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CONF-9207114--3

PNL-SA--20998

DE93 008253

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July 1992

Presented at the
67th Annual Conference of
Western Economic Association
International
July 9-13, 1992
San Francisco, California

Prepared for
the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

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COSTS OF CLIMATE CHANGE: ECONOMIC VALUE OF YAKIMA RIVER SALMON

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This work resulted from a continuing multidisciplinary analysis of species preservation and global change. The paper explores the economic cost of a potential regional warming as it affects one Pacific Northwest natural resource, the spring chinook salmon (Oncorhynchus tshcawytscha). Climate change and planned habitat improvements impact the production and economic value of spring chinook salmon of the Yakima River tributary of the Columbia River in eastern Washington.

The paper presents a derivation of the total economic value of a chinook salmon, which includes the summation of the existence, commercial, recreational, and capital values of the fish. When currently available commercial, recreational, existence, and capital values for chinook salmon were applied to estimated population changes, the estimated change in the economic value per fish associated with reduction of one fish run proved significant.

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I. INTRODUCTION

Recent considerations for listing some stocks of salmon in the Pacific Northwest as threatened or endangered under the Endangered Species Act highlight the numerous environmental threats faced by these stocks. It now becomes necessary to add climate change to the traditional anthropogenic threats of hydropower, overfishing, irrigation withdrawals, and pollution. However, it is not entirely clear whether climate change, as it might be experienced in the Pacific Northwest, would be beneficial or harmful to the salmon and steelhead resource. Much depends on whether annual precipitation would increase, decrease, or occur at a different time of the year.

To predict Pacific Northwest climate under global warming, some researchers have used the results from computerized world climate simulation models known as general circulation models (GCMs). Lashof and Tirpak (1990) compiled a comprehensive volume summarizing GCM research to date. Interestingly, all the existing GCMs agree that the Pacific Northwest would be warmer and wetter if the world's climate were to become warmer. However, the agreement may be only coincidental. Climate researchers are concerned with the lack of geographical resolution, as well as the pervasive disagreement among model results concerning the direction of change in regional precipitation in most cases (Grotch, 1988; DOE Multi-Laboratory Committee, 1990; EPA, 1991).

The authors employed a second approach using past climate anomalies as analogs to infer the possible characteristics of future climate was used in this work. This approach has been used extensively by Soviet researchers (Budyko and Izrael, 1991). A climatic event of 6,000 to 8,000 years ago in the mid-Holocene can serve as a model of the Pacific Northwest with temperatures about 2°C above modern levels (Kutzbach, 1983;

Chatters, 1989; Chatters, et al. 1991). Analog methods have the advantage over the GCMs becuase the pattern of local and regional effects of past warming can be observed in great detail. In the Pacific Northwest, for example, the analog method, unlike the GCMs, provides consideration of significant orographic features, such as the Cascade Mountains, in estimating the storm tracks and the mountains reliably. GCMs, on the other hand, are not able to distinguish arid east-slope environments from the mild environments of the west-slope. This study uses the observed effects of past climate change on Pacific Northwest river systems and related landscapes to infer how a similar future climate change might affect a specific river system containing a significant salmon resource -- the Yakima River.

II. SIMULATING CLIMATE-INDUCED CHANGES IN FISHERIES PRODUCTION

Previous work (Chatters, 1986; Chatters, 1989; Chatters, et al., 1991; and Neitzel, et al., 1991) provided information for this study on the Yakima River environment, the prehistoric Eastern Washington climate, and the effect of the changed climate on the Yakima River spring chinook salmon. Neitzel et al. (1991) characterized the effects of a regional warming on the stream conditions for salmon in the Columbia River basin. Much data for the Yakima region had been collected specifically to support the fisheries enhancement plans for the subbasin and the Northwest Power Planning Council (NPPC) models.

A. *Simulating Climate Change*

To test the implications of climate change on spring chinook salmon production in the Yakima subbasin, the authors simulated the effects of climate change cases on a computer using the NPPC salmon modeling system. The methods used are detailed in

Chatters et al. (1991). The modeling system consists of two models: the Tributary Parameter Model (TPM) and the System Planning Model (SPM). The TPM models the Yakima River subbasin as a series of 214 reaches, for which the user must specify four survival parameters: egg-to-smolt survival rate, smolt-to-smolt survival rate, pre-spawning survival rate, and smolt capacity. Egg-to-smolt survival refers to survival of the eggs and juveniles to the point of smoltification. Smolt-to-smolt survival rate denotes the survival rate of the juvenile from the upstream onset of smoltification to the point where it enters the Columbia River on its way to the ocean. Pre-spawning survival denotes the survival of adult salmon from entry (return to) into the Yakima from the Columbia, until eggs are laid in the tributaries. Smolt capacity, which is the overall available juvenile habitat, is calculated as a function of smolt density. A third model, the Smolt Density Model (SDM) can be used to re-calculate smolt densities, but offered no significant improvement in SPM model results for the effort required, and was not used in this simulation.

The TPM weights the value of each of the survival rates by the relative smolt capacity of each river reach and calculates the weighted average values for the subbasin. The smolt capacity of each reach is summed to generate a smolt capacity for the entire subbasin. These values are then entered into the SPM, which calculates migratory and oceanic survival, and eventually estimates the equilibrium return of salmon to the stream of origin. The SPM tracks several generations at once and can be used to show a time path of stock growth over several decades, if desired. However, because survival conditions are dynamic and vary considerably from year to year, estimates of future runs indicate the production level a species would achieve if allowed to reach equilibrium. Fisheries managers use the SPM primarily to assess impacts of management policies on long-run equilibrium levels of particular stocks of fish, rather than to chart stock population levels on a year-to-year basis. The NPPC (NPPC, 1989; NPPC, 1992) provides a more detailed description of the SPM.

B. *The Cases of Fisheries Enhancement and Climate Change*

The NPPC modeling system simulated the effects of climate change and fisheries enhancement on potential spring chinook salmon production in the Yakima subbasin. Two cases were developed to simulate the Yakima subbasin without fisheries enhancement ("Existing Conditions" in Table 1), and two other cases were developed with the assumption that fishery enhancement projects proposed for the NPPC Fish and Wildlife Program would be successfully implemented ("Enhanced Conditions," Table 1). The goals of the NPPC became incorporated into the Yakima Fisheries Project (YFP) (BPA, 1990) under legislation from the Pacific Northwest Electric Power Planning and Conservation Act of 1980 (Clune and Dauble, 1991). The first in each pair of cases represented a simulation of the Yakima environment with current climate, while the changed climate was assumed in the second. Full implementation of the YFP ("Enhanced Conditions") will involve supplementing existing salmon and steelhead runs, improving fish passage, and improving habitats (BPA, 1990).

Figure 1 presents an example breakdown of possible futures that are faced by Yakima River spring chinook that reach the ocean and survive to adulthood, based on PFMC (1992). Table 1 contains the values of the survival parameters used in the SPM to simulate each case. It should be noted that currently there is no spring chinook salmon hatchery in the subbasin.

Figure 1. Potential Path of Yakima Spring Chinook Considered for Analysis.

III. VALUATION OF IMPACTS

In order to place a dollar value on the effect of global warming, the value of a spring chinook salmon in the Yakima River was calculated using the following formula for the value accorded to these salmon by both users and nonusers:

Value = Existence + Commercial + Recreational + Capital + Other.

VALUE signifies the expected dollar value of an adult spring chinook salmon. EXISTENCE represents the dollar value assigned to an existing fish by nonusers. RECREATIONAL denotes the probability of a chinook being caught by a recreational angler times the current estimated average recreational value of fish. COMMERCIAL denotes the probability of being caught commercially times the current estimated average commercial value. The CAPITAL value refers to the value of a fish that survives upstream migration to eventually spawn a future stream of returning adults. Encompassed in the capital value of the fish are the values of maintaining genetic diversity and maintaining the spring chinook gene pool, which factor in the continued survival of the run (Winans, 1989). Minimum maintenance of the gene pool is addressed at some level in the policy arena by listing species as endangered or threatened under the Endangered Species Act. The OTHER values acknowledged to exist, but which are currently not possible to reliably estimate, include the ceremonial and subsistence values to Native Americans. These values may be quite substantial, given the importance of the chinook as a focal point in the religious beliefs of Northwest tribes and reliance on salmon in their diet. Scott et al. (1987) estimated the ceremonial value to be at least as high as the recreational value.

A. *Existence Value*

Existence value can be described as the value a person derives from the knowledge something exists. Krutilla and Fisher (1985) define existence value as the value placed on the knowledge of the existence of gifts of nature, even though these gifts would never be directly experienced on-site. For this application, existence value is defined as the dollar value placed on a spring chinook salmon in the Yakima River by those individuals who do not use the resource and do not plan to use the resource in the future. Olsen et al. (1990) estimated an existence value of $17.67 (adjusted for inflation to $18.75 ($1992)) for a chinook salmon in the Columbia River. It should be noted that this reflects a marginal value based on an individual's willingness to pay for improvements that would double the chinook salmon run in the Columbia River (Olsen, et al., 1990). However, since willingness-to-accept compensation values are generally larger than willingness-to-pay values, and because losses in remnant stocks are likely to be more valuable at the margin than increases in preexisting stocks, it was assumed to be a conservative estimate of the existence value of chinook salmon in the Yakima River. All adult fish are assigned this value since it signifies a value assigned by nonusers and, therefore, is independent of whether the fish eventually is caught by commercial or recreational interests, spawns, or dies of natural causes prior to spawning.

B. *Commercial Value*

The expected commercial value consists of two parts: the probability of a spring chinook salmon being caught commercially and the value, if caught. The probability of being caught equals the number of spring chinook salmon caught divided by the total number of fish available. A Yakima River spring chinook salmon was assumed to have the same chance of being caught as any other spring chinook salmon from any other

Columbia River run entering the ocean. For the Columbia River, the average size of the adult-equivalent spring chinook salmon run was 104,291 fish in the ocean with an average commercial catch of 10,818 fish for the period 1981-1991 (PFMC, 1992). To account for in-river commercial catch, the 1981-1991 average commercial catch inside the mouth of the Columbia (1927 fish) was divided by the average run size at the mouth of the Columbia of 80,245 to yield 0.0240. This denotes the probability that an individual spring chinook salmon will be caught commercially within the Columbia River. For ocean harvest, the SPM assumed a spring chinook salmon harvest rate of 0.056 for Columbia River stocks. The cumulative probability, 0.056 + (1 - .056) x 0.0240, together yields 0.0787, or the total probability of a spring chinook being caught commercially.

Since no commercial spring chinook salmon fishery currently exists in the Yakima River, ocean commercial troll data for Columbia River ports (PFMC, 1992) provided the basis for estimates of commercial value per fish. Native American tribal commercial catch from in-river fisheries and ocean net fisheries generally is sold at a lower price than commercial catch from troll fisheries. Thus, the price used here may be somewhat generous. It was assumed that the marginal cost of catch associated with greater or lesser abundance of fish is near zero. In 1991, the average dressed weight of chinook salmon delivered to Washington ports in the Columbia River ocean fishery was 10.6 pounds. The exvessel value per pound was estimated by dividing the total exvessel value paid by the total dressed weight of salmon landed, which yielded a value of $1.42 per pound. Multiplying the 10.6-pound, average dressed weight by $1.42 per pound resulted in a value per fish of $15.05. Multiplying the $15.05 value per fish by the 0.0787 probability of being caught results in an expected commercial value of $1.18 per ocean adult.

C. *Recreational Value*

The expected recreational value equals the recreational value of the fish times the probability of being caught by a recreational angler. The recreational value of a fish is defined as what a consumer (angler) would be willing to pay for the fish, above and beyond his or her out-of-pocket expenses required to catch a chinook salmon. Typically, these willingness-to-pay or consumer surplus values are estimated using a survey research methodology and "nonmarket" valuation techniques, such as the travel cost model or contingent valuation method.

ICF Technology Inc. (1988) conducted a study for the state of Washington to estimate economic impacts and net economic values of the state's salmon fisheries. They reviewed many existing publications and estimated a weighted average of net recreation benefits for salmon fishing from shore, private boat, and charter sport fishing of $52.25 per trip for Columbia River fisheries. They also estimated the weighted average catch per trip to be 0.20 fish (ICF 1988). Following through the analysis, ICF estimated that to catch one salmon required an average of five trips. This estimate resulted in an average net consumer surplus of $261.25 per adult fish.

Since recreational spring chinook salmon fishing in the Yakima subbasin is prohibited, data for Columbia River salmon runs (PFMC, 1992) were used to calculate a recreational catch probability with the same methodology used to calculate commercial catch rates. The average run size for 1981-1991 was 104,291 fish, and the average recreational ocean and in-river catch for the same period was 6,761, which gives a 0.0648 probability of a Yakima chinook salmon being caught by a recreational angler. Again, it was assumed that a Yakima chinook has the same chance of being caught as any other chinook in the Columbia River. When this probability of being caught is multiplied by the recreational value of a spring chinook salmon, the expected recreational value equalled $16.93 per ocean adult.

D. *Capital Value*

Salmon that return to spawn necessarily avoid all catches and mortalities in their journey from ocean to spawning bed. The average Yakima spring chinook life cycle covers three years (YIN, et al. 1990). The capital value of a fish is defined as its spawning or reproductive value taken to an infinite time horizon. In this paper, this is represented by the present value of the contribution to catch and noncatch values of a base-year spawning salmon over the next 50 generations (150 years) as follows, since at positive discount rates virtually no value is added by periods more than 150 years in the future:

$$V=\sum_{i=3}^{150}\frac{\frac{(C_i+R_i)}{S_{Year_0}}}{(1+r)^{Year_i}}$$

where V = capital or spawning value per fish
C = expected commercial value per fish
R = expected recreational value per fish
S = number of spawning salmon
r = social discount rate
i = {3, 6, 9, 12, . . . 150}

Note: This begs the question of whether discounting is a valid technique to use when species preservation is at stake. A very large and growing literature (Kolb and Scheraga (1990) among others) has addressed this issue. The authors leave this issue for ethicists and others stating that calculating economic values, not social values, was the intent. A 3% discount rate was used in this analysis.

III. TOTAL VALUE OF AN INDIVIDUAL SPRING CHINOOK SALMON

The total economic value of a Yakima spring chinook salmon varies under differing subbasin conditions that result from fisheries enhancement activities and climate change. Changes in subbasin conditions affect adult fish populations. As Yakima populations vary in size, ocean and Columbia River catch probabilities also should vary slightly to reflect the increase or decrease in total adult spring chinook in the system. These slight changes in catch probability would result in equally slight changes in the estimated catch values. However, in this analysis catch probabilities were held constant. Changes in climate or subbasin productivity also result in significant changes in estimated capital values. Equations used to derive the total value of Yakima spring chinook salmon necessarily vary depending on the particular climate/subbasin case being analyzed. Under the differing cases of climate/subbasin characteristics, the value equation for an individual adult fish in the ocean is as follows:

$$\text{Total Value}_{\text{current situation}} = \$18.75 + \$1.18 + \$16.93 + \$19.48 = \$56.34,$$

$$\text{Total Value}_{\text{current climate/enhanced fishery}} = \$18.75 + \$1.18 + \$16.93 + \$83.28 = \$120.14,$$

$$\text{Total Value}_{\text{climate change/current fishery}} = \$18.75 + \$1.18 + \$16.93 + \$9.15 = \$46.01,$$

$$\text{Total Value}_{\text{climate change/enhanced fishery}} = \$18.75 + \$1.18 + \$16.93 + \$40.92 = \$77.78.$$

At first, these values may appear surprising since the estimated value per fish is lower when the fish is comparatively "scarce" (under poorer survival conditions brought on by climate change). However, this is not a case of an the inward shift of a supply curve in a static framework, but rather the case of productivity over time of environmental capital. In fact, it is implicitly assumed that the real price of fish in each fate category remains constant as abundance increases or decreases. This seems reasonable for commercial catch, because the West Coast market is controlled by Alaskan and British Columbia catches and Japanese market conditions rather than local abundance. It may be less reasonable for recreational values.

IV. Results

If the Yakima spring chinook salmon population is successfully supplemented by the experimental hatchery, and the rearing habitat and passage are improved, the total adult production of spring chinook salmon in the YFP enhancement cases could increase more than four times, from 9,800 per year to more than 45,000 per year (Figure 2). Under climate change, spring chinook salmon production decreased by 60.1% from current conditions, and by 53.3% from improved conditions (Figure 2). These reductions of more than 50% not only would impact the resource, but also the budgetary and fiscal planning for the Yakima River fishery enhancement efforts. Figure 3 illustrates the estimated spawner production path over time by case. The changes in estimated equilibrium spawning returns by case fuel the corresponding changes in capital or spawning value, and therefore total value.

FIGURE 2
Estimated Equilibrium Yakima Spring Chinook Ocean Adult Production by Case

FIGURE 3
Estimated Yakima Spring Chinook Spawning Returns Over Time by Case

A. *Model Sensitivity*

A sensitivity analysis was performed to test the overall effect on total value per fish caused by changes in selected variables used as factors in the total value equation. Sensitivity variables included discount rate, catch probabilities for commercial and recreational catches, existence value, commercial value, recreational value, and number of $year_0$ spawners (used to seed the initial values of the fishery production functions used in the SPM). There are miriads of additional variables embedded in the SPM that related to the underlying production numbers. No sensitivity of those variables was conducted in this work. Table 2 illustrates the sensitivities resulting from 10% and 20% percent positive and negative changes in one variable, while holding all others constant. Discount rate and $year_0$ spawners each demonstrated a nonlinear effect on total value. The rate of change in total value varied as these variables were individually incremented, and increased faster for a negative increment. The effect of recreational value proved linear, but the rate of change in total value decreased as the variable was progressively incremented. The other variables tested showed only 1:1 linear effects on total value. In three of the four cases, recreational value demonstrated the greatest effect on total value at the 10% increments. At the 20% increments, $year_0$ spawners and recreational value showed the greatest effect on total value in two cases each. Discount rate showed the third greatest effect on total value.

TABLE 2
Sensitivity of Total Value to 10% and 20% Changes in Equation Variables by Case
(Percent change in Total Value and absolute value of differences)

V. Conclusion

A. *Net Present Value Implications*

In each of the cases considered, the net present value (NPV) cas calculated for the resulting 150-year stream of adult salmon production. The estimated annual adult fish production was multiplied by the estimated total value per fish. This resulted in a 150-year stream of total stock values. The following equation estimated the NPV by case:

$$NPV_{Case} = \frac{TV_n}{(1+r)^n}$$

Where: NPV_{Case} = Net present value by fishery/climate case
TV_n = (Adult Run $Size_n$)(Total Value per fish)
r = Social discount rate (3% used for consistency)
n = Year

As demonstrated in Table 3, changes in climate and overall fishery productivity (and resulting changes in capital value) greatly effect the net present value of the salmon stock.

TABLE 3
Net Present Value of Yakima River Spring Chinook Stock by Case

B. *Policy Implications*

Currently, the YFP has three possible development alternatives. The public involvement process currently under way[1] will indicate whether the project will be implemented to restore and enhance seven stocks, five stocks, or three stocks of Yakima River salmon. Spring chinook are included under each of the alternatives. No new enhancement activities will occur if at least the three-stock alternative is not chosen (BPA 1992).

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[1] All public land managing agencies are required by law to conduct a public involvement process when significant resource changes are being evaluated.

The NPV estimates presented can provide a primary element of the benefits side of a benefit/cost analysis performed to rate the YFP investment across a range of resource options, should such an analysis be performed. Such an analysis would have to include the present value of other benefits such as knowledge and technology gained from the experimental hatchery-outplanting program that would become applicable to other rivers. The cost side of the analysis should include the present value of construction, operation and maintenence, and experimentation costs that would be incurred. An available, but rough, estimate of the net present value of these costs is $37.989 million for the three-stock alternative, minimum implementable alternative to be considered, based on work in progress.[2] Additional costs that would need to be quantified include the cost of any foregone power generation that may be required to fulfill salmon production goals, and any lost irrigation withdrawls. The cost of debt service also factors in overall project costs.

These fishery production simulations indicate that a considerable effort must be made to simply maintain spring chinook salmon runs at current levels if a warming similar to that of the mid-Holocene ever becomes a reality. These results imply that, if climate change is accepted as reality, greater levels of effort would be required to produce the desired enhancement of spring chinook salmon production. The enhancement effort now in progress is necessary to keep Yakima River spring chinook salmon from becoming threatened or endangered if average annual temperatures increase. It should be noted that even under this assumed climate change, the planned enhancements are estimated to more than double the spring chinook salmon runs over existing levels and achieve an

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2 *Yakima Fisheries Project Draft Environmental Impact Assessment*, prepared by Pacific Northwest Laboratory for Bonneville Power Administration, 1992, currently in review.

estimated six-fold increase in production over the climate-change-without-enhancements case.

These results need to be viewed with caution because the climate warming used in this simulation is not an extreme one. It is entirely possible that the warming we used could be a near-term reality, possibly occurring as soon as 2010, on the way to a more drastic climate change of 3°C, corresponding to a doubling of atmospheric carbon dioxide and other "greenhouse gases" (Chatters 1989).

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TABLE 1
Values Assigned to Key Variables in the System Planning Model to Simulate the Impacts of Climate Change on Spring Chinook Salmon in the Yakima River Subbasin

Production Parameters	NPPC Existing Conditions Current Climate	NPPC Existing Conditions Climate Change	NPPC Enhanced Conditions Current Climate	NPPC Enhanced Conditions Climate Change
Natural Stocks				
Survival Rates (1=100% survival)				
Pre-spawning survival	0.8000	0.7987	0.9000	0.8825
Egg-smolt survival	0.2119	0.1974	0.2397	0.2215
Smolt-smolt survival	0.4856	0.4084	0.7534	0.5889
Smolt capacity (millions)	2.44	1.64	3.87	2.47
Hatchery Stocks				
Survival Rates (1=100% survival)				
Pre-spawning survival	NA	NA	0.9000	0.8825
Egg-smolt survival	NA	NA	0.6480	0.6480
Smolt-smolt survival	NA	NA	0.7534	0.5889
Smolt capacity (millions)	NA	NA	1.65	1.65

Source: Chatters et al. 1991.

TABLE 2

Sensitivity of Total Value to 10% and 20% Changes in Equation Variables by Case
(Percent change in Total Value and absolute value of differences)

	Case 1	| Diff |	Case 2	| Diff |	Case 3	| Diff |	Case 4	| Diff |
Discount rate								
+10%	-2.94%		-1.51%		-6.38%		-4.71%	
+20%	-5.45%	2.51%	-2.80%	1.29%	-11.78%	5.40%	-8.70%	3.99%
-10%	3.50%		1.79%		7.62%		5.61%	
-20%	7.72%	4.22%	3.93%	2.14%	16.81%	9.19%	12.37%	6.76%
Year 0 Spawners								
+10%	-3.15%		-1.81%		-6.21%		-4.72%	
+20%	-5.76%	2.61%	-3.31%	1.50%	-11.55%	5.34%	-8.77%	4.05%
-10%	3.84%		2.21%		7.82%		5.93%	
-20%	8.64%	4.80%	4.97%	2.76%	17.33%	9.51%	13.15%	7.22%
Existence value								
+10%	3.33%		4.08%		1.56%		2.41%	
+20%	6.66%	3.33%	8.15%	4.07%	3.12%	1.56%	4.82%	2.41%
-10%	-3.33%		-4.08%		-1.56%		-2.41%	
-20%	-6.66%	3.33%	-8.15%	4.07%	-3.12%	1.56%	-4.82%	2.41%
Recreational value								
+10%	6.15%		5.49%		7.69%		6.84%	
+20%	11.25%	5.10%	10.11%	4.62%	13.89%	6.20%	12.19%	5.35%
-10%	-6.15%		-5.49%		-7.69%		-6.84%	
-20%	-11.25%	5.10%	-10.11%	4.62%	-13.89%	6.20%	-12.19%	5.35%
Commercial value								
+10%	0.53%		0.44%		0.75%		0.75%	
+20%	1.05%	0.52%	0.87%	0.43%	1.49%	0.74%	1.49%	0.74%
-10%	-0.53%		-0.44%		-0.75%		-0.75%	
-20%	-1.05%	0.52%	-0.87%	0.43%	-1.49%	0.74%	-1.49%	0.74%
P(recreational catch)								
+10%	3.14%		1.81%		6.28%		4.67%	
+20%	6.29%	3.15%	3.62%	1.81%	12.57%	6.29%	9.33%	4.66%
-10%	-3.14%		-1.81%		-6.28%		-4.67%	
-20%	-6.29%	3.15%	-3.62%	1.81%	-12.57%	6.29%	-9.33%	4.66%
P(commercial catch)								
+10%	0.31%		0.18%		0.65%		0.59%	
+20%	0.63%	0.32%	0.36%	0.18%	1.30%	0.65%	1.19%	0.60%
-10%	-0.31%		-0.18%		-0.65%		-0.59%	
-20%	-0.63%	0.32%	-0.36%	0.18%	-1.30%	0.65%	-1.19%	0.60%

Case 1: Current situation
Case 2: Current fishery / climate change
Case 3: Enhanced fishery / current climate
Case 4: Enhanced fishery / climate change

TABLE 3
Net Present Value of Yakima River Spring Chinook Stock by Case

	NPV ($MM)	% Difference from Case 1
Case 1	22.653	
Case 2	10.338	-54.4%
Case 3	179.514	+692.5%
Case 4	59.147	161.1%

Case 1: Current situation
Case 2: Current fishery / climate change
Case 3: Enhanced fishery / current climate
Case 4: Enhanced fishery / climate change

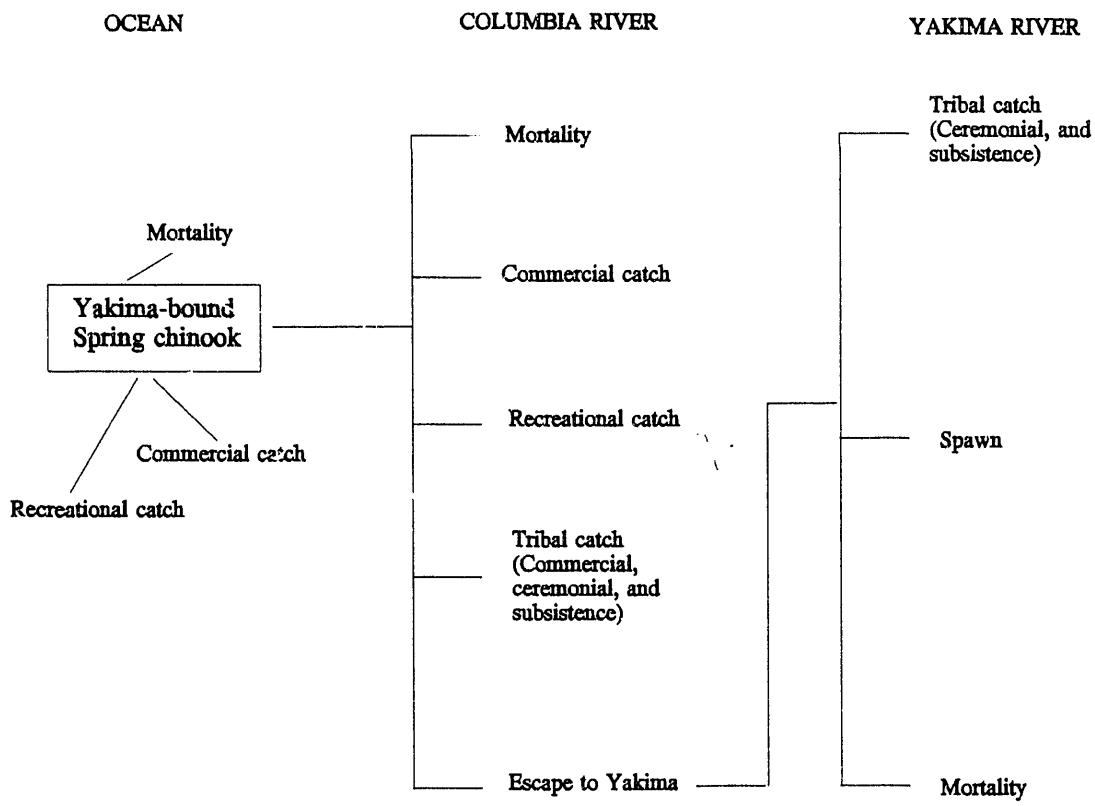

Figure 1.
Potential Path of Yakima Spring Chinook During Upstream Run

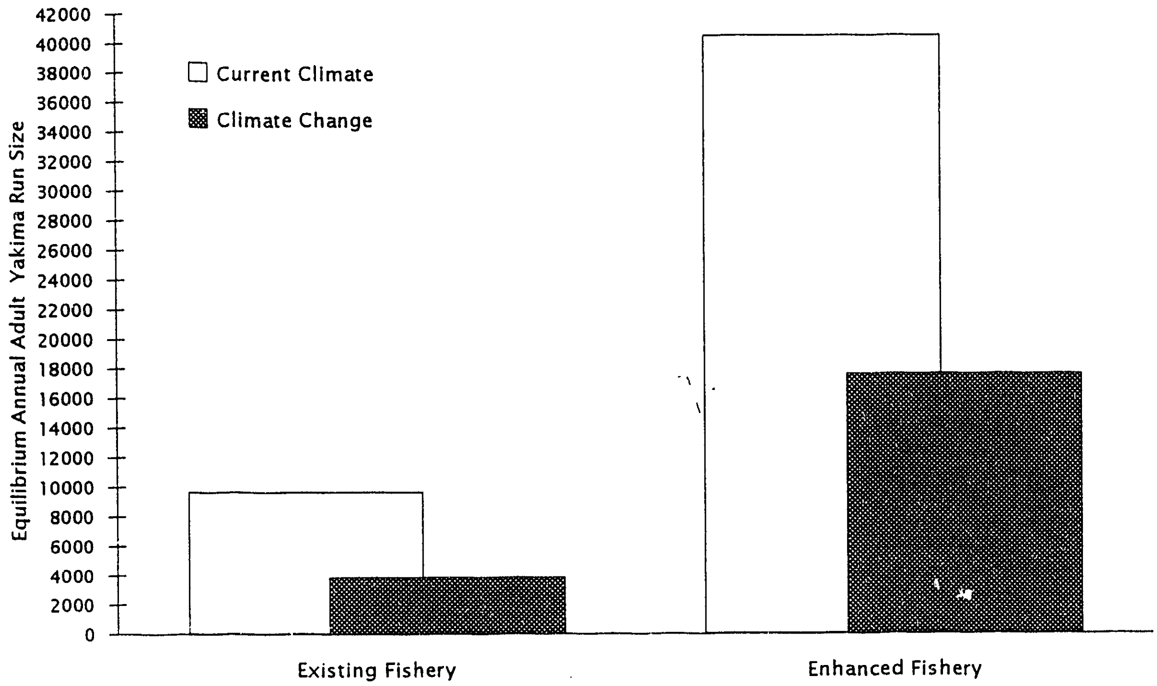

Figure 2.
Estimated Equilibrium Yakima Spring Chinook Ocean Adult Production by Case.

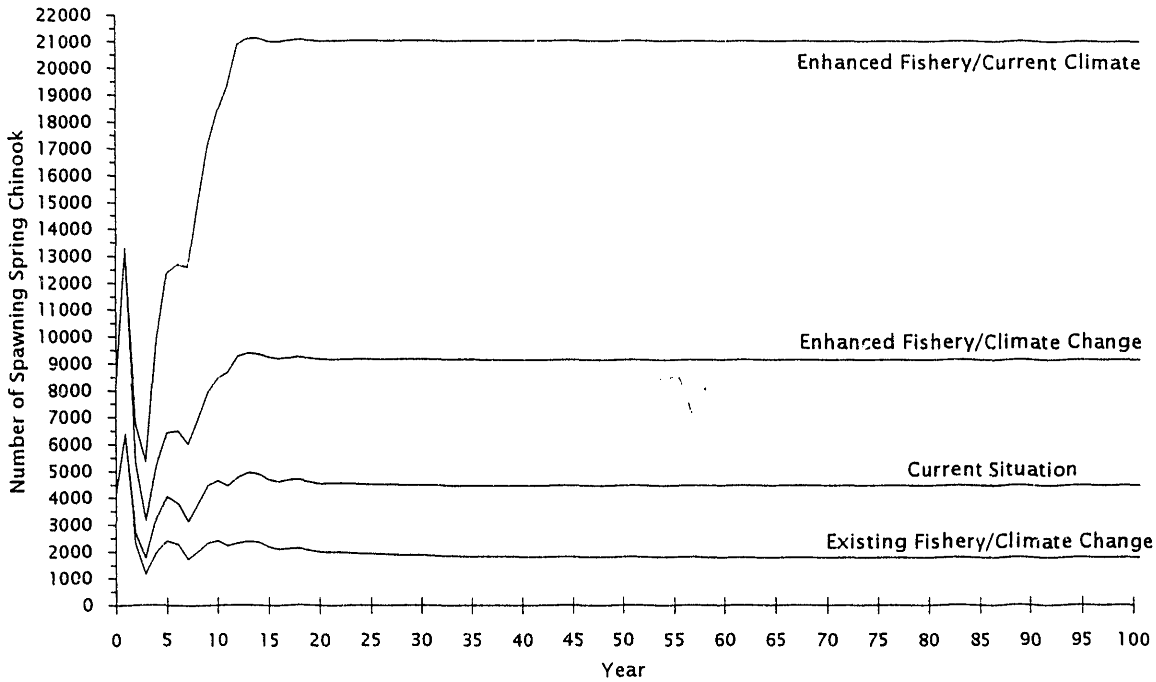

Figure 3.
Estimated Yakima Spring Chinook Spawning Returns Over Time by Case.

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