Appendix D

STAFF ANALYSIS OF BIOLOGICAL BENEFITS OF MAINSTEM PASSAGE ACTIONS

During the course of this amendment proceeding, the Northwest Power Planning Council has examined the biological, economic and hydroelectric impacts of a wide range of options to enhance the biological status of Snake River salmon populations specifically and all Columbia Basin salmonid populations in general. Each of the options was analyzed extensively by Council staff. These deliberations culminated with the Council adopting a set of amendments to its Fish and Wildlife Program at its meeting in Portland, Oregon on December 13-15, 1994.

This report provides the results of the biological analysis of the adopted actions. The package was termed Option 7 during the amendment process. Option 7 is very similar to the Council's previous Alternative 6. The Council received the results of the analysis of Alternative 6 prior to its December 6, 1994 meeting and the analysis of Option 7 was provided prior to the Council's meeting on December 13, 1994.

The analysis has been confined to the biological impacts of the actions on Snake River spring chinook. Because of their close biological similarities, the results would also be applicable to Snake River summer chinook as well. For this analysis, Snake River spring chinook were treated as a single population above Lower Granite Dam

Description of the action

The Council's adopted rule calls for shorter and longer-term flow, velocity and bypass measures coupled with an evaluation comparing transportation and in-river passage. The evaluation is intended to guide future decisions by the Council regarding the different alternatives. The sequence of actions analyzed is shown in Figure 1. Briefly, however, the analysis consists of the following actions:

<u>1. 1995 Actions</u>

a. Lower Granite drawdown to elevation 710. This action will disable the existing juvenile bypass, but adult passage can be provided with minor modifications. Transportation is eliminated from this project and spill is provided as bypass.

b. Transportation is reduced to a single project, in this case, Little Goose. Collection from Lower Monumental and McNary is eliminated. Transportation is assumed to be in an evaluation mode and would only operate from a single collector project.

c. Spill except at the collector project for up to 80-percent fish passage efficiency constrained by state water quality guidelines.

d. Additional flow as described in Figure 1.

2. 1996 and 1997 Actions

a. John Day Pool at minimum operating level.
b. Lower Granite to near spillway (1996)
c. Additional flow as in Figure 1.

3. 1999 (Alternative A) Actions

a. Little Goose lowered to near spillway. Bypass is enhanced at Lower Granite through the addition of a surface bypass system with an effective fish guidance efficiency of 70 percent.
b. Transportation is confined to Lower Monumental Dam.

4. 2002 Actions

a. Alternative B

i. Lower Monumental and Ice Harbor drawn down to spillway.
ii. John Day drawn down to spillway. Surface bypass system installed with effective fish guidance efficiency of 70 percent.
iii. No transportation; spill at all projects.

b. Alternative C

i. Lower Monumental and Ice Harbor drawn down to spillway.
ii. No transportation; spill at all projects.

c. Alternative D

i. Lower Monumental and Ice Harbor at minimum operating pool.
ii. John Day drawn down to spillway. Surface bypass system installed with effective fish guidance efficiency of 70 percent.
iii. Transportation from Lower Monumental.
iv. Spill at all projects except Lower Monumental.

Management for the evaluation of transportation benefits is to be determined by the National Marine Fisheries Service, with management of additional transportation in any year to be determined by the fishery management agencies. The above specifications assume a certain configuration of transportation for the purposes of the analysis, but should not be regarded as necessarily reflecting how the management agencies might elect to manage transportation.

Alternatives A through D are the end points that depend on Council decisions to be made in 2002 (Figure 1). These decisions should benefit from additional evaluations called for by the Council, especially an evaluation of the relative benefits of transportation and inriver passage. The Council's action included all four alternatives with the final path to be determined in the future.

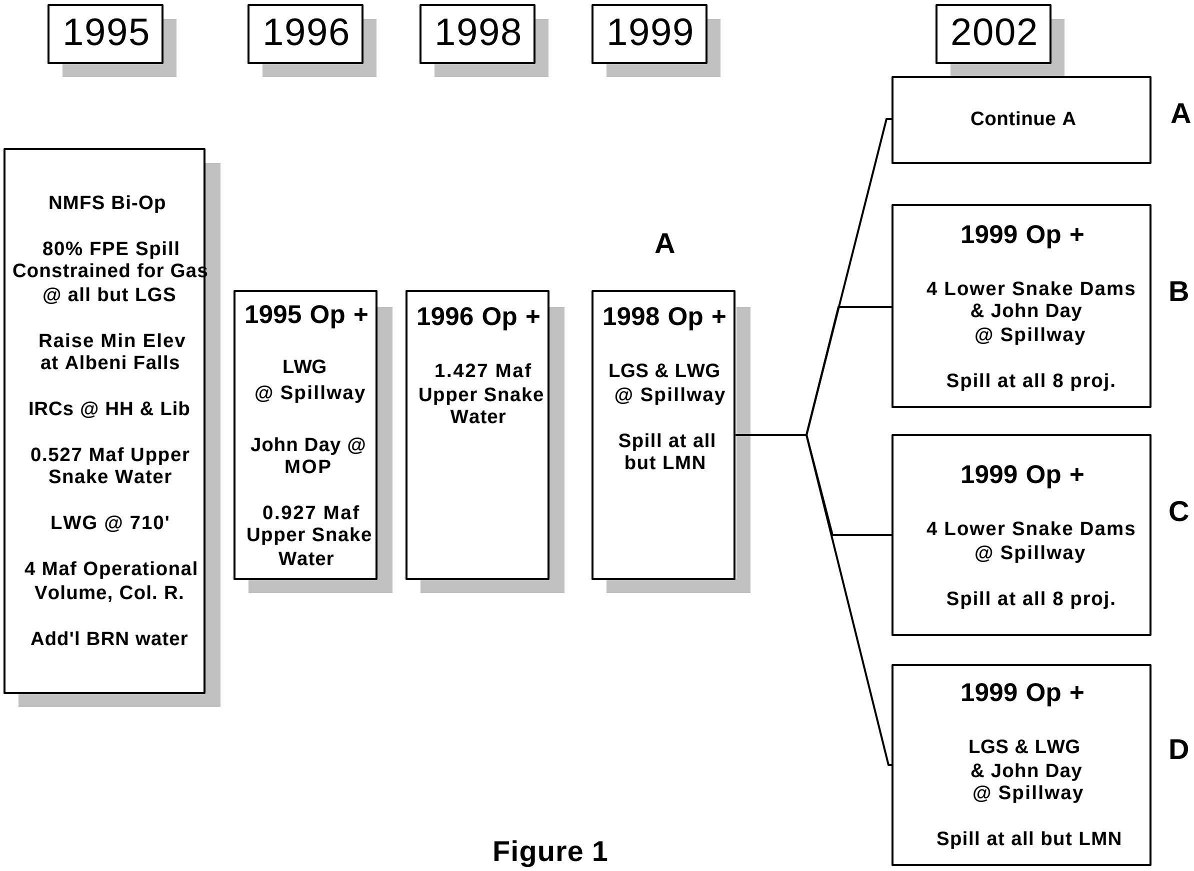

Figure 1

Description of the analysis

Three different analytical tools were used for this analysis. The System Analysis Model was used to examine the hydrological impacts of the option.. This analysis was based on the historical runoff in the Columbia River basin for the years 1929-1978. The result was an array of 50 flows in the Snake and Columbia that reflect the different boxes in Figure 1. These were analyzed using the Passage Analysis Model to estimate the resulting downstream passage survival for each box in Figure 1. The System Planning Model was then used to combine these passage survival rates with other assumptions concerning the salmonid life cycle to produce a simulation of the run into the future reflecting the different paths in Figure 1.

The four possible alternatives, A, B, C, or D, were examined using three different sets of assumptions related to juvenile mainstem passage. These are:

a. A Sims/Ossiander-based model assuming a moderate level of transportation benefits. The transportation benefits are based on the point estimates of benefits from the National Marine Fisheries Service transportation evaluation studies in 1986 and 1989 (Transportation Benefit Ration equals 1.6:1 and 2.4:1 respectively).

b. A similar Sims/Ossiander model using the lower end of the confidence limits for transportation in 1986 of 1.01:1.

These two passage options are similar to those used by the Council staff in the past and are consistent with the analytical work being done by the fishery managers. The result of these assumptions is that juvenile mainstem passage survival rate is a major factor limiting upriver spring chinook populations.

c. A model that assumes that mortality caused by the hydroelectric system is relatively low (HiSurv). This model is similar to that advocated by the Columbia River Alliance and some utility groups. Survival in Lower Granite and Little Goose pools reflects preliminary estimates of survival in Lower Granite and Little Goose reservoirs made by the National Marine Fisheries Service (Skalski and Iwamoto) in 1993 and 1994. Survival in the other pools is derived from the assumption of an 80-percent transportation survival rate (Darryll Olsen, Columbia River Alliance, personal communication) and the transport benefit ratios observed by the National Marine Fisheries Service in 1986 and 1989. The result of this assumption is that juvenile mainstem passage survival rate is not a major factor limiting upriver spring chinook populations. This assumption set is termed HiSurv in the charts.

These options have been used by the Council staff in recent analyses and are documented in the attachment. The intent is to bracket the range of uncertainty in key passage assumptions and to illustrate the implications of different assumptions.

To properly interpret the results of this analysis, it is important to understand that these different passage assumption sets were assumed in the base period and in the simulations of future conditions. For example, if the HiSurv assumption was used, it was assumed to be operating during the base period as well as into the future. Thus, these assumption sets are not different alternatives but are different underlying models of how the system works. The different alternatives to modify the system in the future are overlain on these assumptions.

This analysis did not explicitly treat any potential negative impacts of spill in the sense that there is no explicit mechanism in the analysis linking a level of spill to a level of survival. However, this is not to say that negative spill impacts were not considered. The spill levels used were termed “constrained spill” and are based on empirical observation of dissolved gas levels that occurred in the Columbia and Snake rivers in 1994 during periods of high spill. These observations were used to arrive at an approximation of spill conditions that maintained dissolved gas below a threshold of 120-percent gas saturation level. This provided a relatively high level of fish passage effectiveness, but usually less than the 80-percent level advocated by some fishery management agencies.

In addition to the juvenile passage alternatives, we have included potential impacts of other actions in the program. These include changes in adult passage, pre-spawning survival and tributary survival (egg-smolt stage). Unfortunately, it is not possible to quantitatively link actions to survival in these areas as we do for juvenile passage. In addition, many of these actions affect particular subbasins and populations and not necessarily the population above Lower Granite as a whole. As a result, plausible estimates were used to illustrate the impacts of changes in these survival areas, but they do not represent quantitative estimates of the impacts of specific measures.

The assumption about adult passage is based on observed change in between-dam survival rates that have occurred over the last several years. Relative to the 1975 - 1993 time period, the average adult survival rates provided by the fishery managers for the last ten years (84-93) have shown appreciable improvement (see table below). Without speculating as to the cause of these improvements, we chose adult survival rates into the future from this array of recent passage rates rather than from the 20-year record. This represents an average increase in adult passage survival for survival from below Bonneville to above Lower Granite of 13.6 percent relative to the entire period (1975-1993).

Adult Passage Survival Rates

Period	BON-MCN	IHR-LRG	Total
1975-1993 Average	0.693	0.826	0.572
1984-1993 Average	0.772	0.842	0.650
Percentage improvement	11.5 percent	1.9 percent	13.6 percent

Pre-spawning survival (survival of adults from Lower Granite to the spawning grounds) and tributary (egg-smolt) survival improvements were based on changes suggested by the National Marine Fisheries Service as part of the 1994 biological opinion analysis. Changes in pre-spawning survival were made relative to the estimated adult survival of radio-tagged fish from Lower Granite Dam to spawning areas in 1992 of 69 percent.[1] The medium level changes suggested by the National Marine Fisheries Service increased pre-spawning survival by 13 percent and egg-smolt survival by 8 percent. These changes are intended to reflect improvements in hatchery practices (reduction in the take of wild fish into hatcheries) and improvement to habitat. Because these changes are presumed to result from future actions, they were not fully realized in the analysis until 2002.

<u>Presentation of Results</u>

Two different ways of comparing the biological impacts of the alternatives are provided. The first is the long-term trend in fish returns as a result of the strategy. These charts present the median value of 500 runs of the System Planning Model. While these graphs are visually appealing, they exclude some of the information from the analysis. For example, it must be kept in mind that half the time, the System Planning Model results were below the median line and half the time they were above the line. If a significant number of times the results showed a decline in the run, this might not be evident from looking only at the median.

Because of this, we also are providing probability charts. These show the probability of the System Planning Model result relative to certain run sizes. For example, the charts show the proportion of the 500 System Planning Model simulations that were fewer than 1,000 fish at Lower Granite after 24 years. Because the recent spring chinook returns are on the order of 1,000 fish, this is the probability that the System Planning Model results show a continued decline in the run after 24 years as a result of the alternative. We analyzed the probability that the System Planning Model results at Lower Granite Dam after 24 years would be:

a. Fewer than 1,000 fish;
b. Greater than 1,000 fish;
c. Greater than 5,000 fish;
d. Greater than 10,000 fish.

Because the run size varies from year to year, it is necessary to average the results when calculating the probabilities. For this, we used the eight-year geometric mean. This is similar to using the eight-year

[1]Bjornn, T.C. et al. 1994. Migration of adult chinook salmon and steelhead past dams and through reservoirs in the lower Snake River and into tributaries-1992. Technical report 94-1 to U.S. Army Corps of Engineers and Bonneville Power Administration.

running average. The eight-year period was chosen to encompass two salmon generations and is similar to the statistic used by the fishery managers in the federal court settlement negotiations currently underway.

The first numeric category is based on the level of recent returns of about 1,000 wild spring chinook at Lower Granite Dam. One way to look at these results is that the probability of an average System Planning Model result for a scenario being fewer than 1,000 fish after 24 years provides an indication of how likely it is that the run would continue to decline as a result of the alternative and under the particular assumption set. The second category speaks to the likelihood that the alternative would provide rebuilding above the existing population size. Finally, the other two categories provide an indication of the probability of rebuilding to higher levels. The use of the word *indication* is important. There are a number of unknowns that will affect the future and many scientific uncertainties. This is highlighted by the use of three alternative passage assumption sets in the analysis. Hence, these are not *predictions* of results so much as indicators of the relative effectiveness of the alternatives under different sets of underlying assumptions.

Results

Prior to discussing the results, one important caveat is in order. This analysis treated all Snake River spring chinook above Lower Granite Dam as a single population. However, the Council has acknowledged that there could be a number of important individual populations that are included in this larger designation. The number of spring chinook counted at Lower Granite Dam must be distributed to all of these populations. There is every reason to suspect that when populations are as low as they have been recently (around 1,000 fish) that some of these populations will be composed of very few spawning fish. This could result in genetic drift or other problems that affect survival and reproductive success. These factors are not built into this analysis. In this respect, the results should be considered optimistic.

Baseline

The System Planning Model median baseline for Snake River spring chinook (i.e. no actions beyond the *Strategy for Salmon*) shows the population leveling off at around 1,500 fish (Figure 2a, NoActionBase). The other three lines in Figure 2a suggest that, without improvement in juvenile passage survival, but with improvements in tributary survival, pre-spawning survival and adult passage, the runs would show a slight rebuilding. Over 90 percent of the System Planning Model simulations showed average runs in excess of 1,000 fish after 24 years; 20-40 percent of the time, the results were greater than 5,000 fish at the end of 24 years (Figure 2b). However, none of the baseline situations indicated a reasonable likelihood of rebuilding even to levels that prevailed during the 1980s, and certainly not to levels that would achieve the Council's goals for Snake River spring chinook.

The results of the alternatives will be discussed in the order that reflects the addition of actions. Alternative A and D for example, differ only in regard to John Day pool drawdown to spillway. Similarly, B and C differ in this regard and add the drawdown of all four Snake River projects. The nomenclature of the alternatives reflects previous discussions and is continued to avoid confusion.

Alternative A

Much of the discussion in this section applies generally to all of the alternatives. The impact of the differing underlying assumptions regarding transportation and flow are evident in the results from Alternative A. If transportation is assumed to have a low level of effectiveness, then drawdown of Lower Granite and Little Goose pools could be expected to have a positive impact on rebuilding (Figure 3a). Similarly, if transportation currently has a moderate level of effectiveness (consistent with the point estimates of benefits by the National Marine Fisheries Service), then the results point to a positive, but more modest, level of rebuilding. Under both transportation assumptions, there was a 50-percent or greater expectation of a System Planning Model result in excess of 5,000 fish after 24 years with this scenario (Figure 3b).

In the case of the first model (low transportation effectiveness) it is necessary to assume that transportation has a negative impact on survival relative to inriver passage under most conditions (see documentation appendix). In this case, ceasing transportation itself has a positive impact and accounts for some of the rebuilding for A_Low in Figure 3a and for other alternatives as well. It should be stressed, however, that the low transportation effectiveness assumption is based on the lower confidence limit of a point estimate from a single year (1986). Statistically there is reason to place greater confidence in the point estimates from both 1986 and 1989, which are the basis for the mid-transportation effectiveness assumption; there is less evidence to indicate that transportation is as negative as indicated by the low transportation effectiveness assumption. For this reason, the results using the low transportation assumption are likely to be optimistic regarding rebuilding potential and the moderate effectiveness assumption may the most realistic.

However, if transportation is assumed to have a high level of effectiveness and overall juvenile passage survival is generally high (A_HiSurv), then the drawdown actions in Alternative A have a slightly negative impact on rebuilding relative to the baseline (3a). With this assumption, Alternative A had a 20-percent chance of a result fewer than 1,000 fish after 24 years (Figure 3b) compared to a less than 10-percent chance in the baseline (Figure 2b). In other words, if juvenile inriver passage survival currently is relatively high, and much higher than assumed in the other two models, then actions aimed at improving conditions in the river will have little impact on rebuilding. Further, because with these assumptions transportation survival is very high (80 percent), then actions that decrease transportation, such as drawdown, will have a negative impact on survival.

If transportation were as effective as the HiSurv assumption supposes, then one would have to come to the unlikely conclusion that the development and operation of the hydroelectric system and the resulting modification of the ecosystem have had little effect on downstream migrant survival and are not an important factor limiting spring chinook abundance in the Snake River. In this case, it would be necessary to attribute the present decline in production to some as yet unidentified factor that affects Snake River spring chinook in particular.[2]

<u>Alternative D</u>

This alternative adds the drawdown of John Day to spillway to the drawdown of the upper two Snake River pools in Alternative A. Under the assumptions of moderate and low transportation effectiveness, this action added about 3,000 fish to the results of Alternative A (Figure 4a). A similar change was seen in the System Planning Model probabilities with an increase in the probability of results greater than 5,000 and 10,000 fish (Figure 4b). These increases result from the assumption of a relatively high benefit from changes in water velocity and a relatively low benefit from transport, as discussed above.

This alternative did not result in rebuilding under the HiSurv assumptions because it reduced, but did not eliminate, transportation relative to the base period (transportation continued at Lower Monumental Dam).

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[2] This does not ignore the profound impact of natural environmental conditions on fish survival and production. Ocean conditions in particular have been poor for several years and have affected populations throughout the Northwest. However, Snake River spring chinook have been particularly hard hit and are now at a level of abundance that threaten the continuation of some populations. Thus there is reason to believe that Snake River spring chinook are limited by some additional factor unique to these populations. Development and operation of the Columbia and Snake river hydroelectric systems must stand out as a likely candidate.

However, there was a small improvement over Alternative A because of the drawdown of John Day pool. The probability of a declining run (fewer than 1,000 fish) for Alternative D was about 17 percent for the HiSurv assumption, compared to about 20 percent for Alternative A. This is because under these assumptions, velocity augmentation still had a beneficial effect, and augmentation of water velocity in John Day pool had an overall positive, albeit small, impact.

Alternative C

Under Alternative C, the four Snake River projects were drawn down to spillway in 2002, but John Day pool was maintained at its minimum operating level. Reflecting the previous reasoning, this action had a dramatic positive benefit if it was assumed that transportation currently has a low level of effectiveness (Figure 5a). Rebuilding, in fact, approached levels that occurred in the early 1970s. Positive, although more moderate, rebuilding was seen under the assumption of medium transport effectiveness as well. With this alternative, there were almost no System Planning Model runs that were fewer than 1,000 fish using the low and medium levels of transport effectiveness, and high probabilities of average runs in excess of 5,000 fish for both assumptions (Figure 5b). Even assuming low effectiveness for transportation, there was a probability of almost 70 percent of a result greater than 10,000 fish after 24 years.

Because this alternative eliminated transportation, it increased the negative impacts of the alternative if the HiSurv assumptions were used (again, under this assumption, transported fish had a survival of 80 percent. Eliminating it, therefore, had a negative effect). For example, the proportion of System Planning Model runs after 24 years that were fewer than 1,000 fish was about 27 percent for Alternative C (Figure 5b), compared to about 10 percent in the baseline (Figure 2b).

Alternative B

Adding the further action of drawing down John Day pool to spillway contributed several thousand fish to the median run sizes of Alternative C under the low and moderate levels of transport effectiveness (Figure 6A). For low transportation effectiveness, this alternative produced median run sizes in excess of 25,000 spring chinook at Lower Granite (still substantially below the Council's goal of 50,000 wild spring chinook at Lower Granite Dam). The probability of a System Planning Model result greater than 10,000 fish after 24 years was almost 90 percent for this assumption (Figure 6b). Using the medium level of transport effectiveness, the median return approached 10,000 fish. Overall, the probability of a System Planning Model run greater than 5,000 fish after 24 years was over 60 percent, but the probability of a result greater than 10,000 was only about 25 percent (Figure 6b).

The results under the assumption of high transport and juvenile passage survival (HiSurv) were similar to those seen in the other alternatives. The drawdown of John Day pool had a positive impact compared to the action without John Day drawdown (Alternative C). The probability of a System Planning Model result after 24 years of fewer than 1,000 fish was about 18 percent for Alternative B compared to about 27 percent for Alternative C, this difference being the effect of the John Day drawdown to spillway.

Conclusions

The Council's adopted actions offer the possibility of substantial increases in Snake River spring chinook. However, like all options for salmon recovery in the Columbia River, the outcome is very dependent on a few key assumptions. In particular, these include the relationship between water velocity and in-river survival and the benefits associated with fish transportation. Under some assumptions, the adopted actions could result in either little change or even a decrease in survival. This sensitivity of any recovery action to these assumptions highlights the need for the evaluation features that are central to the Council's approach.

The result assumes continuation of existing environmental conditions. Improvement in ocean survival conditions or the current drought in Idaho could add to the results reported here. However, because of the depleted state of many upriver chinook populations, of greater concern is that further degradation of environmental or habitat conditions would worsen the situation and delay benefits of any rebuilding actions.

Figure 2a.

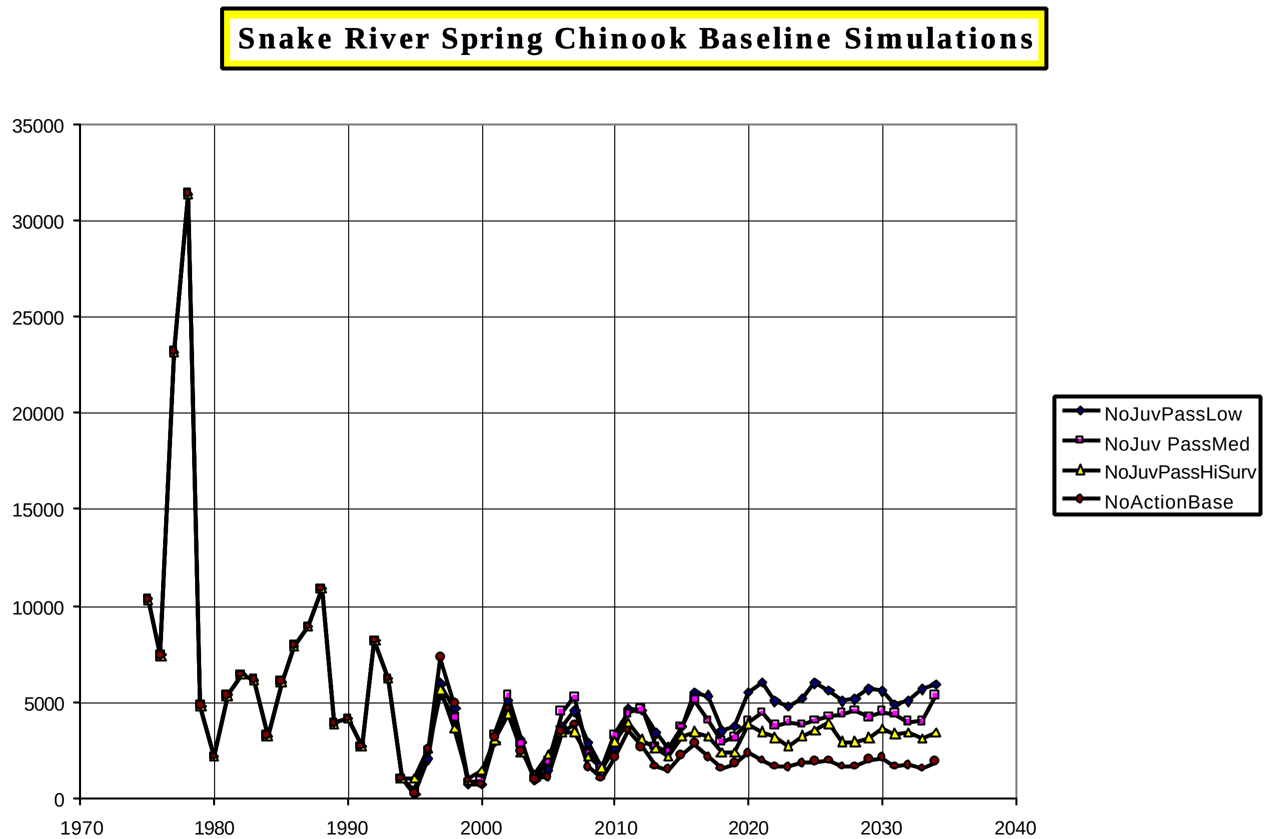
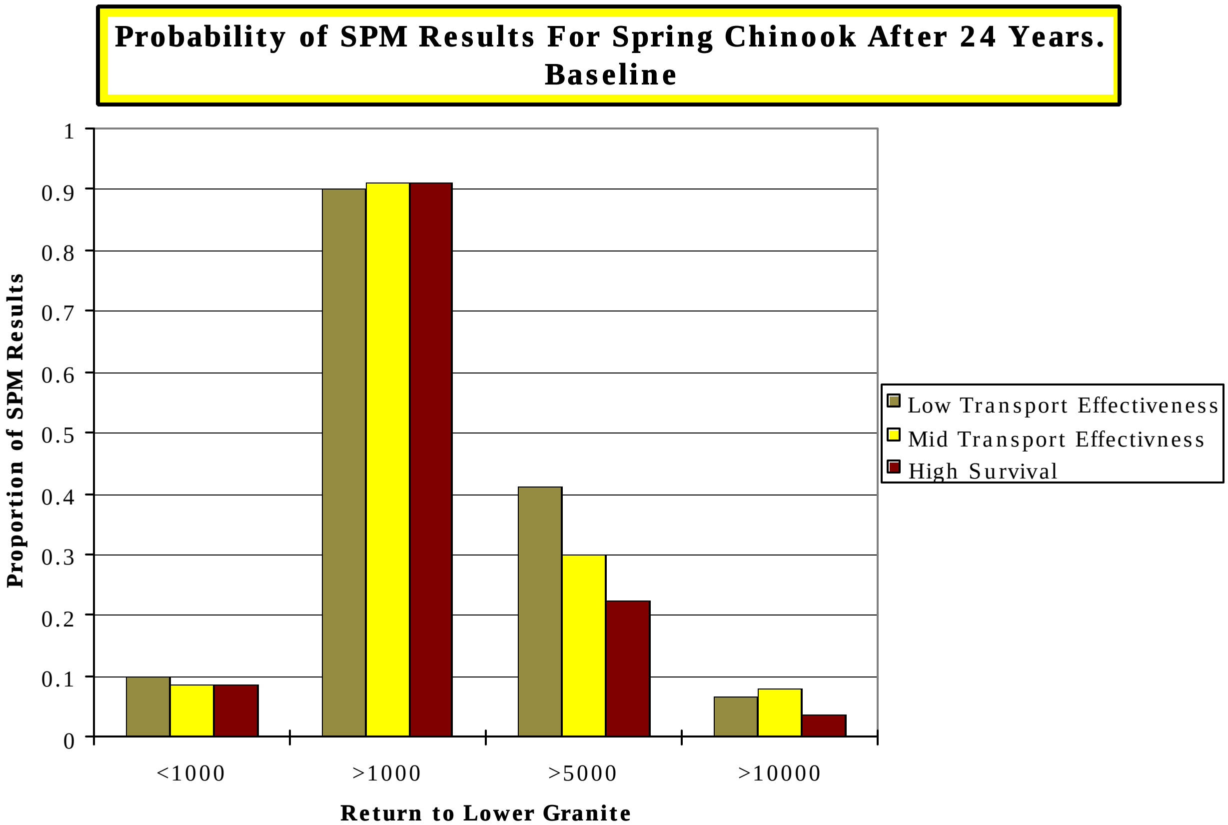


Figure 2b.


Probability of SPM Results For Spring Chinook After 24 Years.
Baseline
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Proportion of SPM Results
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Return to Lower Granite
Low Transport Effectiveness
Mid Transport Effectivness
High Survival

Figure 3a.

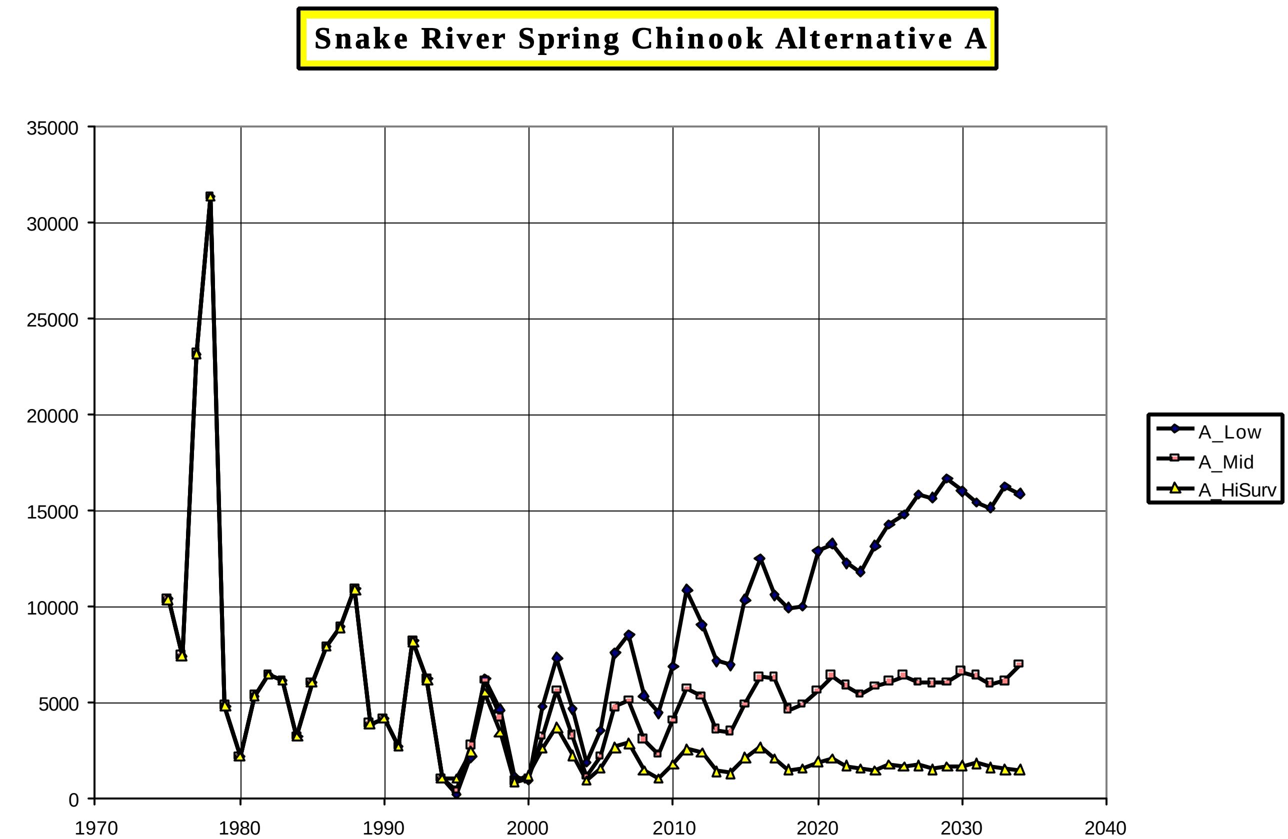
Snake River Spring Chinook Alternative A
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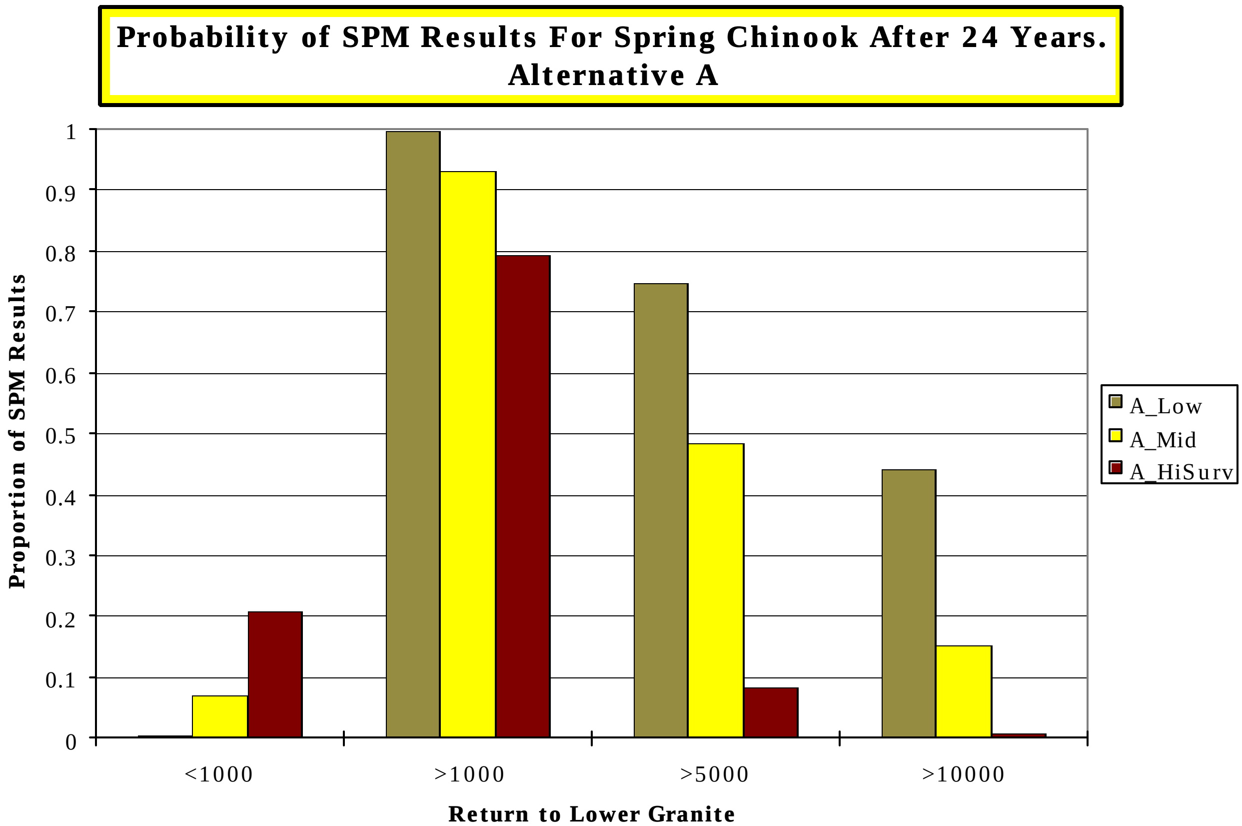
Figure 3b.


Probability of SPM Results For Spring Chinook After 24 Years.
Alternative A
Proportion of SPM Results
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Return to Lower Granite
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A_HiSurv

Figure 4a

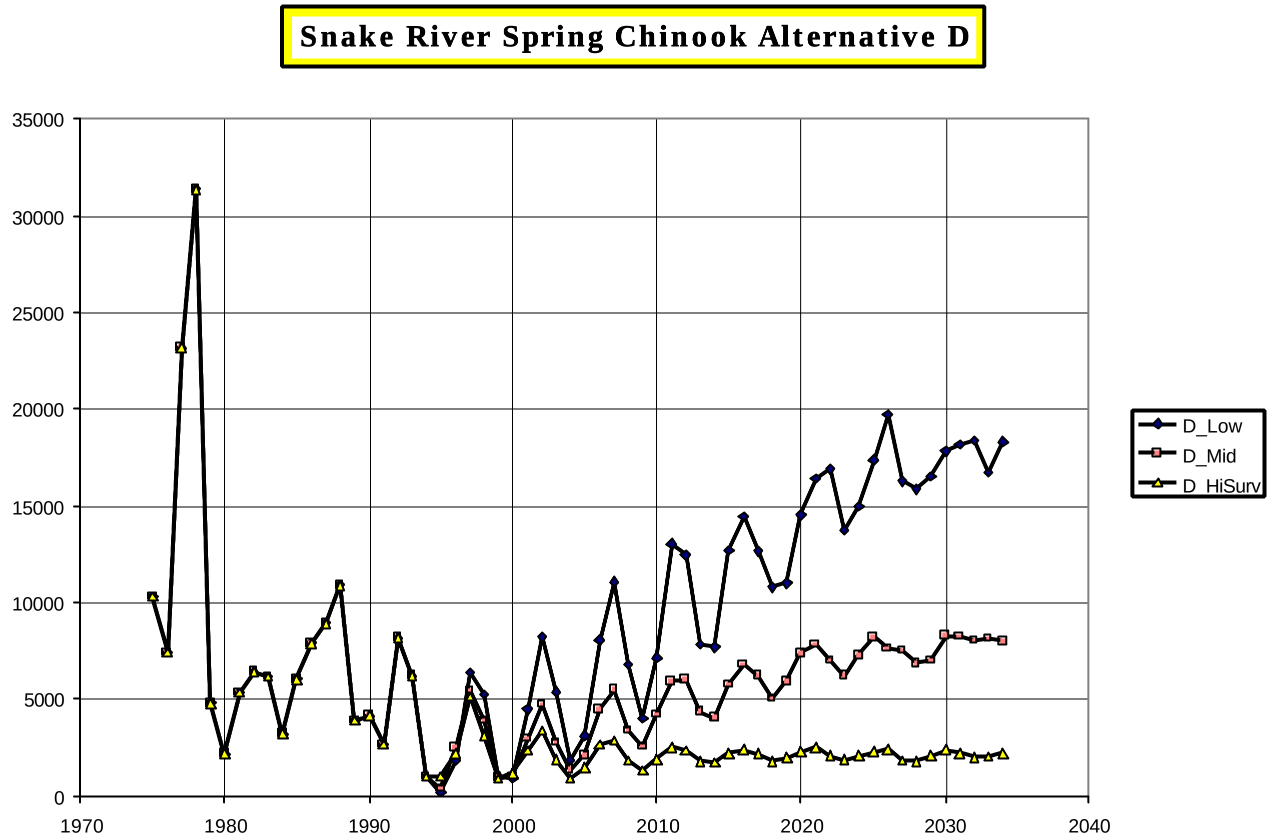
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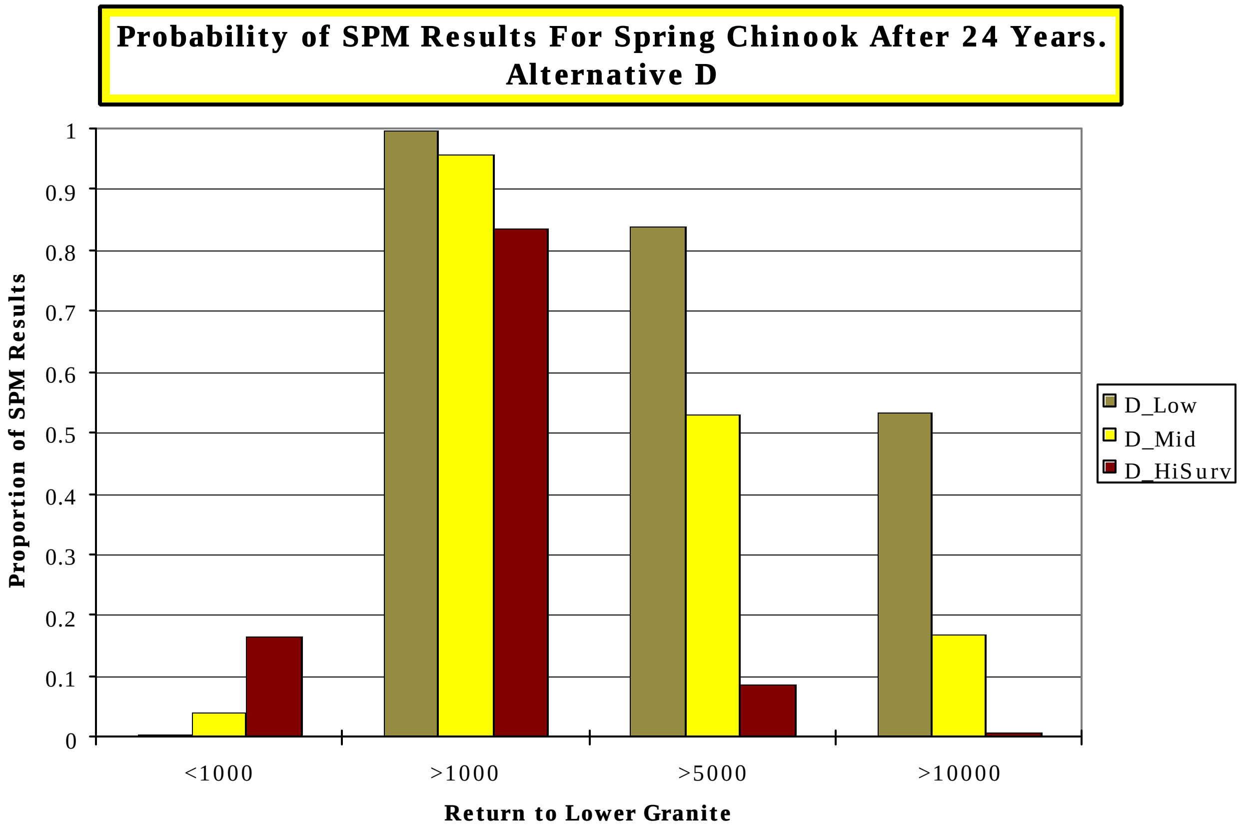
Figure 4b.


Probability of SPM Results For Spring Chinook After 24 Years.
Alternative D
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Return to Lower Granite
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D_HiSurv

Figure 5a.

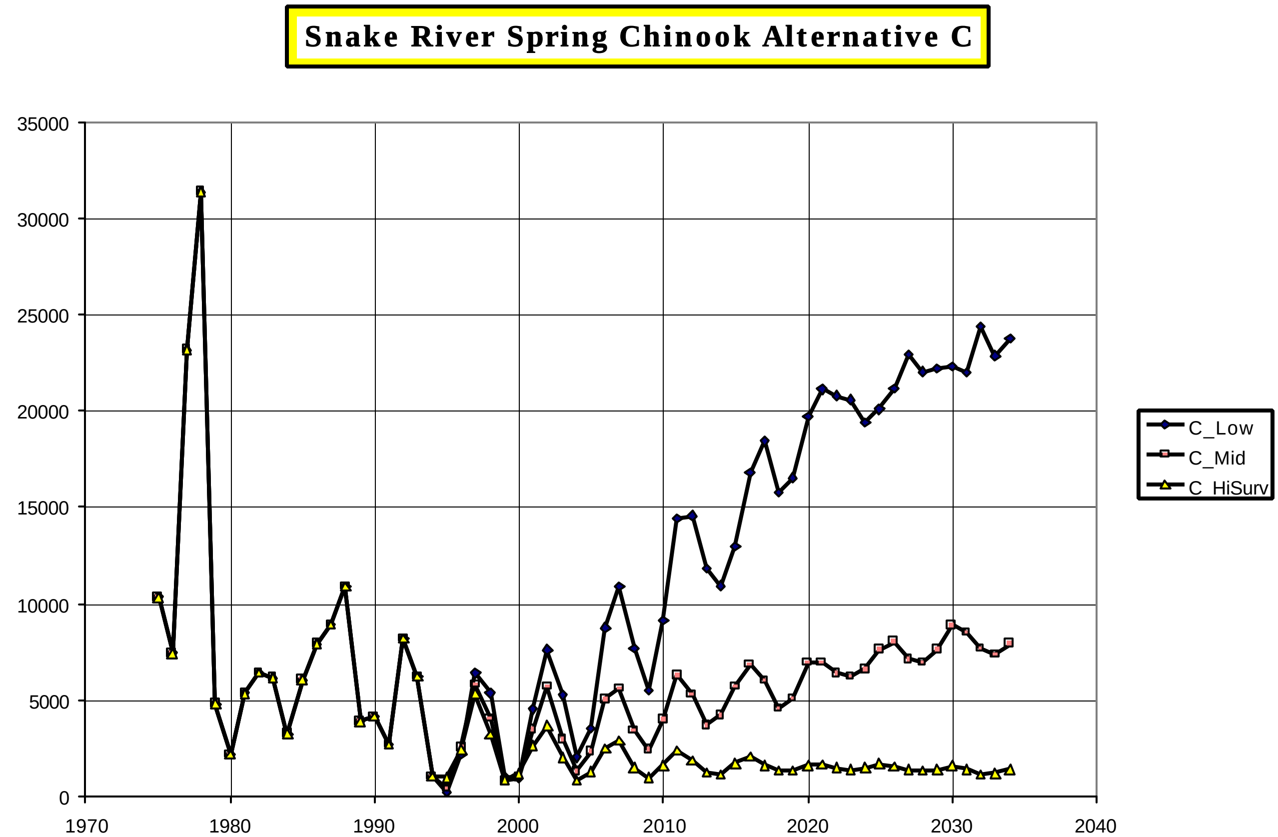
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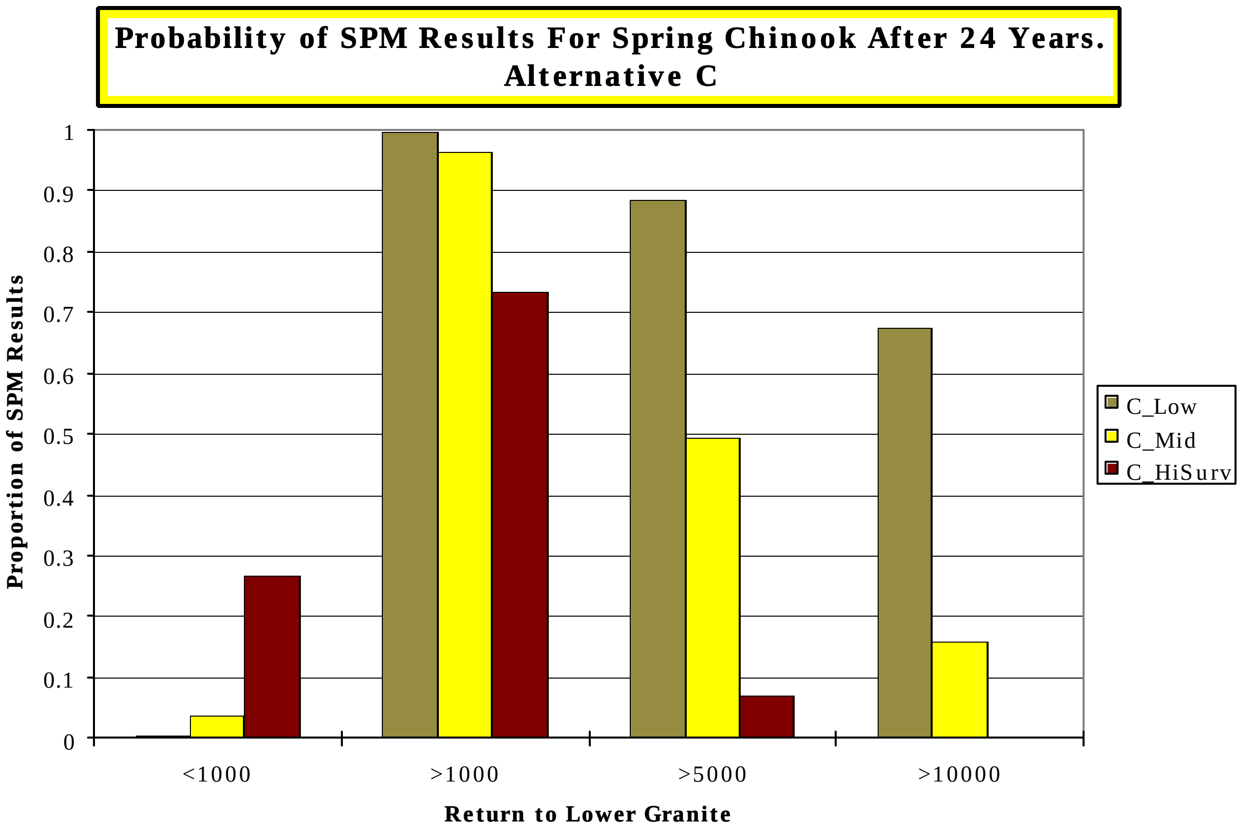
Figure 5b.


Probability of SPM Results For Spring Chinook After 24 Years.
Alternative C
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C_Mid
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Figure 6a.

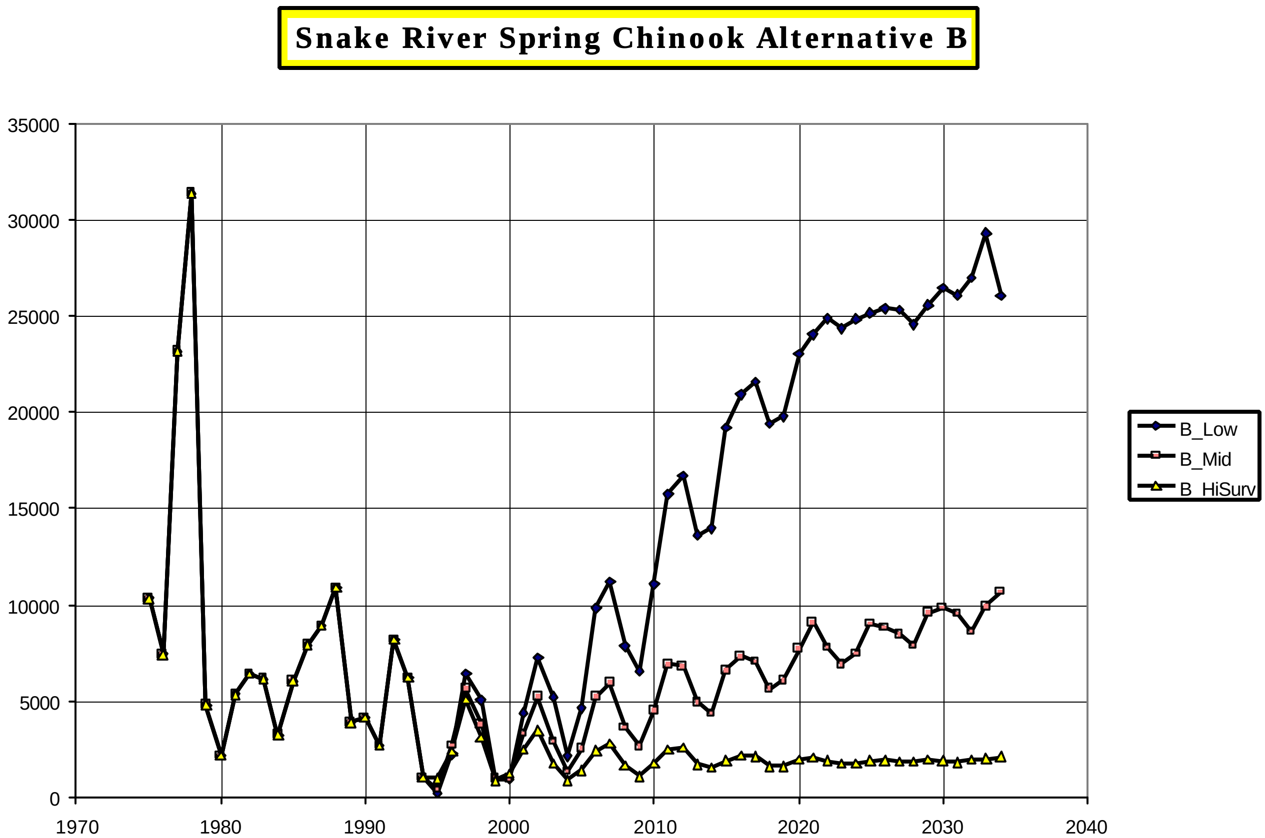
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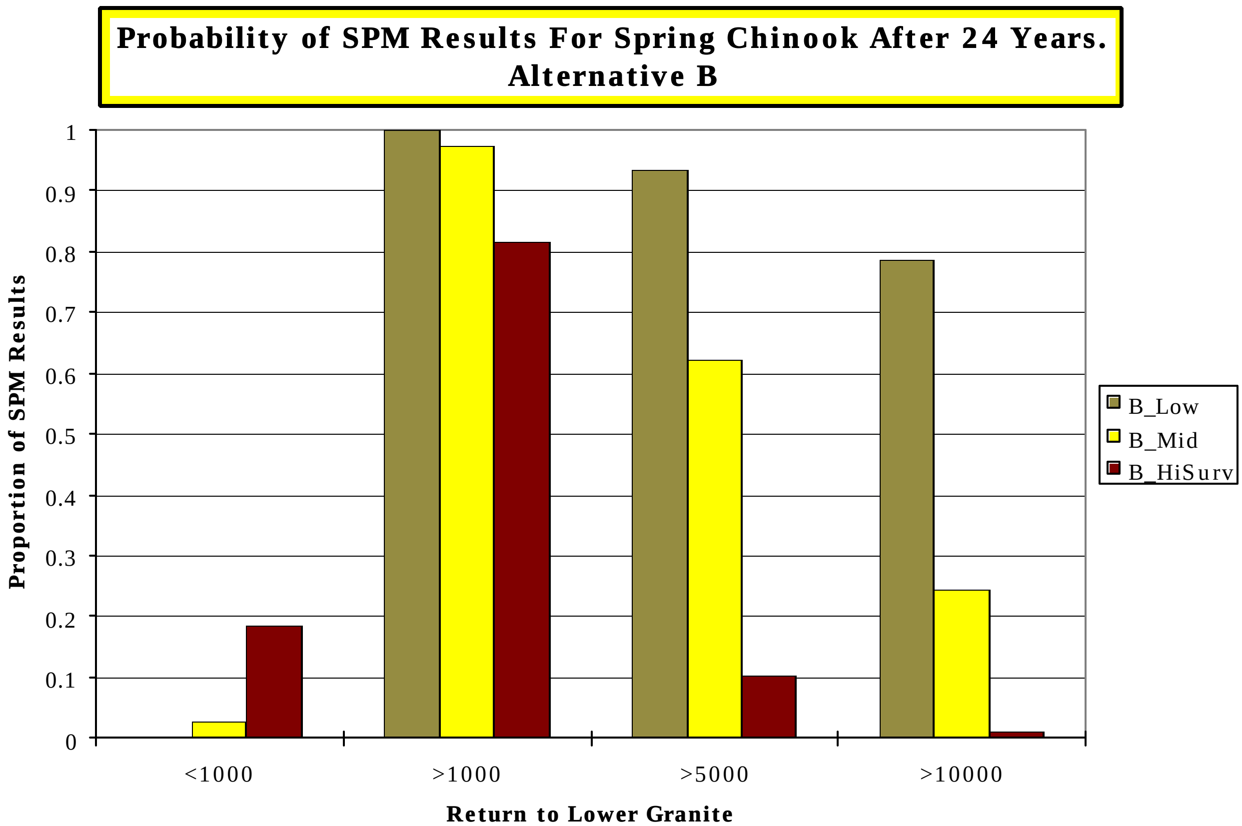
Figure 6b.



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