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Review of Independent Scientists' Report
With Consideration of Stratus Report
Prepared for PG&E by TER
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Review of Independent Scientists' Report with Consideration of Stratus Report

Final Report

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August 29, 2005

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with Consideration of Stratus Report
Final Report**

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Table of Contents

<u>Section</u>	<u>Page</u>
1. Executive Summary	1
2. Background	3
3. Basic Economic Principles	4
3.1 Economic Concept of Value	4
3.2 Nonuse values are not always significant	8
3.3 To the extent that nonuse values exist for I&E reductions, they are not likely to be meaningful.....	9
3.4 Cost does not provide a reliable proxy for value	11
4. 316(b) Regulatory Requirements	14
5. The IS Report is inconsistent with basic economic principles and the EPA 316(b) regulations	17
5.1 The IS Report is not consistent with the EPA Phase II regulations.....	18
5.2 The approach followed by the IS is not sufficient for determining the appropriate scale of restoration.....	19
5.3 The equating of restoration impacts to biological impacts has methodological flaws	21
6. Conclusions	25
7. References	26

1. EXECUTIVE SUMMARY

Cooling water intake structures (CWIS) at large, existing power plants are regulated by the Clean Water Act 316(b) Phase II Rule. The Rule requires impingement reductions of 80 to 95 percent and entrainment reductions of 60 to 90 percent, but also provides for site-specific determinations where the costs of best technology available (BTA), including restoration measures, are significantly greater than the benefits. The correct economic valuation of the benefits of reducing impingement mortality and entrainment (I&E) is therefore an important component of the Phase II Rule, which sets forth requirements for benefits valuation studies (BVSs) that in general must value commercial, recreational and, in appropriate circumstances, nonuse benefits derived from I&E reductions.

This report provides an overview of the basic economic principles that are required to conduct a reliable benefit valuation study. These economic valuation principles are based on a long period of conceptual development, refinement, and extensive empirical testing. Using these economic principles, we lay the foundations for both the Diablo Canyon Power Plant (DCPP) 316(b) BVS conducted by TER in 2005, and our critical assessment of the 2005 Independent Scientists (IS) report, "Diablo Canyon Power Plant, Independent Scientist's Recommendations to the Regional Board Regarding 'Mitigation' for Cooling Water Impacts" (IS Report).

In our critical assessment, we demonstrate that the IS Report (2005) is seriously flawed. We show that it is inconsistent with basic economic principles such as:

- The valuation concepts in the IS Report are based on costs, not values, which lead to implausible and sometimes nonsensical results. The IS Report is therefore inconsistent with basic economic principles and is also contrary to EPA's Phase II Rule requirements for BVSs.
- The IS Report fails to provide any plausible economic justification for the presumption that the effects of the DCPP on forage fish populations would result in significant nonuse values. In fact, the lack of general public awareness about such marginal population changes, the uncertainty about whether or not they would occur, and the large number of substitute resources make significant nonuse values extremely unlikely.

- The IS Report fails to develop any linkages between impingement and entrainment effects, ecological services, and humans. Consequently, it is unable to develop a reliable approach for scaling the size of the proposed artificial reef mitigation project.
- The IS Report fails to consider the basic principle of discounting to standardize the timing of services from the artificial reef relative to the potential impingement and entrainment effects from the DCP. Given the fact that the reef would provide services into perpetuity while the plant has a finite economic lifetime, the failure to consider discounting results in a substantial overstatement of the size of the reef that would be required to offset any potential effects on services, should they occur.
- The IS Report uses methods that are completely inconsistent with the EPA Phase II regulations for CWIS by, among other things, proposing a restoration project with costs significantly greater than the benefits of reducing I&E at the DCP.

Given these flaws, it is not at all surprising that the range of costs from \$10.6 million to \$26 million for the proposed artificial reef greatly exceed the approximately \$1 million upper bound in estimated benefits from reducing I&E at the DCP (TER 2005). As explained below, there is no conceptual or empirical economic rationale that would suggest that such a large differential could be justified by either omitted benefits or unvalued effects. In fact, our estimate of benefits includes the effects of DCP on forage fish based on EPA's recommended trophic transfer approach. Thus, the only category of benefits not included in our range of monetized damages is the potential existence value of forage fish and other organisms that are not captured through the food web. Even the most forceful advocates of monetizing nonuse values argue that a multiple of 2 to 3 of use benefits would account for such benefits. Thus, even the lower bound of the IS Report is ten times the upper bound estimate of our analysis. This fact indicates that the biological valuation approach used in the IS Report results in economic conclusions that are totally implausible. Moreover, it serves to illustrate the type of outcome that can result when an approach ignores such basic economic principles as values based on preferences not costs, and the discounting of future services.

2. BACKGROUND

Recently, two BVSs were conducted specifically for Diablo Canyon Power Plant (DCPP) CWIS impacts:

- **ASA Study (2003):** ASA used EPA's then-existing draft 316(b) Phase II economic guidelines to evaluate commercial, recreational, ecological, and nonuse benefits (using the 50 percent rule of thumb). ASA estimated total value of 80 percent entrainment reduction through 2053 to be \$23,000 to \$4.2 million, of which \$5,000 to \$935,000 was estimated to be nonuse value. The estimate included all fish species entrained (not just the Representative Important Species (RIS)), but excluded crabs. The study included no separate estimate for impingement, and used trophic transfer rates that were changed in the final guidance.
- **TER Study (2005):** We used EPA's final Phase II economic guidelines to estimate total value of reducing impingement by 80 to 95 percent and entrainment by 60 to 90 percent through 2053 to be approximately \$564,000 to \$1 million for all fish species and two crab species. We conclude that nonuse values do not need to be monetized under EPA final Phase II guidelines because I&E had only marginal population effects on non-unique species, and, on the basis of a qualitative analysis, that such values would be low in any event.

The ASA Study is somewhat outdated because of changes in U.S. EPA's economic approach. For example, EPA eliminated the use of the 50 percent nonuse rule of thumb in the final rule. The Agency also changed the trophic transfer factor used to account for the entrainment effects on forage species in terms of forgone production of recreational and commercial species. Finally, the ASA report does not provide a separate estimate of impingement and does account for any crab species in its results.

TER's report is the best estimate of the economic value of I&E reductions at the DCPP. The analysis contained in the report is performed in a manner that complies with EPA Phase II regulations. Additionally, the report uses the latest and most appropriate data on impingement and entrainment at DCPP, and evaluates all fish species, including forage species and two species of crabs. This evaluation incorporates an adjustment factor to reflect the fact that the biological data are based only on representative individual species. It also includes an analysis of the potential

uncertainty in the benefits estimation that is consistent with the state-of-the art in statistical estimation and the EPA regulatory requirements. Finally, the report uses qualitative analysis to assess potential nonuse benefits from reducing I&E impacts at DCP. This analysis, which is based on standard economic principles, concludes that the potential for such benefits from reducing I&E at DCP are negligible.

More recently the IS Study (2005) was produced to evaluate potential mitigation alternatives for I&E impacts at DCP. The IS used a habitat replacement cost approach (HRC) to project the value of I&E reduction based on the costs of constructing sufficient new artificial reefs to produce sufficient larvae to offset losses. The IS valued I&E reduction at \$10.6 million to \$26 million. The report also considers Marine Protection Areas and other potential mitigation alternatives, but devotes most of its attention to the artificial reef construction.

The IS Report, which is discussed in more detail in this report, is inconsistent with Phase II regulatory requirements for benefit valuation studies, because it employs a methodology (HRC) that EPA considered but ultimately rejected in the promulgation of the final 316(b) rule. Moreover, the use of habitat replacement costs as a measure of economic benefits is completely contradictory to long-established economic valuation principles. In particular, the method uses costs to approximate values, a notion which as demonstrated later in this report may lead to nonsensical results. In the case of the DCP, the method grossly overstates the true value of I&E reductions.

3. BASIC ECONOMIC PRINCIPLES

3.1 Economic Concept of Value

The economic concept of value has developed over a long series of contributions from many scholars dating to Adam Smith, Alfred Marshall, and John Hicks. Unlike other broader concepts of value that are linked to inherent or abstract principles, economic value is comparative in nature. In essence, economic value derives from trade-offs: how much of one thing is a person willing to forego to obtain

more of another? In economics, people hold values and are the arbiter of how much something is worth to them. Thus, people have value for preserving fish populations in an economic sense.¹

This anthropocentric nature of economic value differentiates it from valuation concepts arising from an ecological paradigm. In that paradigm, ecological systems are viewed as inherently valuable. For example, Banzhaf and Boyd (2004) note:

Economics is based on an anthropocentric ecological value, while ecology is more concerned with the status, functions, and quality of ecosystems themselves, rather than as producers of human benefit (p. 17).

Bockstael et al. 2000, add to this distinction by indicating that:

Some ecologists and other natural scientists have begun developing their own estimates of the "economic value" of ecosystem services. They believe...that economists fail to appreciate the intricate web of physical interrelationships that can link harm in one part of an ecosystem to negative effects in another. Failing to recognize the complexity of the system can result in an underestimate of the benefits of ecosystem protection (p. 1).

Not surprisingly, given such differences in the fundamental concept of value, disagreements among economists and ecologists over the benefits associated with a specific policy change are common.² In the context of the 316(b) regulations, however, Congress has determined that CWIS permitting decisions are to be based on economic valuations, As EPA made clear in the Preamble to the Phase II regulations:

EPA has established in today's rule national requirements for facilities to install technology that is technically available, *economically practicable, and cost effective* while at the same time authorizing a range of technologies that achieve comparable reductions in adverse environmental impact (69 *Fed. Reg.* 41576, 41583 (col. 2) July 9, 2004) (*emphasis added*).

¹ Bockstael et al. 2000 note that the economic concept of value depends on the distribution of income among individuals and economics measures values in a comparative rather than an absolute sense.

² The National Research Council (2004) argues that differences in terminology and perspectives compound the disagreements between ecologists and economists.

The economic concept of value depends on an individual's determining how much something is worth to him, usually expressed as his or her willingness to pay to have additional units of a good or service. In practice, economic values are used to answer basic questions that are relevant to the evaluation of any public policy choice: how does one determine whether an individual is better off with a policy change or without it? And how does one aggregate the gains and losses from a particular policy?

In economics, two (and sometimes more) alternatives are being compared. An economic valuation estimate will depend on the circumstances in which the valuation question arises. Again, Bockstael et al. (2000) illustrate this key point:

For example, suppose a power plant is being considered for a location that would eliminate a swimming beach. Different people can have quite different values for this change, depending on whether they would use the beach, gain from the lower cost of electricity, or both (p. 3).

They further note that the answer to this valuation question would depend on whether there was another beach close by (a substitute) or whether the loss of the beach would affect any other services, such as surfing or any unique ecological function, such as habitat for an endangered species. Clearly, valuation depends on the context in which the policy is being considered.

Services are an integral part of the economic valuation framework. When economists place a value on a natural resource, they value the services that flow from the natural asset, rather than the asset itself (Smith and Kopp 1993). The services that natural resources provide to humans are relatively straightforward concepts. For example, fish can be combined with other economic inputs to produce recreational or commercial fishing. The value of these services can be determined by observing the choices that people make and making inferences about their value.

Ecological services may also exist, but are much less clear cut. Generally, ecological services involve the services that one natural resource provides to another. However, Banzhaf and Boyd (2004) add further to this concept of ecological services by noting that:

Services are tangible ecological elements (e.g., a population) or qualities (air [or water] quality) that result from ecological functions and processes. Ecological assets are inputs to an ecological production function that yields an ecological service (p. 12).

As Boyd and Banzhaf (2005) discuss, services are the end products of nature that yield human well being. They argue that although ecological services must be derived from the natural environment, they must result in an end-product that is useful to humans. Thus, in the economic paradigm, ecological services are more than simply ecological functions. They include the interaction or at least awareness between people and the natural environment.

Not surprisingly, the valuation of ecological services is the subject of considerable confusion and controversy. Boyd indicates one of the primary reasons for some of the controversy:

Nature and the services that it provides are a significant contributor to human well-being, and society makes decisions every day about whether we will have more or less of it. Knowing nature's value helps us make those decisions. The difficulty is that nature never comes with a convenient price tag attached (Boyd 2004, p. 18).

It has been the attempts to develop such price tags, which has added to the controversy. The disagreements arise, at least in part, from the contention by some that people may have value for natural resources that exceeds the value of their direct uses. These "nonuse values" may stem from a variety of motives, with the most frequently mentioned ones being the preservation of the existence of the resource or the desire to preserve a natural resource for future generations to enjoy.

As we discuss below, nonuse values usually are thought to arise from unique resources that are irreplaceable—i.e., they have few if any substitutes in the economics lexicon. These nonuse values are usually addressed in a qualitative manner, or are measured using survey-based approaches that attempt to simulate a market for the resource services. One of the primary concerns about survey-based measures is that they are based on hypothetical responses, not actual market decisions or choices. The economics literature has clearly demonstrated that such questions lead to hypothetical bias, which implies that survey based methods overstate the true value of the natural

resource (List 2001; Champ and Bishop 2001). Finally, the nature and magnitude of that bias is not sufficiently well understood such that a reliable calibration factor can be developed (Desvousges, Gable, and Johnson 1995).

3.2 Nonuse values are not always significant

As noted above, the total value of a natural resource such as a fish population consists of its direct and indirect use values (i.e., typically commercial and recreational fishing) and, in appropriate cases, nonuse values. A key assumption of the IS Report (as well as the Stratus report [2004]) is that the nonuse values of I&E impacts on fish populations (and in particular on forage species which account for the vast majority of the fish species entrained) may be very significant indeed.³ For example, the report claims that benefit-cost analyses of environmental actions typically evaluate only a small subset of easily measured values (i.e., commercial and recreational fishing values), and typically omit nonuse benefits (such as the contribution of forage species to ecological functions) that may also be associated with I&E impacts. The assertion that nonuse impacts of I&E are significant wrongly fails to recognize that I&E impacts bear very little resemblance to the types of resources that economists have theorized might have significant nonuse values.

The original formulation of nonuse values considered the "existence of a grand scenic wonder or unique and fragile ecosystem" and hypothesized that certain people hold value for such a resource's "preservation and continued availability" (Krutilla 1967). Krutilla's example, the Grand Canyon, certainly qualifies as a grand scenic wonder. Since Krutilla's time, economists' expectations for the sort of resource typically expected to have nonuse values have not strayed far from this original formulation. For example nonuse values have been empirically evaluated for the survival of endangered species such as blue whales (Samples, Dixon, and Gowen 1986), eagles and striped shiners (Boyle and Bishop 1987). When economists have empirically evaluated nonuse values for population impacts, they have looked at significant and certain impacts to populations that are relevant to the survey respondents. For example,

³ EPA has concluded that the best way to value forage species is through trophic transfer models, which allow economists to value forage species in terms of the larger populations of commercially and recreationally important species that could be supported if larger populations of forage species were available to sustain them (EPA 2004b).

Kinnell et al. (2002) evaluates use and nonuse values for certain decreases of 30% and 75% in the total duck populations using a survey frame of Pennsylvania duck hunters. By contrast, the I&E impacts of DCPD on average have much lower percentage impacts on the larvae of fish species, and even lower impacts on the number of adult fishes forgone as a result of the larval entrainment (since most fish larvae have short natural life spans anyway). To our knowledge there has never been a serious theoretical or empirical evaluation demonstrating support for nonuse values for the sorts of marginal impacts to obscure, sustainable, regenerating populations that are hypothesized to occur in the case of most I&E impacts.

3.3 To the extent that nonuse values exist for I&E reductions, they are not likely to be meaningful

To the extent that nonuse values do exist for marginal changes in fish populations, there are no theoretical or empirical reasons to believe that they are meaningful. Except for the rare situations involving I&E of threatened and endangered species, fish are a renewable resource. The factors that typically support significant nonuse values—significant existence values and lack of substitute goods—simply do not apply in the same way for changes in renewable common fish populations as they do for unique, non-renewable resources.

A comparison of use and nonuse values for fish populations makes this apparent. People are the top predators in the food chain for fish. If nonuse values were truly substantial for changes in fish populations, we would expect that people would stop eating fish because the value of preserving their survival would be greater than their use values (commercial and recreational fishing). There is no empirical data to support the notion that such actions are prevalent, and indeed the fact that commercial and recreational fishing continue supports the conclusion that there is no significant existence value for marginal changes in fish populations.

The reason we do not anticipate meaningful nonuse values for marginal changes in fish population resulting from I&E at the DCPD is the lack of uniqueness at both the level of individual fish and the population. For the types of marginal effects on fish populations anticipated here, the number of substitutes is likely to be quite high. If,

for example, the population of a certain type of fish decreases by 2 percent, there are many substitutes that would exist so that this change would be covered by other fish populations in the same area, as well as fish populations in other locations. A large number of substitutes, which certainly would be the case for forage species, indicates that the per-unit value of any changes in a fish population is likely to be modest, if even measurable.

Clearly, there is a lack of any conceptual rationale for the presumption that there are significant nonuse values associated with I&E impacts. There is also no empirical evidence that large nonuse values are associated with I&E impacts. The Stratus Report's notion that substantial nonuse values are not being included in benefit-cost analyses apparently was based on an empirical study that is totally without any valid economic foundation. Helm et al. (2004) summarize 33 valuation studies that they consider most relevant for measuring the potential nonuse values for the Phase III Section 316(b) rule, which currently is being developed for another category of existing CWISs. They use these studies in a meta-analysis to develop a preliminary estimate of the potential nonuse benefits that would be associated with I&E impacts. As a result of this analysis, the authors (wrongly) conclude that nonuse values would be of a sizeable magnitude.

The analysis contained in the Helm memorandum is fundamentally flawed in a number of areas. Specifically, few of these studies value fish populations, much less the value of marginal changes in fish populations. Most if not all of the studies included involve substantial resource areas, such as large rivers, estuaries, and the water quality for the entire United States. Moreover, many of the studies involve large changes in environmental quality, such as changing an entire river from boatable to fishable water quality, or changing all waterbodies in the United States by the same amount. Some of these studies measure substantial amounts of nonuse values as a percentage of total value. However, even if one assumes that nonuse values are significant for major changes in significant resources, the argument that people will hold similar nonuse values for marginal changes in renewable populations of forage species is without any logical economic foundation.

3.4 Cost does not provide a reliable proxy for value

In contrast to the economic paradigm of resource valuation, the ecological paradigm prefers to use approaches such as the habitat productivity method or habitat equivalency analysis as alternatives to measures based on the willingness to pay. Such approaches balance organism losses with the amount of habitat needed to produce an offsetting number of organisms and calculate the cost of the restoration. The IS endorse the interpretation of habitat replacement costs as benefits in their Report:

The cost associated with the construction of the artificial reef is the single best estimate of the value of the lost resources.

Nevertheless, the IS Report does recognize that cost does not measure value (p. 34):

We realize that the cost of an artificial reef is not equivalent to the "value" of entrainment losses as estimated from a resource economy model.

Despite the foregoing acknowledgement, the IS state that:

- 3) As of July 2004, the estimated cost for the construction of an artificial reef ranged from 10.6 million (85 hectares) to 26 million (200 hectares) dollars (cost of transportation of material could cause these estimates to increase).
- 4) The cost associated with the construction of the artificial reef is the single best estimate of the value of the lost resources. If the reef is of sufficient size and of proper design, it has the potential to compensate for almost all entrainment impacts measured and unmeasured.

The fact of the matter from an economic perspective, however, is that the costs of creating habitat have nothing to do with the value of larvae. Costs are affected entirely by forces that are independent of the factors that influence preferences and value for fish. For example, the recent rise in fuel costs would cause transportation costs associated with reef construction to rise, which would imply that the reef, and hence the larvae, would be even more valuable than before. By the same token, if such prices decline in the future, the value of the reef would decline. Of course, all of

these changes in value would have occurred despite no change in the ecological functioning of the reef.

Costs generally do not equate with a willingness to pay, and therefore do not constitute a proxy for economic value. By way of further example:

- The costs in time and materials that are involved in creating a work of art or sculpture would not represent its value. For some artists or sculptors the market would value their work far greater than the costs, while for others the costs required to make the work would exceed its value.
- Towing an iceberg from a polar region would be an extremely costly way to provide water in California. It is inconceivable that the value of water produced from the method would bear any relationship to its costs.

Thus, there is no economic foundation for the notion that the cost of providing any natural resource or service is a reasonable proxy for its value. Such a conclusion is apparent even within the text of the Stratus and IS Reports.

In recognizing that there is no economic rationale for measuring benefits with costs, the Stratus report asserts that this approach is "cautious" and "preservationist." As noted in the discussion of nonuse values, however, there is very little theoretical or empirical evidence that there are linkages between CWIS impacts and significant nonuse values. Moreover, the viewpoint that measuring benefits incorrectly is cautious or preservationist is incorrect. A better description in this context is that this approach is unfounded. The HRC approach is particularly troublesome when combined with the Stratus Report's stated view that estimated HRC costs "should be compared with the estimated costs of implementing BTA, which is the relevant regulatory benchmark for comparison." In fact, neither of these is an appropriate criteria for decision-making.

To further illustrate the fallacy of using the HRC approach to measuring the benefits of reductions in I&E, it is useful to make a simple comparison with commercial fishing. Commercial fishing and I&E have similar impacts in that they both harvest individuals from a population. A well-known concept in fisheries management is maximum sustainable yield (MSY), which refers to the maximum number of fish that can be removed annually without causing stock depletion. At MSY, removals and

natural mortality are balanced by stable recruitment and growth. The MSY concept is an established method of informed fisheries management that leads to sustainable yields.⁴ However, under the HRC paradigm, the economic value of fish removed at MSY is equal to the cost of creating habitat that produces the harvest. By extension, when the habitat replacement cost method is used to value *sustainable* levels of commercial fishing, we are led to the illogical conclusion that the economic impacts of commercial fishing are equivalent to the cost of *creating* the habitat that supports commercial stocks.

Finally, some proponents have argued that because HRC involves natural resources, which have some inherent value, it is acceptable to merely assume that costs are equal to value. However, such an argument is fallacious. Specifically, the decision of society to invest financial resources to protect natural resources, such as fish, imposes an opportunity cost on society that must be considered. Such funds must be taken away from some other useful economic purpose. Only if the value of that purpose is less, would such a decision be justified. The decision to invest more in natural environments can only come at the cost of not investing elsewhere. The position that the cost of a reef (or any restoration activity) represents value could be used to support clearly absurd ideas such as that water usage should be valued or priced according to the cost of bringing icebergs from the North Pole.

Thus, the HRC approach is not consistent with economic principles, in particular with the principle that costs are not equal to values. Nor does the approach incorporate the fundamental building block of an economic evaluation—the concept of services. Given these shortcomings, EPA decided not to endorse this biological approach. Instead, as discussed in the next section, it promulgated a rule that incorporates the economic approach to valuation.

⁴ The recent PEW Oceans Commission (2003) report characterizes the state of the world's fisheries. Commercial over-fishing is cited as a primary factor in depressed stocks (I&E is not mentioned). This over-harvesting is a result of the failure of the enforcement mechanisms not the concept of a maximum sustainable yield.

4. 316(B) REGULATORY REQUIREMENTS

In July of 2004, the EPA promulgated regulations for determining the impact of CWIS on fish populations for existing power plants, the so-called Phase II regulations.⁵ The regulations require impingement reductions of 80 to 95 percent and entrainment reductions of 60 to 90 percent and provide for site-specific determinations where costs of best technology available (BTA), including restoration measures, are significantly greater than the benefits.

Additionally, an evaluation of benefits of reducing I&E impacts is an important component of the Phase II regulations. Specifically, EPA has specified requirements for benefits valuation studies (BVSs) that in general must value commercial, recreational and, in appropriate circumstances, nonuse benefits derived from impingement and entrainment (I&E) reductions. Specifically, the regulations state:

If you are seeking a site-specific determination of best technology available for minimizing adverse environmental impact because of costs significantly greater than the benefits of meeting the applicable performance standards of Section 125.94(b) at your facility, you must use a comprehensive methodology to fully value the impacts of impingement mortality and entrainment at your site and the benefits achievable by meeting the applicable performance standards (EPA 2004a, p. 41,690).

The regulations go on to specify the additional requirements of an uncertainty analysis and a peer review of the comprehensive benefits estimation methodology. In a comprehensive benefits study, recreational benefits are measured using valuation estimates based on people's choices of recreation sites that reveal the value of improved fish catch. Commercial fishing benefits are measured using market prices for the landed species. Equally important, the value of additional forage fish is included in the benefits analysis using the trophic transfer approach. This approach recognizes that the biological consequences of changes in forage fish stocks are measured

⁵ *Federal Register*, Environmental Protection Agency, 40 CFR Parts 9, 122, July 9, 2004.

through a bioeconomic model that links increased recreational and commercial catch to increased numbers of forage fish. (See Stavins 2004.)⁶

Forage fish that are not part of the food chain for recreational or commercial species would not be valued in the production foregone approach adopted by EPA in the final rule. Nonetheless, the remaining value of these fish would be modest because they are not likely to have significant nonuse values. (See Section 3.2 and 3.3 above.) Moreover, as we discuss below, EPA provides for the ability to analyze nonuse values on a case-by-case basis using qualitative analysis. Nevertheless, the Agency requires that these qualitative assessments be based on conventional economic valuation principles, not cost based approaches.⁷ (See EPA 2004a.)

Equally important, EPA expressly rejected the proposals to include cost-based measures as an alternative to economic valuation. Specifically, the Agency states:

In general, costs should not be confused with values (EPA 2004b, p. 2496).

The Agency goes on to further state in response to Dr. Robert Stavins (2004) comments on the proposed rule that argued against habitat replacement costs:

EPA agrees with Dr. Stavins' initial statement: "EPA's [proposed but abandoned] HRC method, which the Agency claims in its economic analysis is an alternative method for valuing benefits, is actually nothing of the kind. The Habitat Replacement Cost method is pure and simple a measure of costs not benefits. The habitat replacement costs are the design, implementation, administration, maintenance, and monitoring costs of various identified means of restoring aquatic habitats in the hopes of producing the same in situ services and service flows that are associated with the various technological alternatives under consideration. In other words, these are the costs of another alternative and one that can be very costly for achieving the same functions as targeted by the proposed regulation (EPA 2004b, p. 2502).

⁶ In its response to comments on the notice of data availability for the proposed draft Phase II rule, EPA specifically acknowledges that valuing impacts on forage fish is best accomplished by examining the impacts of forage fish on commercial and recreational species. The Agency views the production foregone as the preferred methodology (EPA 2004b, p. 2522.)

⁷ There is no support in the final regulations for the Water Board staff's position that habitat replacement cost is a qualitative benefits approach. Even qualitative approaches should reflect the same valuation concepts that are embodied in a quantitative estimate. That is, value is based on willingness to pay and that substitutes are an essential part of the valuation context.

Although EPA extensively evaluated HRC during its development of the Phase II Rule, EPA ultimately decided that the HRC method should not be used as a means of estimating benefits due to "limitations and uncertainties regarding the application of this methodology" (EPA 2004a, p. 41,625). In fact, EPA ultimately determined that "none of the methods it considered for assessing nonuse benefits provided results that were appropriate to include in this final rule, and has thus decided to rely on a qualitative discussion of nonuse benefits" (EPA 2004a, p. 41,624).

The Phase II regulations also incorporate EPA's Economic Guidelines for Preparing Economic Analyses (hereafter EPA Guidelines) (EPA 2000), which also recognize that there is no basis in economic theory or practice for using replacement costs to approximate benefits.⁸ The EPA Guidelines are quite explicit:

From the perspective of economic theory, the appropriate measure of benefits of a policy is the sum of the individual willingness to pay for that policy (EPA 2000, p. 62).

Alternative approaches that estimate the total value of ecosystems based on the cost of the entire ecosystem or its embodied energy...have received considerable attention as of late. However, the results of these studies should not be incorporated into benefit assessments. The methods adopted in these studies are not well-grounded in economic theory, nor are they typically applicable to policy analysis (EPA 2000, p. 98).

Clearly, the EPA Guidelines recognize that the measurement of value is based on individuals' preferences, not costs. Moreover, there is no reason to expect that costs would be even a reasonable proxy for benefits. Costs may be higher, lower, or the same as benefits, but that will depend on the unique circumstances of each situation.

In the final Phase II Rule, EPA provides the following guidance on how to assess the nonuse benefits associated with reductions in I&E (EPA 2004a, p. 41,647–41,648):

⁸ Mitigation cost or replacements costs may be used to approximate value in a very limited context. For example, the action to mitigate must be a voluntary action. Second, the action must be the least cost alternative for achieving the mitigation. Neither of these conditions applies to valuing reductions in CWIS impacts. (See Stavins 2004, Bockstael et al. 2000.)

- Nonuse benefits may arise from reduced impacts to ecological resources that the public considers important, such as threatened and endangered species. Nonuse benefits can generally only be monetized through the use of stated preference methods. When determining whether to monetize nonuse benefits, permittees and permit writers should consider the magnitude and character of the ecological impacts implied by the results of the impingement and entrainment mortality study and any other relevant information.
- In cases where an impingement mortality and entrainment characterization study identifies substantial harm to a threatened or endangered species; to the sustainability of populations of important species of fish, shellfish, or wildlife; or to the maintenance of community structure and function in a facility's waterbody or watershed, nonuse benefits should be monetized.⁹
- In cases where an impingement mortality and entrainment characterization study does not identify substantial harm to a threatened or endangered species; to the sustainability of populations of important species of fish, shellfish, or wildlife; or to the maintenance of community structure and function in a facility's waterbody or watershed, monetization is not necessary.

As we demonstrated in our BVS (TER 2005), a qualitative assessment can be based on economic principles without explicitly including monetized benefits. Such an approach demonstrates that there is no basis for thinking considerable nonuse values are being excluded from the BVS. Most likely, these benefits would be negligible.

5. THE IS REPORT IS INCONSISTENT WITH BASIC ECONOMIC PRINCIPLES AND THE EPA 316(B) REGULATIONS

This section consists of three subsections which demonstrate that the IS Report is neither consistent with economic principles nor is it consistent with the EPA Phase II regulations.

⁹ In cases where harm cannot be clearly explained to the public, monetization is not feasible because stated preference methods are not reliable when the environmental improvement being valued cannot be characterized in a meaningful way for survey respondents. (Note that this footnote is in fact part of the quoted EPA text.)

5.1 The IS Report is not consistent with the EPA Phase II regulations

As noted above, the IS have offered a report on mitigation impacts to the Regional Water Board. Specifically, the IS Report states that the goal of the IS is to

...provide the Regional Board with our best professional judgment regarding environmentally beneficial projects (type of projects, scale, and balance) that might be funded as part of PG&E's Diablo Canyon Power Plant permit.

In evaluating mitigation, however, the IS Report moved from biology into the realm of economics. This movement is a consequence of the methodology chosen by the IS to evaluate mitigation, which focuses on evaluating the productivity of habitat to replace organisms that may be lost as a result of I&E at DCP. The IS Report is thus based on a foundation of using the cost of replacement habitat to value the I&E impacts associated with the DCP.

As noted above, however, EPA specifically rejected the notion of using cost as a proxy for value because it was inconsistent with the Agency's own Principles and Guidelines for conducting economic analysis. As we have demonstrated in this report, the confusion of costs with values leads to nonsensical results.

Finally, the IS Report results in a scale of mitigation projects that is substantially greater than what would be justified on the measured benefits. Specifically, the IS Report implicitly argues that nonuse values from I&E losses at DCP are sufficiently large to justify a mitigation project that has lower bound costs that are ten times greater than the upper bound of the economic benefits that are estimated for reducing such losses (TER 2005). However, EPA's Phase II regulations clearly state that such benefits need only be addressed in a qualitative manner except in unusual circumstances, such as the impingement or entrainment of endangered species. The TER (2005) report shows that such a qualitative assessment demonstrates that nonuse benefits would be modest at most because of the marginal nature of the impacts and the presence of substitute resources.

However, assuming for the sake of argument granting that nonuse benefits might be significant (which is not the case), there is little or no chance that such benefits would be large enough to justify even the lower end of the range of costs estimated by the IS Report. For example, even the most ardent advocates for the notion of sizeable nonuse benefits only argue for an adjustment factor of 2 to 3 times greater than use benefits.¹⁰ Including such an adjustment would still only justify a reef about one-half the size of the smaller reef proposed by the IS Report. Thus, by ignoring the Phase II regulations, the IS Report has proposed a scale for the mitigation alternative that is substantially greater than what would be required to offset the loss in both human use and ecological services.

5.2 The approach followed by the IS is not sufficient for determining the appropriate scale of restoration

We also do not believe that the IS methodology is capable of evaluating the correct *scale* of restoration. While the appropriate type of project is an ecological issue, the appropriate scale is an economic and regulatory matter.

An evaluation of the Rule supports this contention. Under the final Phase II Rule, restoration is possible under either Alternative 3 or Alternative 5. Under Alternative 3, restoration measures must be scaled such that they can (EPA 2004a, p. 41,609).

...increase fish and shellfish in an impacted waterbody or watershed and result in performance substantially similar to that which would otherwise be achieved through reductions in impingement mortality and entrainment...

However, when the actions required to comply under Alternative 3 result in costs that are significantly greater than the benefits of meeting the performance standards, the site-specific approach (Alternative 5) is triggered (EPA 2004a, p. 41,597):

In today's final rule, a facility that demonstrates to the Director that the costs of compliance with the performance standards and/or restoration

¹⁰ Ackerman (2002) one of the most ardent critics of economic analysis argues for a factor between two and three times use benefits in his comments on EPA's proposed rule.

requirements would be significantly greater than the benefits will be given a site-specific determination of best technology available for minimizing adverse environmental impact.

In our economic assessment (TER 2005) that employed the methodologies EPA used to calculate national benefits, we estimated the total value of meeting reduction standards (reducing impingement by 80 to 95 percent and entrainment by 60 to 90 percent) through 2053 to be \$564,000 to \$1 million for all fish species and 2 crab species. This assessment concludes that nonuse values would not need to be monetized under EPA guidelines because I&E had only marginal population effects on non-unique species.¹¹

A site-specific determination implies that implementing a restoration solution that does not meet the performance standards is appropriate, as indicated by the following text (EPA 2004a, p. 41,597):

The standards of the rule have not changed since proposal, with the exception of one clarification: in the final rule, the alternative site-specific requirements established by the Director must achieve an efficacy that is as close as practicable to the performance standards and/or restoration requirements specified in § 125.94(b) and (c).

The relevant regulatory document is the Site-Specific Restoration Plan. As stated by EPA, this plan must contain the following information (EPA 2004a, p. 41,690):

A demonstration that the proposed and/or implemented design and construction technologies, operational measures, and/or restoration measures achieve an efficacy that is as close as practicable to the applicable performance standards of § 125.94(b) without resulting in costs significantly greater than either the costs considered by the Administrator for a facility like yours in establishing the applicable performance standards, or as appropriate, the benefits of complying with the applicable performance standards at your facility;

¹¹By way of comparison, EPA estimates that the commercial and recreational benefits for the entire California Region would be only \$3 million dollars, which is only one-third the *lower* bound cost of the artificial reef in the IS Report (EPA 2004b).

Based on this language, restoration efforts should not only be scaled commensurate with biological impacts, but should also be limited by economic considerations where the cost of 316(b) compliance is significantly greater than the economic benefits. Therefore, quantifying the magnitude of benefits and appropriately applying the concept "significantly greater" provide the regulatory framework for expected compliance expenditures and scale of restoration efforts under the Phase II Rule. As we discussed above, even the lower end of the mitigation alternative proposed by the IS Report results in costs that are ten times greater than the measured economic benefits. Even if substantial nonuse benefits have been ignored (which is not the case), they would not be of sufficient magnitude to justify the scale of the proposed restoration alternative.

5.3 The equating of restoration impacts to biological impacts has methodological flaws

The IS Report apparently uses the concept of value to equate impacts of the proposed artificial reef to impacts caused by the DCP. The proposition that these impacts are appropriately matched by the methodology has serious methodological flaws in that it does not measure changes in ecological services nor does it account for uncertainty or discounting in the scaling of restoration alternatives.

The IS Report provides estimates of mortality for the species that are impinged and entrained at DCP. It also frequently discusses the types of organisms such as phytoplankton that are not quantified in the studies that measure I&E effects. However, noticeably lacking in the Report is any quantification of whether the loss in various organisms has reduced any ecological services. To the extent that such organisms are vital to ecological functions, and to the extent that such functions are important to people's well-being, it would seem logical that noticeable reductions in some types of services would have been observed during the history of DCP operation.¹² The IS Report simply equates reductions in organisms to reductions in services. As Banzhaf and Boyd (2004) argue, services involve changes in populations, not simply a reduction in

¹²The lack of a focus on services results in other statements in the IS Report that are not substantiated. For example, the geographic scale from which the losses occur is large, so the scale of the project should be large (IS Report, p. 5). In the services paradigm, the scale of the restoration would be determined by the loss in services, not simply whether the reductions would occur over a large area.

ecological functions. Although quantifying such service reductions can be challenging, the equation of organisms to services nevertheless implies that such populations have no opportunity to compensate for the reductions, and that the loss in individual members of a species automatically reduces ecological services.

Additionally, the IS Report has not fully explored the implications of uncertainty in developing its conclusions. For example, the IS Report reiterates the important point that the ecological effects of the artificial reef are uncertain (IS Report, p. 5 and p. 20). However, it is also clear that although the numbers of individual organisms that are impinged and entrained is rigorously measured, the population impacts of the loss in these organisms are not known with any degree of scientific certainty.¹³ The IS Report approach taken does not attempt to identify even relative levels of uncertainty. Moreover, the importance of uncertainty to human decisions (our best indicator of value) has been recognized and mathematically formalized since the middle of last century (von Neumann and Morgenstern 1944). The quantification of the value of uncertainty is in the measurement of risk aversion. The intuition is that when people face choices with comparable returns, they will choose the less-risky alternative (Friedman and Savage 1948). With respect to the financial quantification of uncertainty, this issue was detailed by Markowitz (1952a, 1952b) and Tobin (1958).

A comparison of high yield bonds to treasury bills provides a good illustration of how uncertainty influences value. These bonds pay high yields to bondholders because the borrowers don't have any other option. Their credit ratings are less than pristine, meaning there is substantial risk of default. To compensate for this uncertainty, purchasers of high yield bonds require higher payments. By comparison, treasury bills carry a comparatively low yield. In this case, the backing of the government lends a level of certainty to the investment, reducing the yield requirement.

So, understanding the value relationship between the impact of DCPD and the effectiveness of the reef requires understanding the uncertainty in each. This is especially important if there is a meaningful difference in uncertainty. For example,

¹³Some studies that have evaluated the effect of I&E on fish populations have concluded that there is no measurable impact (EPRI 2003; Texas Commission 2003).

considering both ranges of uncertainty, it is possible that DCPD is not impacting fish at the population level, because of biological compensation for the loss of individuals, for example. It is also likely that any restoration activity will be productive. Thus, the IS Report is comparing a mitigation alternative (the artificial reef) that is certain to produce positive benefits to a potential loss that is sufficiently uncertain that it may or may not occur. Given this relative difference in uncertainty, one would expect that even a smaller reef would be a prudent and reasonable outcome.

The IS methodological approach is also flawed because it ignores discounting. The approach used to identify equivalence matches current production to current impacts. However, as exhibited by the following quote, there is a high likelihood that restoration projects will provide permanent benefits, while it is a certainty that DCPD will eventually cease operation.

The benefits of marine reserves are permanent, and will likely be manifested throughout the ecosystem. By contrast, entrainment losses are temporary (IS Report 2005, p. 23).

An implication of the foregoing is that proposed projects will be productive when there is no impact to offset. This situation leaves open the question of how these more-than-offsetting future impacts should be valued. When the value of such projects is from future *use* values, such as benefits to commercial and recreational fisheries, the accepted approach is to discount these values appropriately. For example, OMB guidance supports a 3% annual social discount rate which would be used for recreational fishing benefits, and a 7% commercial discount rate for commercial fishing benefits (OMB 1992). For values in the distant future, the rate of discounting can have a substantial effect. For example, a \$100 payment 50 years in the future has a current value of \$22.81 when the discount rate is 3%; when the discount rate is 7%, the \$100 is worth \$3.39.

As this example indicates, when *use* values are being considered, discounting lessens the relevance of impacts that are in the future. This means that when permanent projects are intended to offset temporary impacts to use values, projects that are somewhat less than offsetting of current impacts can be completely offsetting of impacts over time. However, a major rationale (at least implicitly) in the IS Report for

the equating of value in the manner employed is that there are substantial *nonuse* value impacts. Present value calculations are well-suited to value use benefits. However, when discounting is applied to the benefits provided by natural systems the effect is to discount the interests of future generations. The bequest component of nonuse values is based on the interests of future generations. Bequest value is current value for all future nonuse existence value. Much like a time capsule, bequest values are *more* valuable because they are experienced in the future—not less valuable.

The implication is that when part of the value of a restoration project is nonuse value arising from ecological services a small permanent restoration project can offset much larger impermanent impacts. This is because when the plant shuts down, permanent nonuse/ecological services more than offset temporary impacts. The bequest component of nonuse value realized at that point and into the future is not subject to discounting. Because these values would not be subject to discounting, a *small* amount of more-than-offsetting ecological/nonuse benefits realized at some point in the future, and continuing indefinitely can be offsetting. This view is consistent with economic theories related to nonuse and the regulatory evaluation requirements of nonuse values in the 316(b) context. In particular, economic theory tells us it is irreversible impacts that have large nonuse impacts. EPA recognizes the importance of permanent impacts with the requirement to quantify nonuse only when there are impacts to threatened and endangered species.

Finally, even if one were to adopt the conventional discount rate for social investments of 3%, it would still be likely that the size of the IS-recommended reef is much larger than necessary to offset any potential service losses. Specifically, suppose that the DCP has an economic lifetime until the year 2053 or 48 years, and the artificial reef would produce benefits into perpetuity. Using the 3% discount rate would imply that the artificial reef would produce benefits into the future for at least 22 years longer than the economic lifetime of the plant, if we assume that most of the benefits are discounted in 70 years. During this last 22-year time period, there would be no offsetting I&E impacts, thus the net impact would be even greater than during the first 48 years of the reef's lifetime. In summary, the failure to consider the potential roles that discounting services would play, along with the role of services themselves, results in a mitigation alternative that is substantially larger than is necessary.

6. CONCLUSIONS

The IS Report has proposed an artificial reef to mitigate the I&E impacts at the DCP. This report has considered the consistency of this mitigation alternative with basic economic principles and the EPA Phase II regulations. Our analysis demonstrates that the IS Report is not consistent with basic economic principles, especially in that it rejects the economic valuation concepts that people are the best judge of value and that cost is an inappropriate proxy for value. Moreover, the IS Report fails to consider the differences between the economics and ecological views of natural resource services. Furthermore, the IS Report does not evaluate the potential effects of discounting on the scale of the restoration alternatives they evaluate. Nor, does the IS Report evaluate the differences in the relative uncertainties between the mitigation alternative and the potential I&E impacts. All of these concepts are endorsed by the EPA regulations. The consequence of these omissions is that the IS Report proposes a mitigation alternative that is ten to twenty-six times larger than what would be justified based on any reasonable scientific measurement of economic benefits.

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Employment Chronology

- 1994 to date **President**
Triangle Economic Research
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- 1996 to date **Research Professor**
Duke University
Durham, NC
- 1989 to 1994 **Program Director/Senior Program Director**
Center for Economics Research
Research Triangle Institute
Research Triangle Park, NC
- 1980 to 1989 **Senior Economist**
Center for Economics Research
Research Triangle Institute
Research Triangle Park, NC
- 1975 to 1980 **Assistant/Associate Professor**
Department of Economics
University of Missouri at Rolla
Rolla, MO
- 1986 **Visiting Lecturer**
Meredith College
Raleigh, NC
- 1984 to 1985 **Visiting Lecturer**
University of North Carolina at Chapel Hill
Chapel Hill, NC
- 1980 to 1984 **Visiting Lecturer**
North Carolina State University
Raleigh, NC



Education

Ph.D., 1977, Economics, Florida State University, Tallahassee, Florida

M.S., 1974, Economics, Florida State University, Tallahassee, Florida

B.A., 1972, Economics, Stetson University, Deland, Florida

Key Projects

- "Evaluation of the Use of Survey Methods by Appraisers to Value a Commercial Property" (ChevronTexaco)
- "Evaluation of the Use of Contingent Valuation Surveys to Measure Diminished Property Values in Mississippi" (confidential client)
- "Evaluation of Market and Survey-Based Methods for Measuring Damages from Underground Storage Tanks (USTs) to Both Residential and Commercial Properties" (confidential client)
- "The Role of Individual Factors in Using Market and Survey-Based Methods for Measuring Potential Damages to Classes of Residential Properties in Colorado Springs, Colorado" (Davis Graham Stubbs)
- "The Role of Individual Factors in Using Market and Survey-Based Methods for Measuring Both Residential and Commercial Properties in Oklahoma" (confidential client)
- "The Reliability of Survey and Market-Based Methods for Measuring Damages from Increased Eutrophication in Lakes" (confidential clients)
- "Comments on the Benefit Estimates of EPA's Proposed Phase II 316(b) Rule" (The Utility Water Act Group)
- "Benefit-Cost Analysis of Various Regulatory Alternatives for 316(b) Compliance in Connecticut" (confidential client)
- "Benefit-Cost Analysis of 316(b) Regulatory Alternatives in California" (confidential client)
- "Groundwater Damages at the South Valley Superfund Site in New Mexico" (confidential client)
- "Creel/Angler Survey on the Lower Passaic River" (Chemical Land Holdings)
- "Human Use Compensatory Restoration Strategy for Onondaga Lake" (Honeywell International)

- "Review of New Jersey's Groundwater Damage Assessment Formula" (New Jersey Site Remediation Industry Network)
- "Environmental Costs for Particulate Matter and Mercury: An Assessment of the Recent Literature" (Xcel Energy)
- NRDA for a major waterway in the Northeast (confidential client)
- "Alternative Santa Clara River HEA" (confidential client)
- "Saginaw Bay and River Natural Resource Damage Assessment" (General Motors)
- "Evaluating the Reliability of Contingent Valuation (U.S. Environmental Protection Agency)
- "Measuring Environmental Costs for Resource Planning" (Northern States Power Company)
- "Natural Resource Damage Assessment for Lavaca Bay, Texas" (Alcoa)
- "Natural Resource Damage Assessment for the Clark Fork Basin in Montana" (ARCO)
- "Using Conjoint Analysis to Value Health" (Health Canada et al.)
- "Wisconsin Energy Research Project" (consortium of Wisconsin utilities)
- "Estimating the Market Potential For 'Green' Products" (Niagara Mohawk)
- "Fox River Natural Resource Damage Assessment" (Fox River Group)
- "Kalamazoo River Natural Resource Damage Assessment" (Kalamazoo River Study Group)
- "St. Lawrence River-Massena Natural Resource Damage Assessment" (Reynolds, Alcoa, General Motors)
- "Wisconsin Externalities Costing: Principles & Practices" (Task Force on Externality Costing, Wisconsin utilities)
- "Measuring Benefits of the Effluent Guidelines: An Evaluation of the Benefits Transfer Technique" (Office of Science and Technology, U.S. Environmental Protection Agency)
- "Information, Risk Perception, and Mitigation: Behavioral Responses to Environmental Risk" (National Science Foundation)
- "Natural Resource Damage Assessments for the Martinez, California; Gasconade River, Missouri; and Arthur Kill, New Jersey Oil Spills" (various clients)
- "Communicating Risk Effectively" (Office of Policy Planning and Evaluation, U.S. Environmental Protection Agency)

- "Valuing Reductions in Hazardous Waste Risks" (Office of Policy Analysis, U.S. Environmental Protection Agency)
- "Evaluating Risks of a High-Level Nuclear Waste Repository" (State of Nevada)
- "A Comparison of Benefit Estimation Approaches" (Office of Policy Analysis, U.S. Environmental Protection Agency)

Expert Reports

- "Expert Report in the Matter of *Beck, et al. v. Koppers Industries, Inc., et al.*" August 1, 2004.
- "Declaration of William H. Desvousges, Ph.D. Pursuant to 28 U.S.C. § 1746." April 15, 2005.
- "Supplemental Report in the Matter of *Palmisano, et al. v. Olin Corporation.*" February 7, 2005.
- "Expert Report in the Matter of *LaBauve, et al. v. Olin Corporation.*" December 10, 2004.
- "Expert Report in the Matter of *Cole, et al. v. ASARCO, et al.*" August 23, 2004.
- "Expert Report in the Matter of *Daniels, et al. v. Olin Corporation.*" August 16, 2004.
- "Expert Report in the Matter of *Kellum, et al. v. Kuhlman Corporation, et al.*" July 2003.
- "Expert Report in the Matter of *Susann Stalcup, et al. v. Schlage Lock Company, et al.*" April 1, 2003.
- "Expert Report in the matter of *Muise/Tzannetakis et al. v. GPU Energy.*" December 2, 2002.
- "Expert Report in the Matter of *State of New Mexico v. General Electric Company et al.*" February 1, 2002.
- "Expert Report in the Matter of *Major Andrews et al. v. Kerr-McGee Corporation, Inc. et al.*" June 29, 2001.
- "Expert Report in the Matter of *State of Montana v. Atlantic Richfield Company.*" June 12, 1995.

Testimony

Provided expert witness testimony in the matter of *LaBauve, et al. v. Olin Corporation*. Civil No. 03-567 in the U.S. District Court, Southern District of Alabama. February 14, 2005.

Provided expert witness testimony in the matter of *Betty Jean Cole, et al. v. ASARCO Incorporated, et al.* Case No. 03-CV-327(H) M in the U.S. District Court, Northern District of Oklahoma. October 8, 2004.

Provided expert witness testimony in the matter of *Daniels, et al. and Palmisano, et al. v. Olin Corporation, et al.* Case No. C 03-01211 RMW in the U.S. District Court, Northern District of California, San Jose Division. September 21 and 22, 2004 and February 23, 2005.

Provided expert witness testimony and participated in Daubert hearing in the matter of *State of New Mexico v. General Electric Company, et al.* Case No. CIV 99-1254, Case No. CIV 99-1118. Consolidated by Order dated June 14, 2000. January 2004.

Provided testimony to the Public Service Commission of Wisconsin in the matter of "Application of Wisconsin Electric Power Company; Wisconsin Energy Corporation; and W.E. Power, LLC for a Certificate of Public Convenience and Necessity for Construction of Three Large Electric Generation Facilities, the Elm Road Generating Station, and Associated High Voltage Transmission Interconnection Facilities to be Located in Milwaukee and Racine Counties. Docket No. 05-CE-130. September 8, 2003.

Provided expert witness testimony in the matter of *Kellum, et al. v. Kuhlman Corporation, et al.* Civil Action No. 2001-0313 through 2001-324 in the Circuit Court of Copiah County, Mississippi. August 19 and August 20, 2003.

Provided expert witness testimony in the matter of *Susann Stalcup, Craig Lewis and Sharon Lewis v. Schlage Lock Company, Ingersoll-Rand Company and Eagle-Picher Industries, Inc.* Case No. 02-RB01188(OES). June 12, 2003.

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Provided expert witness testimony in the matter of *Muise/Tzannetakis et al. v. GPU Energy*. January 22, 2003.

Provided expert witness testimony in the matter of *Andrews et al. v. Kerr-McGee Corporation et al.* Civil Action No. 1:00-CV-00158-B-A in the U.S. District Court, Northern District of Mississippi, Eastern Division. October 16, 2001.

Provided expert witness testimony in the matter of *State of New Mexico v. General Electric Company, et al.* Case No. CIV 99-1254, Case No. CIV 99-1118. Consolidated by Order dated June 14, 2000.

Provided expert witness testimony in the matter of *State of Montana v. Atlantic Richfield Company* in the U.S. District Court, District of Montana, Helena Division. Case No. CV-83-317-HLN-PGH. July 13, 1995. Rebuttal Testimony provided February 1, 1996.

Provided testimony on the matter of "The Role of Contingent Valuation in Natural Resource Damage Assessment" before the U.S. House of Representatives Subcommittee on Commerce, Trade, and Hazardous Materials. June 20, 1995.

Provided testimony before the Public Utilities Commission of the State of Minnesota in the matter of "The Quantification of Environmental Costs." Docket No. E-999/CI-93-583. Testimony in November 1994. Rebuttal in March 1995, and Sur-rebuttal in April 1995.

Testified before the National Oceanic and Atmospheric Administration (NOAA) Contingent Valuation Panel in the matter of "Using CV to Measure Nonuse Damages: An Assessment of Validity and Reliability." August 12, 1992.

Provided testimony to Wisconsin Public Service Commission in the matter of "Accounting for Environmental Externalities in Electric Utility Planning." November 26, 1991.

Areas of Specialization

Property Valuation

Prepared expert report that critiqued reports provided by the plaintiff's economic experts in a lawsuit alleging groundwater contamination at a Superfund site in the western U.S. Created a sophisticated hedonic property value model demonstrating that the Superfund site had no effect on residential property values.

In several states, directed projects evaluating the use of surveys to measure diminished property values, commercial and residential property values, potential damages to residential and commercial properties, and potential damages from various contaminants.

Critiqued the contingent valuation survey of a plaintiff's expert in a series of lawsuits alleging property damages caused by a wood-treating facility in Mississippi. Demonstrated that the survey is unreliable for use in litigation.

Natural Resource Damage Assessment

Developed comprehensive assessment plans for complex assessments.

Performed preliminary assessments for both oil-spill and hazardous-waste sites.

Designed state-of-the-art studies to measure potential losses for recreation and groundwater services. Studies included data-collection protocols and implementation.

Performed critical analyses of studies that used contingent valuation to measure nonuse values.

Designed and directed studies to measure potential recreation losses and to evaluate potential restoration gains.

Critiqued the transfer study used by the plaintiff's expert in a Louisiana lawsuit seeking restoration funds to convert floatant freshwater marsh habitat to uplands. Provided an alternative estimate of the value of the wetlands.

Benefit/Cost Analysis

Prepared comments on economic issues in EPA's proposed 316(b) regulations for The Utility Water Act Group.

Directed a benefit analysis of technology-based effluent guidelines for municipal and industrial dischargers.

Directing projects to measure benefits of 316(b) regulatory alternatives for several utility clients

Served on peer review committee associated with benefits transfer data needs for Environment Canada.

Served as peer reviewer on benefits transfer for Ontario Ministry of the Environment.

Directed a feasibility study of using benefit-cost techniques to assist in the planning of estuaries cleanup. The study used case studies of two estuaries: the Albemarle and Pamlico Sounds.

Prepared a handbook on benefit-cost assessment for water programs that included chapters on measuring benefits and costs, selecting a discount rate, and assembling a benefit-cost assessment.

Compared alternative approaches for estimating the recreation and related benefits of the Monongahela River in Pennsylvania. Developed a survey questionnaire to measure recreation, user, option, and existence benefits for different levels of water quality. The survey design enabled a comparison of bidding games, direct-question, and contingent-ranking techniques for measuring benefits. Used clustered sampling techniques to sample 393 households, and compared the direct survey results with benefits estimates derived from an indirect estimation technique.

Survey Design and Management

During the past 15 years, designed and managed large-scale surveys. Experienced in using bidding games, direct-question, contingent-ranking, and discrete-choice techniques for measuring benefits of natural resource and environmental policies. Directed focus groups to determine appropriate terminology, to evaluate the effectiveness of alternative visual aids used in the surveys, and to assess the various survey issues. Developed surveys to evaluate the following:



- Health benefits from reduced cardiac and respiratory morbidity using conjoint analysis
- Market penetration for "green" products using conjoint analysis
- Customer willingness to pay for "greener" electricity using conjoint analysis
- The role of quality-of-life measures in the benefits of improved life extension
- Natural resource damages
- Risk-communication effectiveness
- Radon risk perceptions and willingness to pay to reduce perceived risks
- Benefits of hazardous waste management regulations
- Risk perceptions related to the proposed siting of a nuclear waste repository and willingness to pay to reduce those perceived risks
- Recreation benefits demand
- Recreation, user, and option benefits for different levels of water quality

Environmental Costing

Provided analysis and testimony for the eastern Wisconsin utilities in hearings on environmental costing before the Wisconsin Public Service Commission.

Estimated the environmental externality costs of resource planning options for the eastern Wisconsin utilities and for Northern States Power.

Participated in environmental costing workshop and served on peer review committee for Ontario Hydro.

Health Economics

Conducted focus groups and used verbal protocols to develop stated-preference conjoint survey questionnaires.

Conducted large-scale stated-preference conjoint survey to measure benefits of reduced cardiac and respiratory morbidity.

Designed/conducted pilot study of quality of life and enhanced longevity using conjoint stated-preference methods.

Designed and distributed radon information materials that were sent to 2,000 homeowners in the state of New York who had their homes tested for radon. Supervised interviews with homeowners, sequenced over a nine-month to two-year period, to elicit their perceptions of radon risks and tracked any expenditure decisions to reduce these risks. The expenditures were used to estimate a willingness-to-pay measure of the value of reductions in radon risks. The research design also evaluated the effectiveness of an information policy for reducing radon risks.

Developed and evaluated alternative approaches for encouraging Maryland homeowners to test for radon. Developed and pretested risk communication materials that ranged from radio public service announcements to public display posters and brochures. Used a three-community experimental design with 1,500 baseline and follow-up interviews in each community to measure effectiveness.

Professional Associations

- American Economic Association
- Southern Economic Association
- Association of Environmental and Resource Economists (AERE)
- Member of Nominating Committee for AERE, 1983 and 1986
- Society for Risk Analysis
- American Public Opinion Research

Honors and Awards

- Recipient, Research Triangle Institute Professional Development Award, 1985
- Nominated for Outstanding Young Man of Rolla, Missouri, 1979
- Outstanding Teacher Award, University of Missouri at Rolla, 1977 to 1979
- Scholar-Diplomat, U.S. State Department, 1978
- Graduated *cum laude*, Stetson University, 1972

Professional Leadership

- Vice President, Association of Environmental and Resource Economists, 1992 to 1994
- Associate Editor, *International Journal of Energy Studies*, 1989 to 1993
- Associate Editor, *Journal of Environmental Economics and Management*, 1992 to 1994
- Associate Editor, *Water Resources Research*, 1984 to 1987

Journals and Book Reviews

- *American Economic Review*
- *Review of Economics and Statistics*
- *Land Economics*

- *Journal of Environmental Economics and Management*
- *Growth and Change*
- *American Journal of Agricultural Economics*
- *Southern Economics Journal*
- *Mansfield's Principles of Microeconomics*
- *Marine Resource Economics*
- *National Science Foundation*
- *Journal of the American Statistical Association*

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