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VALUING THE SALMON RESOURCE: COLUMBIA RIVER STOCKS UNDER CLIMATE CHANGE AND FISHERY ENHANCEMENT

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VALUING THE SALMON RESOURCE: COLUMBIA RIVER STOCKS UNDER CLIMATE CHANGE AND FISHERY ENHANCEMENT

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INTRODUCTION

This paper represents an update to ongoing multidisciplinary research in the area of climate change and associated regional impacts to fisheries and economies. This work particularly deals with the total value of Columbia River salmon and the idea that fish have capital value, articulated here as spawning value. Earlier work dealt solely with the Yakima River spring chinook fishery's response to climate change and fishery enhancement programs and the associated direct economic effects (Anderson et al. 1992). We have expanded our modeling attempts to examine similar impacts in the Grande Ronde River subbasin of the Columbia River basin, and added the summer steelhead stock to the analysis. Relatively recent developments and improvements in climate change modeling and fishery modeling enabled us to attempt such an endeavor.

The total value of a fish would theoretically imply the summation of per-fish use and nonuse values. Our study used the primary data reported by others to assign per-fish values to the various components of total value. Specifically, we examined commercial value, recreational value, existence value, ceremonial value, and capital or spawning value that could be attributed to an individual fish. The values we estimated are based on spring chinook. We continue to refine similar values for summer steelhead.

A particular contribution from the present work is the notion that fish have spawning value. Any fish surviving to spawn a new generation has capital or spawning value. In this analysis, we argue that any fish surviving to spawn has spawning value. We represent this value as the sum of the present value of expected benefits from catching offspring from the i^{th} generation of spawners. Our formulation uses the fishery production/stock recruitment model embedded within the Northwest Power Planning Council's (NPPC) System Planning Model (SPM). Based on this model, capital value V_S per adult spring chinook in the ocean is represented mathematically by:

$$V_S = \sum_{i=1}^{50} P_i^s \cdot \frac{\bar{B}_i}{(1+3r)^i} .$$

In the above equation, P^s is the probability of a salmon living from egg to spawner. Expected benefits B_i are derived at the end of each fish life-cycle (3-year life used for Yakima, 4-year life

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used for Grande Ronde). This value is the sum of two products: commercial catch probability multiplied by catch revenue and recreational catch probability multiplied by the total recreational catch consumer surplus. An annual social discount rate r of 3 percent was used in this analysis.

VALUE PARAMETERS CONSIDERED

Commercial Value

Expected commercial value is the market price for ocean-harvest spring chinook multiplied by the commercial catch probability. Using data from Pacific Fishery Management Council (PFMC 1992), we estimated the market price per fish to be $15.05. Meanwhile, using PFMC data (PFMC 1992) and the NPPC System Planning Model, we estimated the commercial catch probability to be 0.0787. Multiplying these values resulted in an expected commercial value of $1.18 per ocean adult.

Recreational Value

We defined recreational value to be the recreational user's willingness to pay, in addition to trip expenses, to catch one spring chinook, multiplied by the probability of catching a spring chinook recreationally. Since most reporting of results in contingent valuation or travel cost studies that we found were based on values per trip, we made an assumption about the portion of a salmon fishing trip's value that could be attributed to catching a chinook.

ICF Technology Inc. (1988) estimated a weighted average of net recreation benefits for salmon fishing from shore, private boat, and charter sport fishing of $59.82 ($1992) 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 $299.10 per adult fish caught. Scott et al. (1987) used an average consumer surplus per spring chinook caught of $294.55 ($1992) in a benefit-cost study of mitigation alternatives for Columbia River salmon and steelhead.

A fishing trip may have several joint products that all contribute to the use value of that trip, such as the travel to the site, being in the company of others, enjoying solitude, and catching a fish. We assumed that the sport angler derives the same average consumer surplus per trip, whether or not fish were caught. Based on that assumption, the $59.82 value per trip was chosen to be an estimate of the average consumer surplus derived per salmon caught recreationally in the Columbia River system. 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, which gives a 0.0648 probability of a spring chinook salmon being caught by a recreational angler. When this probability of being caught was multiplied by the recreational value of a spring chinook salmon, the expected recreational value equaled $3.88 per ocean adult.

Ceremonial Value

Native Americans are assumed to derive value from the use of spring chinook for subsistence as well as religious ceremonies. Scott et al. (1987) judged that Indian ceremonial value should be at least as high as the recreational value of others for the purposes of benefit-cost analysis. Since no empirical estimate of consumer surplus for a ceremonial catch has ever been reported, we did not attribute any value to such a use, recognizing that our total value estimate becomes more conservative.

Existence Value

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 or Grande Ronde River by those individuals who do not use the resource and do not plan to use the resource in the future. Existence value may increase if the nonuser perceives that the species is in danger of extinction. For example, the existence value for the Yakima River spring chinook run may be $1 million, but that can mean that 10,000 returning fish are valued at $1 million, or one returning fish is valued at $1 million. Using contingent valuation techniques, Olsen et al. (1990) estimated an existence value of $18.75 ($1992) per 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). Based on the work of Scott et al. (1987), it is also possible to conclude that no existence or option values need to be attributed for relatively small changes in overall species abundance of stocks that will otherwise survive and for which there are close substitutes. No existence value was used here.

Climate Modeling Approach

The climate analog approach was used to postulate the terrestrial and aquatic ecosystem effects if a similar warming period occurred in the Northwest of today. In light of persistent General Circulation Model questions, the climate analog or "paleo-science" approach has been demonstrated to effectively reconstruct the Northwest's climate of the mid-Holocene, a period when average temperatures were around 2°C higher than at the current time (Chatters et al. 1992). The authors ignored the fact that any actual future temperature increase could be continuous and gradual, eventually proceeding well past this range. Temperatures of, say, 4°C above modern-day temperatures, such as Cline (1992) discusses, are not relevant for salmon management purposes because the resource ceases to exist at those temperatures.

Fisheries Modeling Approach

Neitzel et al. (1991) detailed the effects of such a warming on the fish stocks of the Columbia River basin. Using their approach, parameters were developed and applied using the Northwest Power Planning Council's fishery modeling system, including the Tributary Parameter Model and the System Planning Model (NPPC 1992). The four variables shown by Neitzel et al. (1991) to be critical determinants of salmon and steelhead survival include stream volume, stream temperature, freshet timing, and sedimentation. These were respectively simulated in the NPPC models as smolt capacity, egg-smolt survival rate, smolt-smolt survival rate, and prespawning survival rate. See Anderson et al. (1992) for full treatment of these variables.

EMPIRICAL RESULTS

As a result of the fisheries and climate work mentioned, four cases were developed for economic analysis for each stock and subbasin being considered. Case 1 reflects the current situation for all stocks in all subbasins. Case 2 represents the existing fishery under a 2°C warming. Case 3 represents each fishery under the current climate and maximum enhancement documented by the NPPC goals found in the Subbasin Plans (YIN 1990, for example), which generally call for a doubling of run size. Case 4 represents Case 3 under the climate warming mentioned.

The total economic value of 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 subbasin 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 available. These slight changes in catch probability would result in equally slight changes in the estimated use values. In this analysis, catch probabilities were held constant because we currently lack information on the harvest response of commercial and recreational anglers to these fish population changes. Table 1 highlights the economic values we estimated.

Table 1. Total Value per Adult Spring Chinook and Net Present Value by Climate/Fishery Case ($1992)

Subbasin Case	Commercial Value	Recreational Value	Capital Value	Total Value	% of baseline	NPV ($MM)	% of baseline
Yakima 1	1.18	3.88	11.50	16.56	–	6.96	–
Yakima 2	1.18	3.88	7.59	12.65	76	3.18	46
Yakima 3	1.18	3.88	16.24	21.30	129	30.56	437
Yakima 4	1.18	3.88	14.62	19.68	88	11.10	159
Grande Ronde 1	1.18	3.88	15.86	20.92	–	3.86	–
Grande Ronde 2	1.18	3.88	11.90	16.96	81	2.43	63
Grande Ronde 3	1.18	3.88	30.27	35.33	169	17.87	463
Grande Ronde 4	1.18	3.88	25.45	30.51	146	13.51	350

Policy Implications

Currently, the Yakima Fisheries Project (YFP) has three possible development alternatives (DOE 1992). 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.

The NPV estimates presented can provide a primary element of the benefits side if a benefit/cost analysis is performed to rate the YFP investment across a range of resource options. The net present value of project costs is estimated to be $37.989 million for the three-stock alternative, the minimum implementable alternative to be considered (DOE 1992).

If climate change is accepted as reality, greater levels of effort would be required to produce the desired enhancement of spring chinook salmon production. It should be noted that even under this assumed climate change, the planned enhancements are estimated to more than double long-run equilibrium spring chinook salmon runs over existing levels and achieve an estimated six-fold increase in production over the climate-change-without-enhancements case.

REFERENCES

Anderson, D.M., S.A. Shankle, M.J. Scott, D.A. Neitzel, and J.C. Chatters. 1992. "Costs of Climate Change: Economic Value of the Yakima River Salmon." Presented at the 67th Annual Conference of the Western Economic Association International, San Francisco, California, July 1992. PNL-SA-20998, Pacific Northwest Laboratory, Richland, Washington. (In review for publication in Contemporary Policy Issues.)

Chatters, J.C., Butler, M.J. Scott, D.M. Anderson, and D.A. Neitzel. 1992. "Paleoscience Approach to Estimating the Effects of Climatic Warming on the Salmonid Fisheries of the Columbia Basin." PNL-SA-21384, Pacific Northwest Laboratory, Richland, Washington. (In review for publication in Canadian Journal of Fisheries and Aquatic Sciences.)

Cline, W. R. 1992. The Economics of Global Warming. Institute for International Economics, Washington, D.C.

ICF Technology Incorporated (ICF). 1988. *Economic Impacts and Net Economic Values Associated with Non-Indian and Sturgeon Fisheries*, pp. 27-53 and appendices. ICF Technology Inc., Redmond, Washington.

Krutilla, J. V., and A. C. Fisher. 1985. *The Economics of Natural Environments: Studies in the Valuation of Commodity and Amenity Resources*. Resources for the Future, Washington, D.C.

Neitzel, D. A., M. J. Scott, S. A. Shankle, and J. C. Chatters. 1991. The Effect of Climate Change on Stream Environments: The Salmonid Resource of the Columbia River Basin." *Northwest Environmental Journal,* 7(2): 271-293.

Northwest Power Planning Council (NPPC). 1992. *Salmon and Steelhead System Planning Documentation, 1992 update of user information for the System Planning Model*, Monitoring and Evaluation Group, Portland, Oregon.

Olsen, D., J. Richard, and R. D. Scott. 1990. *A Study of Existence and Sport Values for Doubling the Size of the Columbia River Basin Salmon and Steelhead Runs*. Prepared for Bonneville Power Administration, Portland, Oregon.

Pacific Fisheries Management Council (PFMC). 1992. *Review of 1991 Ocean Salmon Fisheries*, Pacific Fisheries Management Council, Portland, Oregon.

Scott, M. J., R. J. Moe, M. R. LeBlanc, and J.W. Currie. 1987. "Columbia River Salmon: Benefit-Cost Analysis and Mitigation." *Northwest Environmental Journal*, 3(2): 121-152.

U. S. Department of Energy (DOE). 1992. *Yakima Fisheries Project Draft Environmental Impact Assessment*. DOE/EIS-0169, prepared for Bonneville Power Administration by Pacific Northwest Laboratory, Richland, Washington.

Yakima Indian Nation (YIN), Washington Department of Fisheries, Washington Department of Wildlife. 1990. *Yakima River Subbasin: Salmon and Steelhead Production Plan*, Yakima Indian Nation, Toppenish, Washington.

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