A MODEST PROPOSAL FOR THE EXTENSION OF NON-MARKET VALUATION METHODS

submitted to *Land Economics*
April 1992

Andrew G. Keeler
Department of Agricultural and Applied Economics
301 Conner Hall
The University of Georgia
Athens, GA 30602

A MODEST PROPOSAL FOR THE EXTENSION OF NON-MARKET VALUATION METHODS

Abstract

Welfare economics must adapt to the growing consensus over the assignment of rights to animals. We extend non-market valuation techniques to the study and measurement of the preferences of chinook salmon regarding their aquatic habitat and the value of their existrence. We find that these techniques are as valid for fish as for humans. Our applied study indicates that opportunites exist for Pareto-improving trades between salmon and California agricultural and hydropower interests.

A MODEST PROPOSAL FOR THE EXTENSION OF NON-MARKET VALUATION METHODS[1]

Introduction

In an important recent book, Roderick Nash places the development of environmental ethics into the broader framework of the expansion of rights. He argues that the extension of rights to animals and plants, and even to inanimate entities like mountains and oceans, should be seen as part of the same process which expanded rights in the English tradition from the nobility (in the Middle Ages) to white male landholders, then to white males, and eventually to women and non-white minorities. This development has important implications for welfare economics. The determination of whose welfare matters in applied welfare analysis must ultimately be based on whose rights are important. If economists had been working eight hundred years ago, it is probable that only the utility functions of landed nobles would have been considered. If the welfare of serfs were to be included, it would only be because that welfare mattered to the nobles and not because the serfs themselves had any right to inclusion in the economic calculus. This is directly analogous to the situation in the economics of natural environments that exists today. The "welfare" of elephants, tropical hardwoods, and unmined mountain ranges matter only insofar as the entities to whom economists extend rights–human beings–value them. If Nash's argument is correct and the existing consensus on the scope of rights continues to broaden, then economics must be prepared to include non-human preferences in its determination of welfare-improving economic policy.

As economists we have two alternatives in dealing with this challenge. The first is to develop instruments which will let us understand and measure the preferences of animals so that we can include these preferences in our applied welfare analysis. Undeniably, this is a difficult task, both conceptually and operationally. The alternative, however, is to admit that the expansion of rights to animals is a subject of study beyond the reach of welfare economics. We owe it to both past and future pioneers of economic inquiry to refuse to recognize *any* such limits.

The obvious problem in measuring the preferences of animals is that they do not allocate their scarce resources through markets. Fortunately, economists concerned with measuring the benefits of environmental amenities have developed a number of operational techniques for measuring the preference of humans in situations where markets do not exist. The same assumptions and leaps of faith necessary to put dollar values on human preferences in missing and incomplete markets work just as well for the preferences of animals. The three most important operational techniques are contingent valuation surveys, travel cost methods, and preference revelation through experiments. The purpose of this article is to demonstrate that these same techniques can be used to measure the preferences of animals. We will apply these techniques to a situation where the preferences of humans have already been extensively measured -- the alternative uses for water in the San Francisco Bay - Sacramento/San Joaquin River System (SFB/SSJ). By identifying and including the preferences of Chinook Salmon *(oncorhynchus tshawytscha)*, we will be better able to provide information on the economic dimensions of water

allocation decisions to the policy-making process. In the context of presenting the results of our applied preference measurement studies, we will discuss in theoretical terms how the methods of contingent valuation surveys, travel cost studies, and experimental economics apply to non-human subjects.

In this article we stop short of determining *how much* the preferences of animals are worth relative to those of humans. Ultimately, this is a question of rights, and as such must be decided politically. For the purpose of our applied study, such a determination is fortunately not necessary[2].

Applied Study

Chinook salmon in the Sacramento River depend on adequate water flows at key times of the year in order to successfully reproduce and survive (Kimmerer, et al.). These water flows are reduced when water is diverted upstream for irrigation or the timing of flows past dams is altered for optimal utilization of hydroelectric generation facilities. Thus water allocation decisions present tradeoffs between the fish population on the one hand, and the cost of producing electric power and agricultural commodities on the other. Several studies have begun the process of identifying the economic tradeoffs between a greater fish population and greater water use in agriculture. In all of these studies, however, the salmon have been considered for their direct market value to the commercial and sport fisheries and their non-market value in terms of existence and bequest values (Meyer; Loomis, Wegge, Hanemann, and Kanninen). We wish to expand

this analysis to include the salmon's own preferences over their continued existence relative to agricultural production. As a further exercise, we will also investigate the value that salmon place on the continued existence of the human population of the SFB/SSJ area.

Contingent Valuation Methods

The most popular technique for valuing human preferences in non-market situations is the contingent valuation method (CVM). The aim of CVM is to obtain by direct questioning an accurate assessment of the monetary value of alternative outcomes when no market exists for those outcomes (Carson and Mitchell). Initial research by ichthyological behavioral consultants Samaki & Pesca determined that the average reading comprehension level of the average Central Valley chinook was 1.9 standard deviations below that of the average Walnut Creek, CA fourth-grader - a level our consultants deemed too low for accurate responses to a written survey. Accordingly, we chose in-"person" interviews[3]. Respondents were chosen by a random mid-water trawl just southeast of the Farallon Islands during the 1989 fishing season. They were interviewed in a spacious, well-lit holding tank aboard a marine research vessel.

Since contingent valuation surveys were used to determine the pure non-market value of salmon to people[4], we chose to use this methodology to allow salmon to express similar valuations of themselves and of humans. We showed the respondents 16" by 18" color photographs of six salmon smolts (juvenile salmon at the stage of outmigration) and

then asked them via enumerators[5] to value those six smolts relative to neomysis, a food known to be popular with SFB/SSJ salmon. The subjects were asked to indicate how much neomysis they would give up in order to ensure the survival of the six smolts by modulating their forward fins – each fin movement in a one-minute span indicating one kg. of neomysis. The mean response was 55 kg., with a range of 40 - 65 kg and a standard deviation of 9.1. We then selected another sample and repeated the experiment. This time we showed the salmon a 16" by 18" picture of six juvenile humans nearing the outmigration phase of the lifecycle[6]. The mean response was 44 kg., with a range of 0 to 66 and a standard deviation of 18.7. It was later discovered that one of the respondents had died during the experiment, but we interpreted this as a legitimate valuation by revealed preference and retained the observation.

The contingent valuation survey indicated that six juvenile salmon were worth 55 kg. of neomysis to each salmon - at current market values this is equivalent to about $13.46. Six juvenile humans were worth 44 kg., valued at $10.76. There are two points worth noting here. One is that salmon just don't seem to value life that highly–six juveniles are worth somewhat less than dinner and a movie. However, along with this "life-is-cheap" set of preferences goes a remarkably high valuation of human life relative to their own. The existence of a marginal six juvenile humans is worth 80% of the same number of salmon youngsters. Human beings are surely a much more selfish species, exhibiting a valuation of nearer to .00001 of a juvenile salmon life relative to a human one. Thus the fish have a more altruistic attitude toward us than we do toward them.

These results should be interpreted as a willingness-to-pay measure– experience has shown that willingness to accept formulations will often elicit significantly larger valuations (Carson and Mitchell).

How valid are these results? There are three main requirements for the contingent valuation approach to be reliable. The first is a stable underlying utility function over the choices in question and alternative uses of the organism's scarce resources; economists have verified the existence of rational choice behavior in animals in laboratory settings (Battalio, et al.). The second is the absence of strategic behavior on the part of the research subject - here animals are clearly superior to humans. It is difficult to envision even a relatively intelligent animal like a poodle or a parrot deliberately falsifying a response in order to influence the social decision in its favor. The third is the ability to fully understand the content of the choices and all their ramifications, and to understand the survey instrument itself. Here it would seem that animals are at a disadvantage by virtue of lesser mental capacity. We do not, however, weight human responses by intelligence or a demonstration of competence. Instead, we assume a kind of rational revealed preference–people will make choices as if they understand the full ramifications. Indeed, any exclusion of animals on the basis of intelligence tests or competency criteria is inadmissible on both practical (equal opportunity provisions for access to federal research funds), statistical (sample selection bias), and political (correctness) grounds. We believe that if the choices are presented clearly, the presumption of adequate comprehension is as valid for animals as for humans.

Travel cost methods

The second technique for valuing non-market preferences is the Clawson-Knetsch method, which is based on inferring a lower-bound value by observing the expenditures of individuals to enjoy or make use of the good, service, or amenity in question. Often the most significant and most measurable component of these costs is the cost of travel (Johansson). Here there is a straightforward application to the animal kingdom. By observing the travel distance and pattern of animals and using biochemical data for each species, we can convert these patterns to caloric expenditures. We can then value these expenditures at the cost of energy from food or other sources on the free market, or alternatively in terms of the time and foregone opportunities the animal itself expended to obtain these calories. We use this method to infer the value of the recreational and direct use enjoyment that salmon receive from the Delta and Sacramento River environments during upstream migration.

The mean distance from the Golden Gate Bridge traveled by adult salmon in order to spawn has been calculated as 213 km (Kimmerer et. al.). The average weight of these salmon is 16 kg (Kimmerer et.al.). The Sacramento is tidal for about the first 175 km, and above that the downstream current runs on the order of 6 km per hour. Assuming that salmon convert energy to motion at an average efficiency of 50%, spawners collectively expend $1.15 \cdot 10^6$ kj on upstream travel. This is the equivalent of 82,166 packages of four C-cell batteries[7], currently valued at $294,976 at retail prices. This is

the minimum that the opportunity to traverse the Sacramento is worth to the salmon population for the combined purposes of tourism and reproductive activities.

Experimental methods

The third popular technique for valuing non-market goods and services is the experimental method. Human subjects are placed in a situation controlled by the investigator, and the choices they are presented with are carefully designed to reveal the preferences which are sought by the research effort. In the contingent valuation exercise reported above, the fish were asked hypothetical questions and their responses taken as a true indication of their underlying preferences. In the experiments reported here, salmon were presented with actual choices and their preference map inferred from these choices. We used experimental methods to both to determine salmons' preferences over their own existence, and also how they feel about the alternative uses of water which might tend to deny them that existence. A sample of adult salmon was obtained from two mid-water trawls - one between Sherman Island and Rio Vista in order to obtain adults with spawning on the brain, and another near the Farallon Islands to get adults with a more balanced perspective.

The first experiment was performed by placing each salmon in a pool of water too warm to support life for long, and allowing them to escape that pool to cold, food-laden water by means of a leap. After twenty successful leaps by each experimental subject, the height of the barrier was raised in one-foot intervals. The size and number of the leaps

could be interpreted as the salmon's valuation of its own existence. It was found that the spawning adults would leap an average of seven feet (153 jumps) to avoid death, while the other adults would go only four feet (92 jumps) on average. Converting the energy required to lift one pound one foot into energy, and using the weight of each fish in the survey, the average spawning adult was willing to expend 44 packages of C-cells and the non-spawning adults were willing to expend 15 packages. Thus salmon are willing to pay $158 for their continued existence when they can look forward to immediate sex and $54 otherwise. Note that these values are substantially higher than those given in the contingent valuation survey. This is to be expected, however, since in the experiment salmon are giving us their preferences over *their own* lives and not those over anonymous juveniles in a picture. The success of this experiment indicates that such a forced-revelation technique should be tried with human respondents as well.

The surprising finding of our contingent valuation survey that fish place a (relatively) high value on the existence, and therefore presumably the welfare, of humans indicates that their preferences may extend over a much wider range of goods and services than fisheries biologists had previously believed. We decided to see whether they placed any value on the foregone production of agricultural commodities that the fresh water necessary for their continued existence would cost. A non-spawning sample (spawners are uninterested in food, so their responses were viewed as unreliable) was placed in a tank with one kg of neomysis and a varying "consumption bundle" of rice and cotton. These crops were chosen because they are the crops most affected by marginal changes in

exports of Sacramento River water. Salmon were given a choice between the one kg of neomysis and bundles of 1, 5, 10, 100, and 1,000 kg of an equal percentage of rice and cotton. In every single instance for the lower four amounts, the fish chose the neomysis. When 1,000 kg was placed in the tank, so much water was absorbed that the fish died before choosing. We can interpret this inability to choose as an expression of indifference between one kg. of neomysis and 1,000 kg of rice and cotton, in spite of the remarkable difference in the monetary value of these alternate consumption bundles[8]. From this we can infer that salmon place very little value on the competing uses of Sacramento River water.

To the extent that the choices are perceived by the subjects as "real" ones, the actions of the subjects should reveal true preferences and get around the problems of bias and inaccurate understanding of the definition of the choices which plague contingent valuation surveys. Thanks to decades of psychological research, from Pavlov through countless contemporary rat-counting graduate students, the behavior of animals in controlled experimental situations is at least as much of a known quantity than that of human subjects. As with contingent valuation surveys, the results of animal experiments are not called into doubt by the problems of strategic bias in the subjects. In addition, animals are less capable of perceiving that the experiment is somehow an artificial situation and therefore less prone to act in a non-characteristic way because they don't perceive the choice as "real."

Implications for Policy Choices

So far we have discovered the preferences of salmon about their own existence as a species and as individuals, about the existence of humans, about the use of Sacramento River water as upstream conveyance, and about the alternative uses of that water. The relatively low value that salmon put on the survival of their young indicates that their preferences over the "existence value" of marginal salmon should not be a major concern. The significant value they attach to their right to traverse and enjoy the Delta and the Sacramento River, however, indicate that upstream water diversions which affect environmental quality have important impacts on welfare of adult salmon. Further, the results of our experiments indicate that salmon place a very high value on their own individual existence, and water diversions which decrease survival definitely affect their utility. Experimental revelation convincingly shows that the marginal value which salmon place on the marginal product of alternative uses of Sacramento River water is several orders of magnitude lower than that of the humans who reside and farm in California[9].

All of the above suggests that, given the preferences of the fish themselves, salmon can quite easily be compensated for the losses they experience as a result of upstream water diversion. The value of the habitat in terms of recreation and spawning opportunities can be repaid in part by the provision of greater and higher-quality food supplies. Agricultural and hydropower interests could also provide sub-surface video-based travelogues of the Delta and upstream Sacramento during high flows and "migration parks" where salmon could battle their way upstream against artificially generated currents

and waterfalls in a repeating loop. In addition, "honeymoon hotels" of the choicest gravel could be made available to adult couples in the South Bay in compensation for the lost upstream spawning habitat. To the extent that reduced upstream flows threaten individual survival at the outmigration phase, salmon could be compensated for an increased chance of death early in their life with a reduced chance of death through commercial and sport fishing. Fishing regulators could determine how much reduced catch is required to compensate for flow changes using existing biological and hydrological models (Kimmerer, et.al.; Fisher, Hanemann, and Keeler) and the fishing fleet could be compensated either from general revenues or through a surcharge on water use.

Conclusion

We have demonstrated here how the popular techniques for valuing non-market environmental goods can be extended to non-human subjects. It has been shown that if the techniques of contingent valuation surveys, travel cost methods, and experiments can legitimately reveal the preferences of humans, they should work at least as well for animals. In doing so, we have opened up a rich avenue of research which should improve both public policy formation and our own species' collective karma. In applying these techniques to the chinook salmon of the SFB/SSJ, we found that the inclusion of the salmons' preferences indicates that the disequilibrium between salmon and human valuation of the marginal output from water diversions makes it possible for the humans to compensate the salmon and still use the water profitably. By providing this compensation, we can proceed with a clear conscience that our policy is both moral and optimal.

FOOTNOTES

1. This article contains fabricated data, is entirely satirical, and should not be taken too seriously.

2. Given that the political system is currently run by humans, can expect a certain amount of anthropomorphism in the determination. For example, the welfare of dolphins and chimpanzees will in all probability be accorded higher weight than that of spiders and mice, largely because these species share certain social and cognitive characteristics with our own. We can expect this anthropomorphic valuation to be correlated with the existence value of the species, which reflects the value humans place on a species' survival, if not on its rights. The disadvantage is that it is based on a value some marginal quantity of surviving salmon, and therefore does not accurately give a valuation for the whole population. For salmon, we can also consider the Safeway methodology for valuing salmon's rights - if the salmon is worth $6.95 a lb., then their rights should be worth $6.95 a lb. as well. This allows us to take account of seasonal fluctuations in the value of the species's rights as reflected in price changes.

3. We have tried when possible to remove species-ist terms like "in-person"; when their use proved necessary, these terms are enclosed in quotation marks.

4. Loomis, et.al. found an estimate of willingness to pay for the enhancement of the San Joaquin salmon fall run–a population about one-fifth the size of the Sacramento fall run–of $1.8 billion. Meyer found an aggregate willingness to pay for enhancement of the general Central Valley chinook population of $41 per household for an increase of 10,000 salmon in the Central Valley population.

5. Samaki and Pesca originally used well-trained harbor seals as enumerators, but found they were too inclined to consume the interview subjects. Bottlenose dolphins were then hired at much higher union-scale rates, nearly bankrupting this project.

6. A publicity photo from the syndication campaign for a television show, "The Brady Bunch," was used for this purpose.

7. At 7 kj per individual battery. Batteries were selected because they are available at retail outlets throughout the SFB/SSJ study area and are small enough for salmon to carry.

8. One kg of neomysis is worth $.25; a evenly-mixed 1,000 kg bundle of rice and cotton was worth $179 at 1989 prices

9. Loomis, et.al. estimate that for the San Joaquin alone, the cost of maintaining flows adequate to produce acceptable aquatic environmental quality for upmigrating salmon in terms of foregone agricultural and hydropower production is slightly more than $3.5 million per year.

REFERENCES

Battalio, Raymond C., Green, Leonard and Kagel, John H., "Income-Leisure Tradeoffs of Animal Workers," *American Economic Review*, September 1981, *71*, 621-32.

Carson, Richard, and Robert Mitchell, Using Surveys to Value Public Goods: The Contingent Valuation Method, Resources for the Future: Washington, D.C. (1989)

Fisher, Anthony, W. Michael Hanemann, and Andrew Keeler, "Integrating Fishery and Water Management: A Biological Model of a California Salmon Fishery", *Journal of Environmental Economics and Management*, July 1991, 234-261.

Johansson, Per-Olav, The Economic Theory and Measurement of Environmental Benefits, Cambridge University Press: Cambridge (1987).

Kimmerer, W., J. Hagar, J. Garcia, and T. Williams, Chinook Salmon Population Model for the Sacramento River Basin: Version CPOP-2, Biosystems Analysis, Inc., October 1989.

Loomis, J., Thomas Wegge, W. Michael Hanemann, and Barbara Kanninen, "The Economic Value of Water to Wildlife and Fisheries in the San Joaquin Valley: Results of a Simulated Voter Referendum, "*Transactions of the 55th North American Wildlife and Natural Resources Conference* (1990).

Meyer, Phil, Value Associated with King Salmon in the Sacramento/San Joaquin/San Francisco Bay System, Bay Institute of San Francisco: Sausalito, CA (1987).

Nash, Roderick F., The Rights of Nature: A History of Environmental Ethics, The University of Wisconsin Press: Madison, WI (1989).