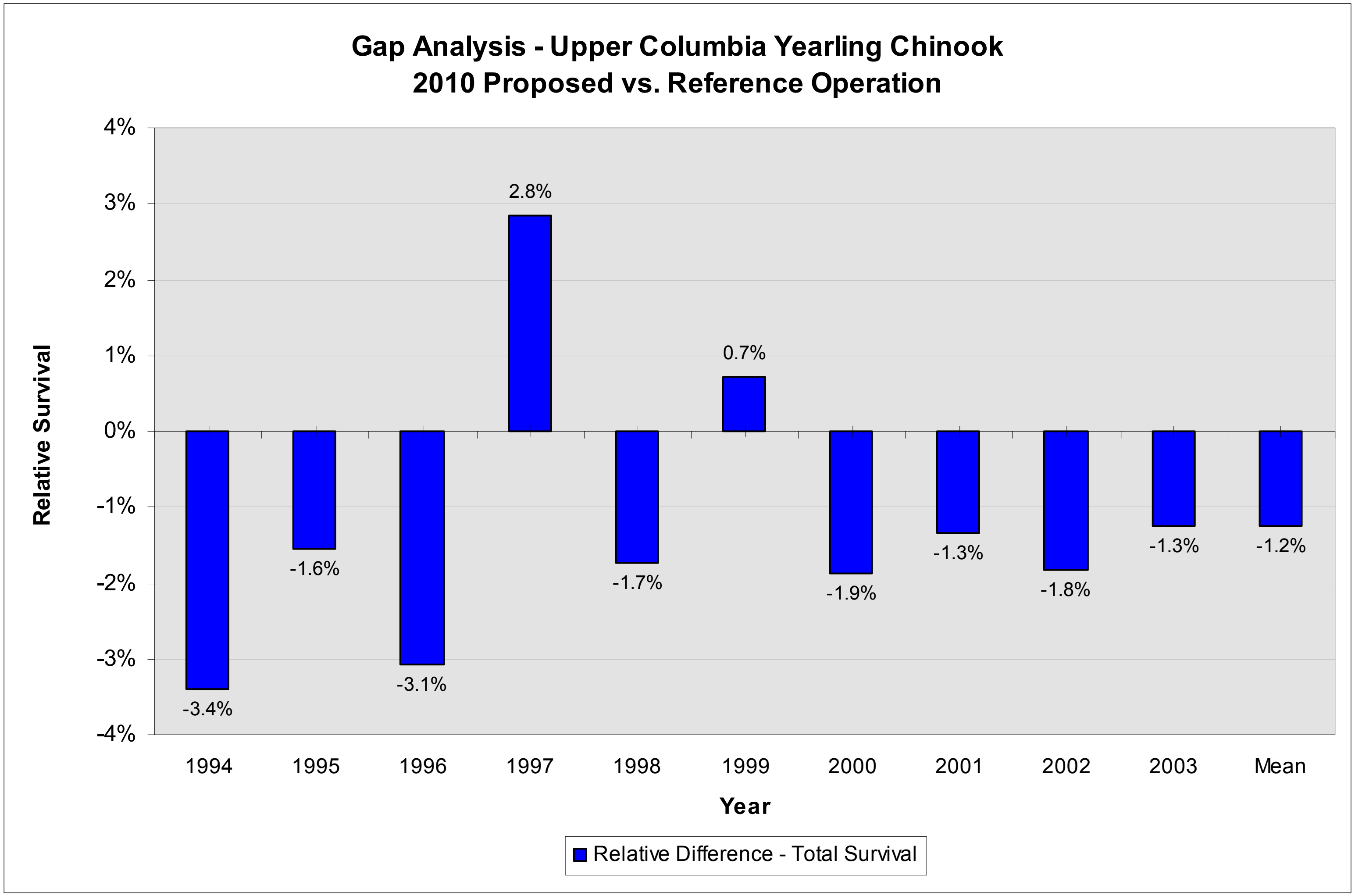

Gap Analysis - Upper Columbia Yearling Chinook
2010 Proposed vs. Reference Operation
Relative Survival
4%
3%
2%
1%
0%
-1%
-2%
-3%
-4%
2.8%
0.7%
-3.4%
-1.6%
-3.1%
-1.7%
-1.9%
-1.3%
-1.8%
-1.3%
-1.2%
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
Mean
Year
Relative Difference - Total Survival

Figure 5.

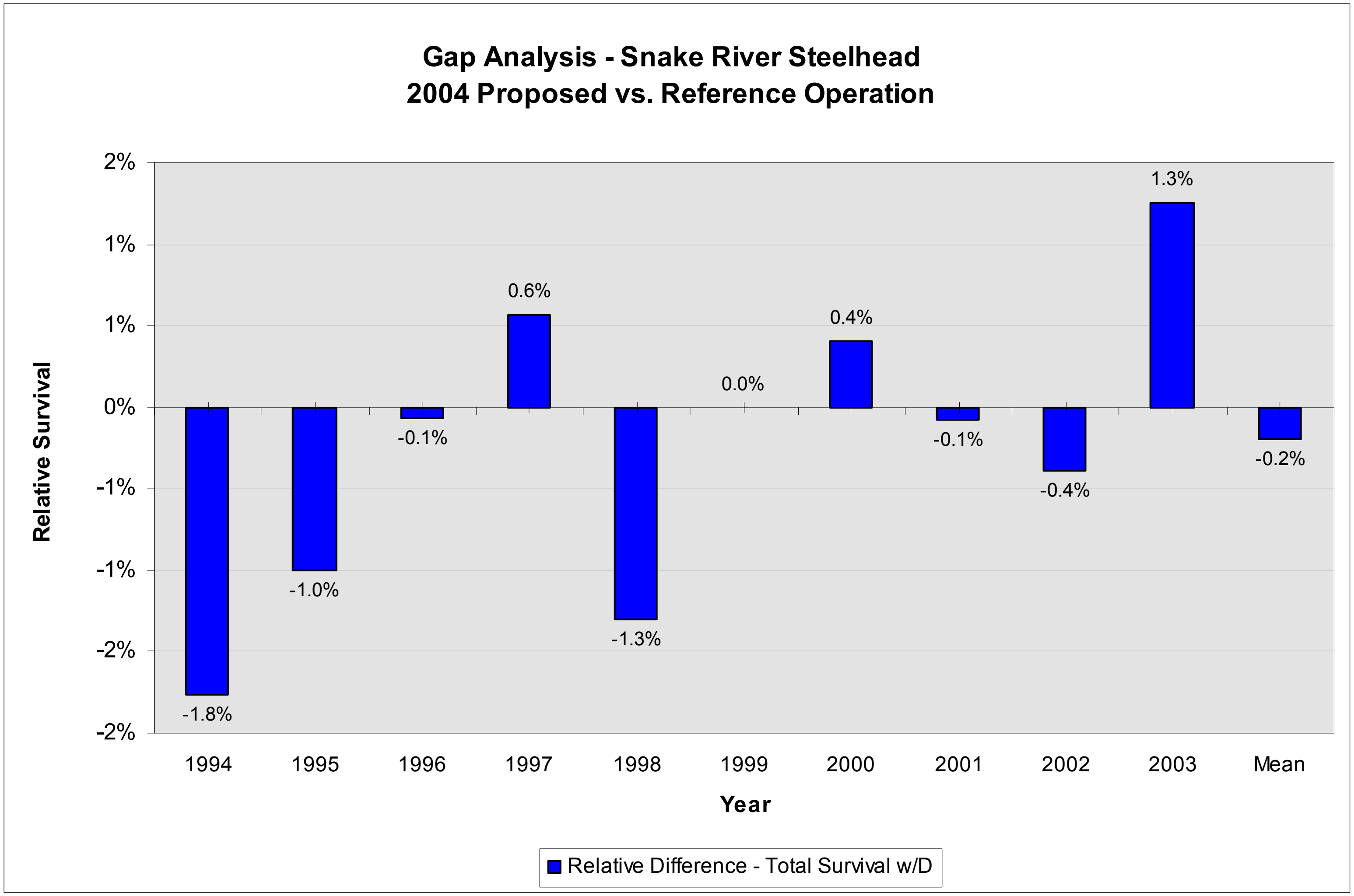

Gap Analysis - Snake River Steelhead
2004 Proposed vs. Reference Operation
2%
1%
1%
0%
-1%
-1%
-2%
-2%
Relative Survival
-1.8%
-1.0%
-0.1%
0.6%
-1.3%
0.0%
0.4%
-0.1%
-0.4%
1.3%
-0.2%
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
Mean
Year
Relative Difference - Total Survival w/D

Figure 6.

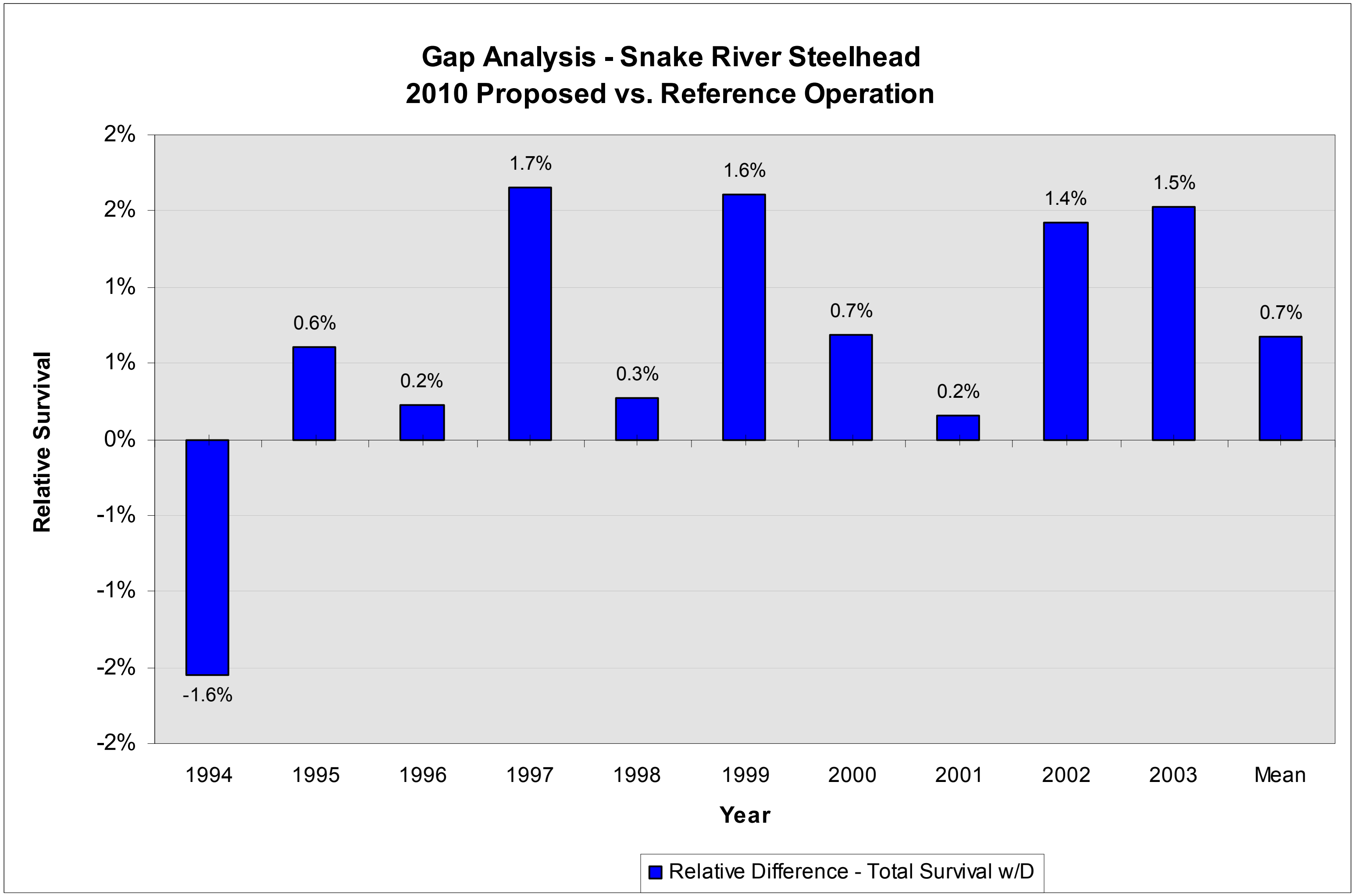

Gap Analysis - Snake River Steelhead
2010 Proposed vs. Reference Operation
Relative Survival
2%
2%
1%
1%
0%
-1%
-1%
-2%
-2%
-1.6%
0.6%
0.2%
1.7%
0.3%
1.6%
0.7%
0.2%
1.4%
1.5%
0.7%
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
Mean
Year
Relative Difference - Total Survival w/D

Figure 7.

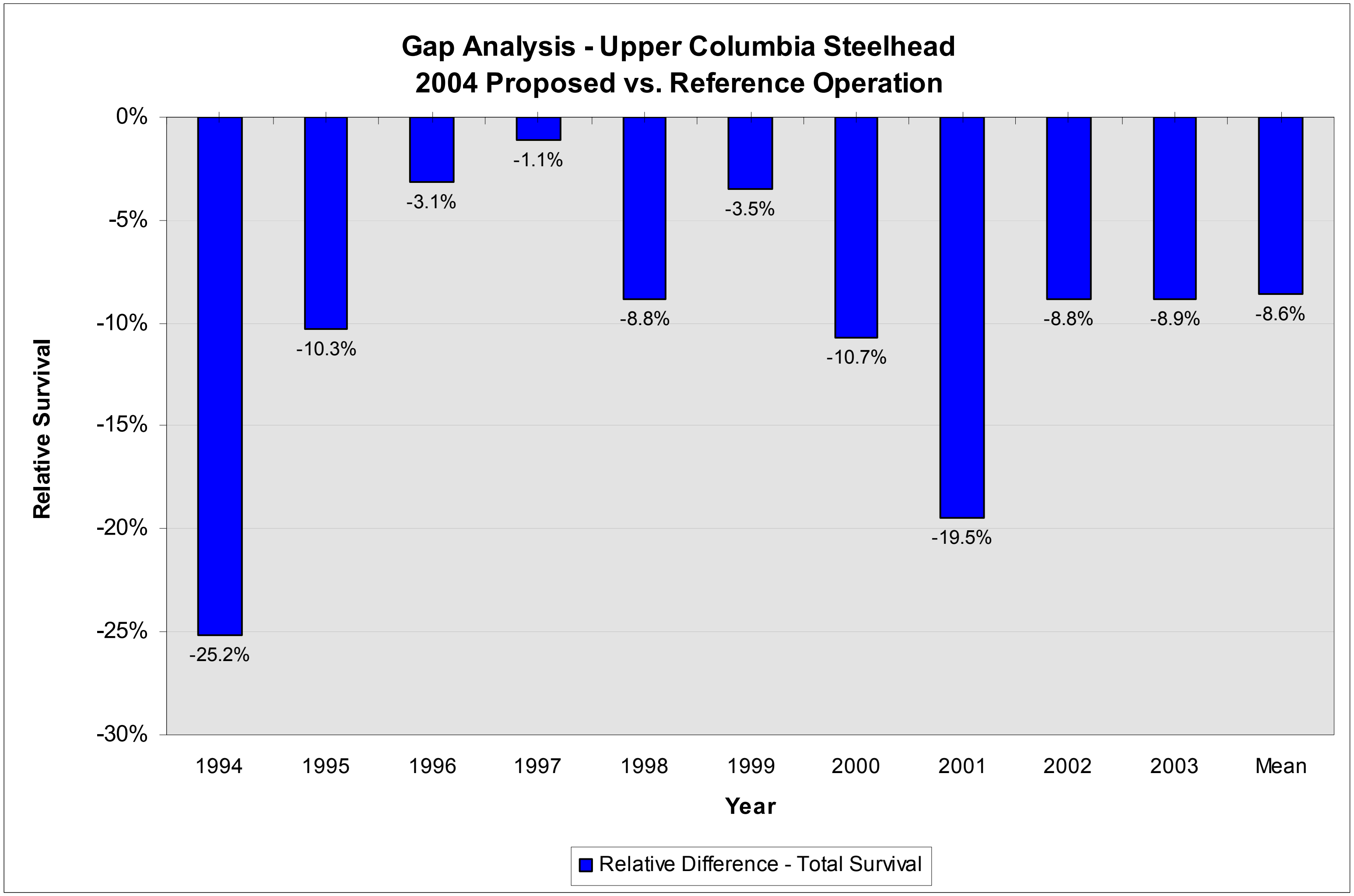

Gap Analysis - Upper Columbia Steelhead
2004 Proposed vs. Reference Operation
Relative Survival
0%
-5%
-10%
-15%
-20%
-25%
-30%
-25.2%
-10.3%
-3.1%
-1.1%
-8.8%
-3.5%
-10.7%
-19.5%
-8.8%
-8.9%
-8.6%
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
Mean
Year
Relative Difference - Total Survival

Figure 8.

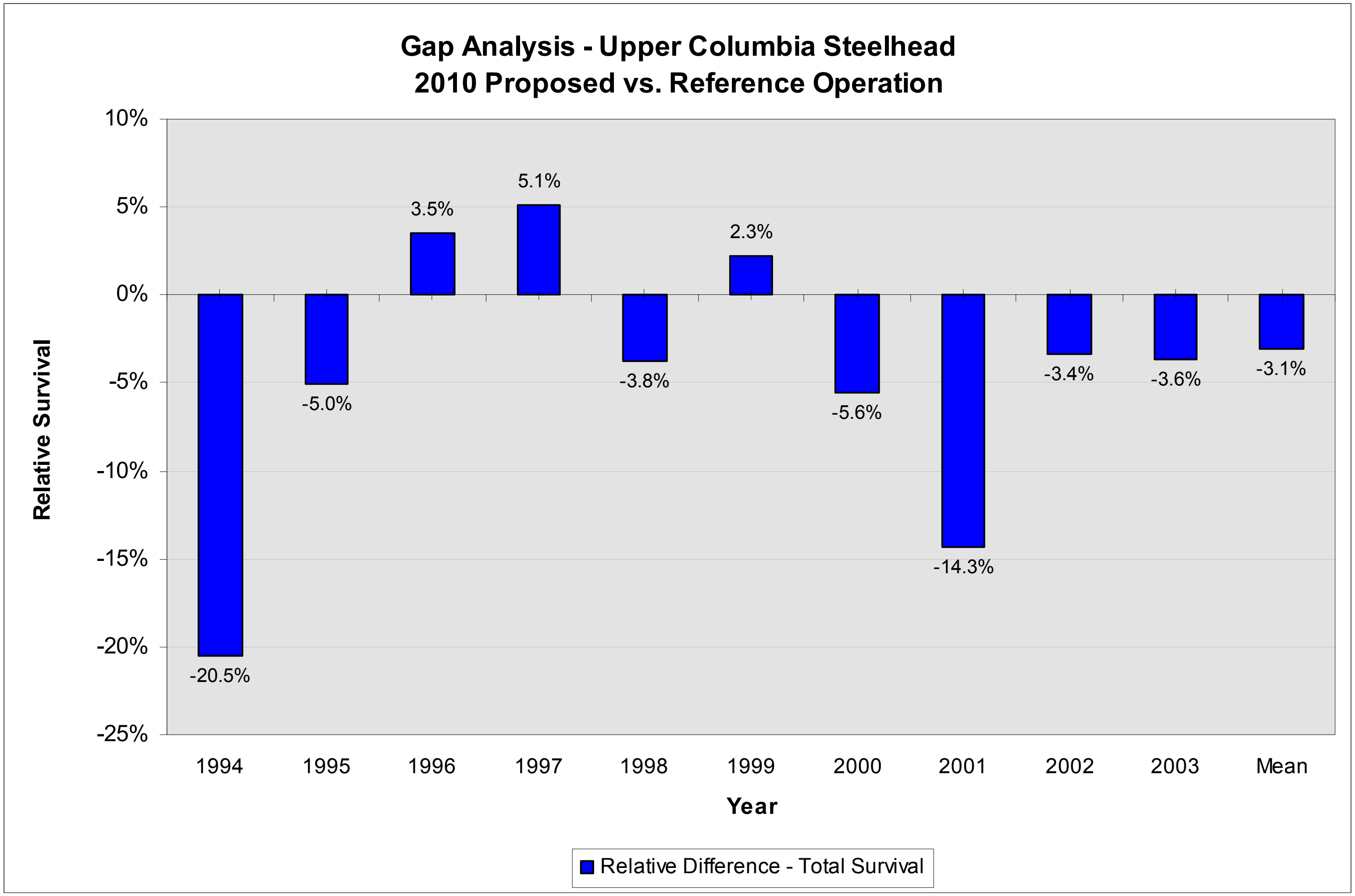

Gap Analysis - Upper Columbia Steelhead
2010 Proposed vs. Reference Operation
Relative Survival
10%
5%
0%
-5%
-10%
-15%
-20%
-25%
-20.5%
-5.0%
3.5%
5.1%
-3.8%
2.3%
-5.6%
-14.3%
-3.4%
-3.6%
-3.1%
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
Mean
Year
Relative Difference - Total Survival

Figure 9.

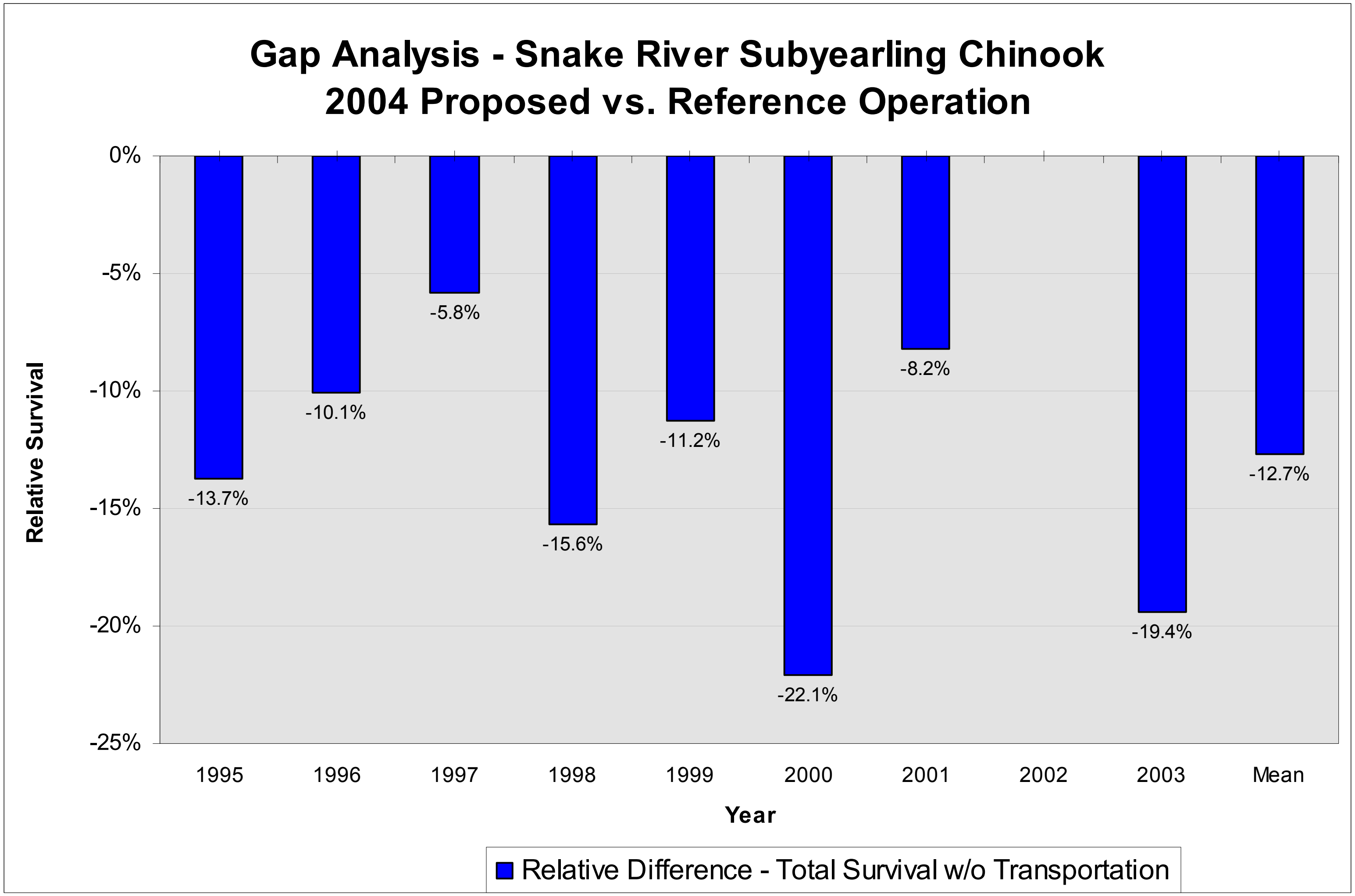
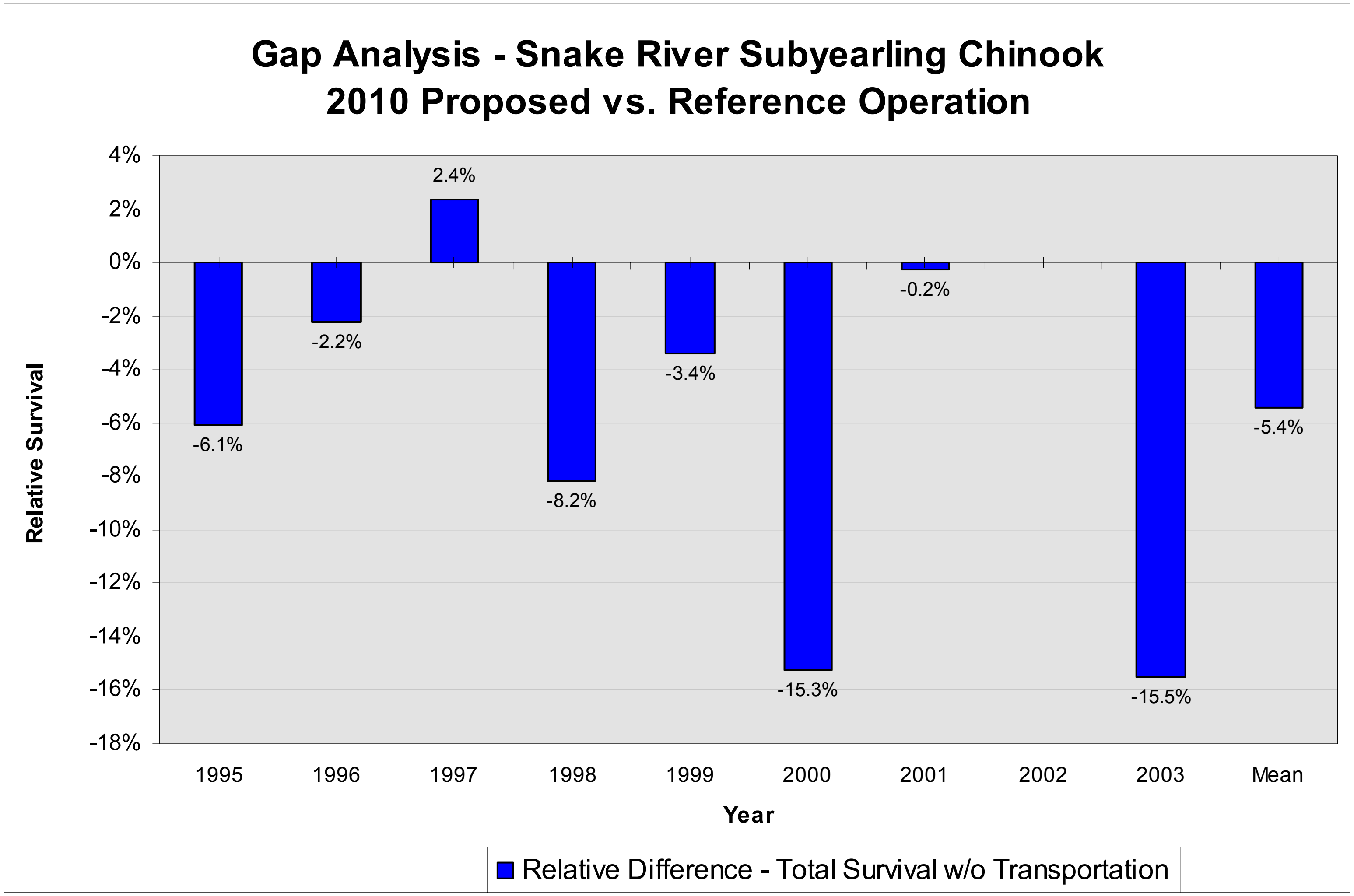

Gap Analysis - Snake River Subyearling Chinook
2004 Proposed vs. Reference Operation
0%
-5%
-10%
-15%
-20%
-25%
Relative Survival
-13.7%
-10.1%
-5.8%
-15.6%
-11.2%
-22.1%
-8.2%
-19.4%
-12.7%
1995
1996
1997
1998
1999
2000
2001
2002
2003
Mean
Year
Relative Difference - Total Survival w/o Transportation

Figure 10



Gap Analysis - Snake River Subyearling Chinook
2010 Proposed vs. Reference Operation
Relative Survival
4%
2%
0%
-2%
-4%
-6%
-8%
-10%
-12%
-14%
-16%
-18%
2.4%
-6.1%
-2.2%
-8.2%
-3.4%
-15.3%
-0.2%
-15.5%
-5.4%
1995
1996
1997
1998
1999
2000
2001
2002
2003
Mean
Year
Relative Difference - Total Survival w/o Transportation

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