Improving the Regulatory Analysis of the Cooling Water Intake Structure Rule: What Does an Economist Want?

Scott Farrow
UMBC

Forthcoming: in L. Heinzerling, R. Morgenstern, W. Harrington, Improving Regulatory Impact Analysis, forthcoming, Resources for the Future Press, 2009.

Appreciation is extended to Frank Ackerman, E.S. Brown, Richard Belzer, Myrick Freeman, Winston Harrington, Lisa Heinzerling, Richard Morgenstern, Nagaraj Neerchal and participants at the Resources for the Future Workshop on Improving Regulatory Impact Analyses for comments on an earlier draft. All views are those of the author.

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I. Introduction

Proponents, opponents, and some who aren't too sure have spilled much ink on the merits of cost–benefit analysis in support of government decisions, including the development of regulations. In this paper, I present a proponent's view in the specific context of establishing requirements for cooling water intake structures (CWIS) at existing power plants (EPA 2004a). The policy context, regulatory proposal, and environmental and economic evaluation of this regulation are summarized by Harrington (this volume). Voluminous comments were filed on particular aspects of the estimation procedures, and one more commenter on such details is unlikely to add much value. In its response to public comments, the U.S. Environmental Protection Agency (EPA) used 5,143 pages; of those, about 1,200 focused on benefits related to economics (EPA 2004e). Consequently, the focus of this chapter is on the consistency of the CWIS cost–benefit analysis with quality criteria to which the agency might have been expected to adhere and significantly less on specific details of the existing analysis.

In the remainder of the chapter, I focus on four topics. First, I discuss criteria for evaluating the economic content of the rule and whether the rule met those criteria. Second, I investigate criteria and outcomes with respect to decision rules for the design of the regulation. Third, I address the challenge faced by agency analysts because of the frontier nature of research linking ecological and economic impacts. Finally, I provide suggestions for improvement.

II. Criteria and Evaluation for the Economic Review of the CWIS Rule

What are the most appropriate economically based criteria for review of the regulatory impact analysis (RIA) conducted by EPA and how did the analysis perform on those criteria? Two sets of criteria appear relevant. The first set refers to analytical standards for the content of the analysis. The second set refers to decisionmaking standards that are at the boundary of economic and other risk management approaches. Although important nuances can be found in the text, I conclude that the RIA met minimum necessary analytical economic standards and may have met additional professional analytical standards. The analysis further met some aspects of economic-based decisionmaking standards but failed a critical one based on the law. I discuss each conclusion in turn.

A. What an Economist Wants I: Analytical Standards for the Content of the Analysis

In contrast to accounting, in which Generally Accepted Accounting Principles (GAAP) are issued by professional organizations, no standards from a professional society are available for cost–benefit analysis (GAO 2005; Bray et al. 2007). Instead, reviewers generally refer to two sources—guidance provided by government agencies and the published literature. These sources are equivalent to the two lowest-ranking sources in a hierarchy of standards for accountants and auditors (GAO 2005). For EPA regulations, the Office of Management and Budget (OMB) and EPA have developed guidance (OMB 1992, 2003; EPA 2000) based primarily on authority derived from executive orders related to cost–benefit analysis and regulatory development. Based on the OMB guidance, Hahn and Dudley (2007), Belzer (1999), and GAO (2005) have

developed scorecards for the basic quality of an analysis. These scorecards provide a way to determine whether the analysis was consistent with elements of OMB guidance and essentially are a type of analytical process check. An analysis substantially lacking these elements would almost certainly be a poor-quality cost–benefit analysis. For instance, questions on the scorecard refer to whether benefits are stated, quantified, or monetized; whether discounting was used and at what rate; whether alternatives were evaluated; and whether uncertainty was incorporated. However, while consistency with the guidance may be viewed as a necessary condition for a good-quality analysis, it is not sufficient. In particular, the analysis may have been done incompletely or incorrectly, in which case the result would be of poor quality.

I provide a slightly modified version of the scorecard used by Hahn and Dudley (2007) in Table 1. In this modification, I have deleted items specifically related to health, safety, or an executive summary as these were immaterial for the case at hand. The right-hand column provides my subjective assessment of the CWIS rule. Note, however, that some items are difficult to answer with a "yes" or "no" and the record was quite extensive. For instance, a reviewer might wish to know whether all or nearly all of the material beneficial impacts of the regulation had been considered, but this is difficult to ascertain without additional information and judgments. In the CWIS case, some commenters believed and I concur that nonuse and some types of fishery stock effects were potentially large and should have been included; consequently a "no" is recorded for "monetized all or nearly all benefits" in contrast to "monetized some benefits". However, this is a matter of judgment on items where information is lacking.

Insert Table 1 about here.

At this analytical process level, the EPA CWIS RIA passes virtually all of the steps of the scorecard, in contrast to many regulations (Hahn and Dudley 2007). The RIA[1] monetized at least some costs and benefits, estimated monetized net benefits, considered alternatives, used a prescribed discount rate, and so on. The RIA earns poorer marks on the clarity of analysis to justify trade-offs made in the regulation and the completeness of the benefits estimation. For instance, the RIA provides no logical or conceptual model up front to convey the sequence of steps, and important components are spread across multiple documents including the Economic and Benefit Analysis (EPA 2004b), Regional Analysis (EPA 2004c) and the Technical Development Document (EPA 2004d). Some of the analyses are quite involved, such as the econometrically estimated Random Utility Model, and others are simpler. Although summary tables of benefit and cost results are provided in both the final *Federal Register* notice and in the Economic and Benefits Analysis (EPA 2004b), these tables provide minimal caution about the analytical steps and the degree of precision. The latter issue also relates to the treatment of uncertainty in the final *Federal Register* notice itself, which does not convey some of the extended uncertainty analyses carried out in various supporting documents. Similarly, although implicit throughout the analyses, EPA provides no direct reporting of an average cost per adverse environmental impact (AEI) for different alternatives. The alternatives analysis, with its implicit wet cooling tower benchmark technology, was not clearly brought into the analysis as a likely "default" technology against which other regulations were measured. This is an example of an instance in which the usual "do nothing" alternative of cost–benefit analysis would not seem to be appropriate given the clear direction to "do something." Consequently, although many of the

[1] The RIA is here taken to be the final notice in the *Federal Register* and the final version of supporting documents. Where important, distinctions among documents are noted in the text.

necessary aspects identified in the guidance were done well, other aspects—such as those identified in Table 1—were touched upon but could have been improved.

What of the role of a review standard based on the professional literature that goes beyond the necessary aspects identified in guidance and scorecard approaches? This criterion is more nebulous because of the ambiguity and vastness of the professional literature as applied to a specific problem. Variations may also exist for standard practice, best practice, and frontier application. However, this concern for the quality of the analysis is related to other guidance from OMB (2002) based on the Data Quality Act. In this guidance document, quality is composed of utility, objectivity, and integrity. Procedural steps are identified through which agencies can achieve quality; these procedures include the use of peer review panels, whereby the review is conducted by people with a professionally equivalent or advanced understanding of the problem investigated by the agency. However, if an analysis appears in a peer-reviewed publication, then it may—but need not—have met the data quality standards. In the case of a peer review panel, peer reviewers are not blind to the identity of the author and are selected by the reviewing authority, whereas in the case of a peer-reviewed publication, the reviewers are generally "blind", and are selected by the editors of the publishing outlet. To some extent, the availability of a document for public comment can be viewed as a nonblind review process in which the selection of the reviewers is based on self-interest, which can include payment from any parties. OMB review of RIAs might be viewed by some as another type of peer review and, in fact, OMB appears to hold that opinion.[2] Three tests might be identified based on these

[2] OMB guidance appears to exempt regulatory analyses from peer review, saying "[t]his Bulletin covers original data and formal analytical models used by agencies in Regulatory Impact Analyses (RIAs). However, the RIA documents themselves are already reviewed through an interagency review process under E.O. 12866…. In that respect, RIAs are excluded from coverage by this Bulletin..." OMB (2005, 2674).

different processes. First, did the agency conduct a peer review of the analysis and, if so, what was the outcome? Second, how did professional commenters respond during the public comment period? And third, is the analysis based on a peer-reviewed publication or, somewhat weaker, is it likely that a peer-reviewed publication would publish a paper based on the analysis? I briefly address these three checks on quality in turn.

Did EPA assemble a peer review panel of the cost–benefit analysis and, if so, what were the results? Partially. A peer review panel was convened for the ecological and fisheries aspects of impingement and entrainment, and a separate panel was convened on nonuse values, although the latter panel addressed a later phase of the regulation. As is often the case, the review panels developed a variety of comments and suggestions for improvement (EPA 2002; RTI International 2005). The reviewers raised a number of issues about broader ecological impacts and fisheries dynamics, although EPA appears to express substantial concern with linking such measures with economic valuation (Stratus Consulting 2004; EPA 2004e). With regard to nonuse values for the later regulatory phase, the panel appeared critical of the particular way in which EPA estimated nonuse values but supported EPA's efforts to provide a nonuse value estimate. OMB reviewed both the proposed and final rules and completed its actions by determining that the rule was "consistent with changes" (Regulatory Information 2002, 2004).

How did professional commentators respond publicly to the final rule? Unfortunately, this is basically unknowable because the public comment period applies only to the proposed rule. However, several professional economists criticized analytical elements of EPA's proposed rule

and, later, data availability, on a variety of fronts.[3] Further, at least two of the economists, Frank Ackerman and Robert Stavins, disagreed with each other (Kysar, this volume), while the other economists presented a somewhat more common methodological view. At the risk of ignoring other economists not obvious in the record, I counted four economists whom I interpret as having similar methodological interpretations and one with a different interpretation.[4] Some of the methods opposed by the larger group of economists were removed from the final analysis, whereas movement of the monetized cost–benefit analysis toward the views of the economist with the minority interpretation appeared to be slight. Because no comment period existed for the final rule, the extent of economic commenter's agreement on the quality of the final rule is unknown.

Finally, was the completed analysis published in a formal externally peer-reviewed source? No. Could it potentially be published in such a source and thus by demonstration meet some level of professional standards? Possibly. Although this question has many facets—including the length of the CWIS analysis, which is more suited to a book than to a journal article, and the lack of a journal currently devoted to cost–benefit analysis—my sense is that a journal article devoted to the CWIS case could appear in an applied, peer-reviewed journal. In particular, the topic is at the frontier of integrating ecological and economic analysis, extensive information is provided in the analysis on technological alternatives, and a variety of quantitative analyses— including some relatively advanced econometric analyses of recreational choices—are provided. I conclude that a paper based on the CWIS rule could potentially appear in a peer-reviewed publication.

[3] Commentators with economics Ph.D.s included Frank Ackerman, Thomas Grigalunas and James Opaluch (together), Robert Stavins, and Ivar Strand. Economists may have been elements of other teams providing comments.
[4] It is true that science is not a democratic, majority process, and the author could add yet one more view on particular analytical aspects of the regulation. However, the challenge I trace here is the difficulty of determining an acceptable level of "quality" given the mandates placed on the agency.

Although the evidence that the CWIS rule met the ambiguous "professional quality" standard is somewhat weaker, the fact that EPA carried out some peer reviews, that its analysis moved in the direction of the majority of professional commentators, and that it may be publishable in a peer-reviewed journal, indicates that it probably meets guidelines provided by the Data Quality Act and the more ambiguous auditing standard of consistency with professional norms. The difficulty in determining the quality of a controversial analysis may also indicate the ambiguity of criteria and the potential usefulness of work in this area.

B. What an Economist Wants II: Decisionmaking Standards

Much of the controversy surrounding the CWIS rule appears to involve not only the analytical methods but the decisionmaking standards and the role played by OMB's Office of Information and Regulatory Affairs (OIRA; Heinzerling 2006). The choice of a decisionmaking standard by decisionmakers is outside of the role of economists, although a large body of public policy and economic literature, including cost–benefit analysis, suggests normative decision rules that could be followed in making a government decision. The Federal Water Pollution Control Act as amended in this case states that "[a]ny standard established…shall require…the best technology available for minimizing adverse environmental impact" (33 U.S.C. s. 316(b)). In addition, agencies are directed by Presidential executive orders, primarily Executive Order (EO) 12866 (1993) (a) not to use the RIA to displace the agencies' authority or responsibilities as authorized by law (EO 12866, s.9); (b) to assess both the costs and benefits of an intended regulation and propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs (EO 12866, s. 6); (c) to identify and assess alternative forms

of regulation that, to the extent feasible, specify performance objectives rather than a specific behavior or manner of compliance (EO 12866, s. 8); and (d) to tailor regulations to impose the least burden on society, including various societal elements (EO 12866, s. 11).

Consider first the decisionmaking standard under the law. Although a technology-based standard may appear simpler to define than an economics-based one, the apparent simplicity may belie complex issues in "implementation and interpretation" (Freeman 1980). Importantly in this case, EPA chose never to explicitly define the AEI (EPA 2004a, 41612). Even with the simpler focus on impingement and entrainment used by the EPA, substantial uncertainty about environmental impact remained because of a paucity of what may seem like basic data, such as the natural mortality rate of a species (EPA 2004a, Regional Studies, A6–5). Consequently, it is unknown whether EPA chose the technology that would minimize that impact. Further, the cost of technologies was identified as a possible, though secondary, element of the decision (EPA 2004a; Riverkeeper 2007).

Several weaknesses result from the lack of definition of the AEI, uncertainty about environmental impacts, and secondary use of cost information. Regardless of the definition of the AEI, it has multiple dimensions. EPA at least identified impacts, including the following: effects on various commercial, recreational, rare, sensitive, exotic, and disruptive species; disruptions of ecological relationships and public satisfaction; organic carbon, nutrient, and energy transfer; and decreased local biodiversity (EPA 2004a, 41662). Determination of the AEI would require a weighting of many factors. Analysts would be forced to come up with weights of relative importance, to defend equal weighting, or to explicitly acknowledge impacts that have

zero weight in quantitative or monetized analyses but that may be discussed in the text. Decisions would have to be made about which impacts are material to the decision. Economists would generally seek to use observed or inferred functions of prices as weights; alternatively, other weighting approaches could be devised. In any event, the benefit of the regulation is essentially the reduction in the weighted AEI with a standard economic benefit analysis using monetized weights.

Because any AEI developed based on the record would contain substantial uncertainty about impacts on the environment, it is extremely unlikely that one technology would be unambiguously best, an issue made even more complex by the multiple environments being considered, such as estuaries, freshwater lakes, and rivers. Thus, following the direction of the statute appears to allow for the potential for a benefit evaluation, measured by uncertain AEI reduction, and some evaluation of cost as a secondary element.

OMB guidance (2003) further indicates that in situations of uncertainty, expected (mean) values should be used as the foundation for analysis; however, other treatments of uncertainty could be used, possibly including probabilistic AEI and cost analysis. Consequently, it is conceivable that EPA could have used an analysis that included elements of AEI reduction (benefits) and costs in a manner more consistent with the statute than developing a cost–benefit analysis that did not depend on a definition of AEI.

In general, however, the determination of a decisionmaking standard that complies with the law is a legal question that is not answerable by economists. In hindsight, the actual analysis carried

out by EPA and the regulation failed the decisionmaking standard of both the law and EO 12866 (Riverkeeper 2007) although that conclusion is under review by the Supreme Court at the time of this writing.

What of the additional requirements of EO 12866? Did EPA assess the costs and benefits and choose an approach in which the benefits justify the costs? Yes and no. EPA assessed costs and benefits in the final CWIS regulation; on the basis of that analysis, the monetized benefits did not justify the cost (EPA 2004a; EPA 2004b, D1–4). A break-even analysis was provided to illustrate how large the nonmonetized benefits must be for the rule to break even on a monetized net benefit basis. One possible inference is that statutory responsibilities trumped this element of the executive order because, on a monetized cost–benefit basis, the country would be better off without the rule in the standard interpretation. Alternatively, EPA may have determined that, taken together, the monetized and nonmonetized benefits justified the costs, although they do not appear to explicitly make such a statement in the final regulation (EPA 2004a, 41663).

Did EPA specify a performance objective instead of the manner in which regulated entities must comply? Yes, to a large degree. An important aspect of the CWIS regulation was precisely the effort to identify a performance standard—the degree of mitigation provided by cooling towers—and to specify technological alternatives to meet that standard that also varied by environmental conditions. The regulation specified a set of technologies that meet a range of impingement and entrainment performance reductions as well as some alternative means of compliance. Although this could be seen as an effort to acknowledge the uncertainty in both the

AEI and the performance of technology, the integration of uncertainty and performance could have been better clarified in the determination of the standard.

Did EPA choose an approach that generated the least burden on society? Yes, to a large degree. This is the decisionmaking element closest to the discussion of the appropriateness of cost-effectiveness in Riverkeeper (2007). EPA clearly chose an approach that imposed a significantly lighter burden on society than the cooling tower option that formed the performance basis for the regulation. EPA estimated that a cooling tower option would have an annualized post-tax compliance cost of $2,316 million (EPA 2004a, proposed EBA, B7–10, 2001$) and a total social cost of $3,507 million computed with a 7 percent real discount rate. This compares with an estimated annualized post-tax compliance cost of $250 million (EPA 2004a, final EBA, D1–3, 2002$) and a social cost of $389 million for the final regulation.

Although commenters debated many aspects of these estimates (EPA 2004e), it appears that EPA did incorporate the economic burden on society in its determination. The record provides substantial evidence that the agency considered a lower-cost alternative to meeting a standard with the potential to save approximately $3 billion in annualized dollars or approximately $40 billion in present value[5]. To put this in a different context, the GAO would probably score an

[5] These are approximations without correcting for the one-year difference in the value of the dollar, differences in discount rates used by EPA for costs and benefits, and assuming a 7 percent real discount rate over an infinite time horizon. The difference between the infinite time horizon and a shorter one is $V/r*(1-e^{-rT})$ where V is the annual value, r is the discount rate and T is the terminal time. For instance, a 25-year time horizon at 7 percent would reduce the infinite time horizon value by 17 percent. If the alternative 3 percent discount rate were used, the cost savings would be approximately $100 billion.

approximate $40 billion dollar nongovernmental cost saving if the EPA made the regulatory design change away from cooling towers in response to a recommendation by the GAO[6].

In summary, with regard to what decisionmaking standards were applied, the results are mixed but EPA's failure to comply with statutory requirements appears to trump other aspects of the analysis at the time of this writing. Clearly, however, EPA did not apply a strict monetized cost–benefit decision rule although cost-effectiveness information was applied with the potential for materially reducing the burden on society.

III. The Frontier of Linking Ecological and Economic Systems

In what ways does this case study illustrate weaknesses in linking ecological impacts with a cost–benefit approach? Consider that economists can be preoccupied with the monetary valuation stage and the normative, economics-based decision rules that constitute their area of comparative advantage. However, nothing can be monetarily valued without a change in quantity (or quality) in the environment broadly considered. Here lie the key difficulties in the case study. The environmental impacts of CWIS affect freshwater and saltwater ecosystems in a variety of ways, some of which are poorly understood. In short, the AEI was incompletely specified, a not unusual occurrence for ecological impacts. Even determining what is adverse requires some value judgment. For instance, increased recreational fishing or the congregation of an endangered species such as the manatee near thermal outlets may be viewed as adverse from one

[6] This did not occur; instead I provide this as an illustration of "scoring" cost savings such as used by the GAO (2008).

perspective if it is a deviation from an environmental baseline. In fact, EPA did not define the objective function of its regulation, the AEI (EPA 2004a, 41612).

From the standpoint of *economically* valuing impacts, the challenge is to find the material ecological outputs or services that people value and to find ways to measure those impacts and values. For instance, impingement and entrainment do not easily translate into dimensions that people value. As a consequence, the links that connect the ecological and economic impacts are difficult to measure. Commercially and recreationally landed fish provide the most concrete linkage between the ecological and economic measurements in the RIA, but other linkages proved problematic.

Governmental practitioners and consultants have been asked to resolve such basic research challenges. As indications of this frontier challenge, consider that the Committee on Valuing the Protection of Ecological Systems and Services (C-VPESS) of the EPA Science Advisory Board is drafting a report on the topic that may result in future guidance (EPA 2007, 2008). In addition, a National Research Council report has appeared since the regulation was finalized (Heal et al. 2005). Would the CWIS analysis have been substantially assisted by having these documents available at an earlier date?

First, both the C-VPESS draft report and Heal et al. (2005) discuss the difficulties in modeling ecological and economic systems and in linking the impacts. The Heal et al. report focuses primarily on economic approaches to valuation, embracing both use and nonuse values. The C-VPESS draft report considers an expanded set of valuation methods useful at various stages of

the regulatory process but states that, in the case of RIAs, the economic component is to be "conducted in accordance with the methods and procedures of standard welfare economics" (EPA 2008, 122). The draft report included a survey of methods for social-based valuation approaches that are at the frontier of research; for instance, it posits that people may have different values as citizens than as consumers. However, at least some economists would probably be concerned about the decisionmaking context in which individuals are placed to elicit values for cost–benefit analysis (Spash 2007). For instance, a person placed in the experimental context of a citizen decisionmaker with a group of peers facing a relatively unknown problem may be influenced by the social context, the formation of the group, and the hypothetical nature of the setting, perhaps including issues related to the absence of actual budget limitations or the scope of choices being considered. List et al. (2004) recently found that a lack of social isolation may create a bias roughly equivalent to that created by the hypothetical nature of surveys that elicit economic values. These authors interpret social settings for value elicitation as inducing "respondents to include any number of utility-enhancing values that come from publicly advertising one's own goodwill. But, since these 'externality-type' values are not germane to the good in question, rather to a class of goods, it is incorrect to lump them with any particular good's value" (List et al. 2007, 749).

The C-VPESS citable draft report (the latest version is not citable per its webpage) has a special section on valuation for national rulemaking (EPA 2007, s. 6.1). Examples of draft guidance, which may change includes:

- an early conceptual model of the ecological and economic system being analyzed (EPA 2007, s. 6.1.2.1);

- early identification of socially important impacts that may not be limited to economic methods;

- the early interaction of ecologists and economists to inform the prediction of biophysical changes in value-relevant terms (but the draft report notes, in the concentrated animal feeding operation example used, that "the combination of variation complexity, and gaps in information and understanding make it difficult for the Agency to assess the ecological impacts of its actions, particularly at the national scale;" EPA 2007, 122);

- the likely use of benefit transfer methods and quality checks in the development of monetized valuation measures; and

Had this draft document become final, the advice may have served early on in the CWIS process to help frame and direct research. However, as is the case with general cost–benefit guidance from OMB, it is unlikely to have been a substantial help in resolving the difficulties in defining ecological impacts and linking those impacts to economic valuation measures.

IV. Conclusion: What Does an Economist Want in a Regulatory Analysis?

I will assert the following. Economists want decisionmakers to consider economic trade-offs involved in a decision based on credible information. We want a cost–benefit type of analysis to analyze our definition of efficiency while recognizing that cost–benefit analysis will not

unambiguously identify a socially preferred policy (Arrow et al. 1996). If legal or other constraints exist, we typically want a cost-effectiveness analysis if the law is immutable or a cost–benefit analysis if we are considering changes in the law. We want price or functions of prices as societal measures of value from the interaction of many people in the marketplace. If markets are lacking, we want an experiment conducted that generates numbers *as if* a market existed. We want sufficient precision to distinguish positive from negative net benefit values or to test a specific hypothesis or question. Economists want this information as they seek the largest economy, broadly considered, that is consistent with people's preferences, technology, and environmental conditions. The largest economy, broadly considered, includes leisure time, the provision of environmental amenities, and nonmarket as well as market activity. If the distribution of goods and services that result from market forces in this largest economy is deemed inequitable, then economists currently look to the political process for distributional adjustments. Economists, and some other stakeholders, want an economic analysis to conform to norms of the discipline, which may be difficult to infer. Economists *don't want* decisionmakers to be provided only with distributional information.

Other stakeholders in the regulatory process may want a different type of analysis. For instance, a package of reports might be associated with an analysis. In the context of the CWIS rule, the ecological impacts are important to some stakeholders in their natural units; impacts in natural units also form a first step in an economic analysis. Some other type of noneconomic valuation—such as energy or other modeling of the ecosystem—may gain credence. One can easily imagine however, a set of summary tables that proceeds from qualitative impacts, to quantitative impacts in their natural units, to valuations, and finally to a cost–benefit table. The regulatory

requirement for a cost–benefit or cost-effectiveness analysis, however, identifies an aspiration to report somewhere in the document a specific type of professionally recognized analysis.

What might EPA do to proceed, both in the specific CWIS case and for its economic regulatory evaluations in general? Regarding CWIS, ultimately, EPA created a complex regulation without a transparent message and analysis. An analysis of technologies that considers cost-effectiveness by defining a weighted AEI, taking explicit account of uncertainty and using cost as a secondary consideration, appears to be supported in the legal record and appears to contain many, if not all, of the elements that an economist would want. In particular, an explicit discussion of weighting an AEI may be one way of investigating alternative methods to capture society's preferences.

From a broader regulatory evaluation perspective, creating new interdisciplinary science is a high hurdle for a decision support document like an RIA. EPA and other agencies, such as the National Science Foundation, might choose to foster additional frontier work so that models better linking ecosystems and the environment may be available commercially off the shelf the next time a regulation calls for such analysis. Both Heal et al. (2005) and the C-VPESS draft report (2008) contain recommendations for further research (those of the Heal et al. report are provided in Appendix A). To these research issues, I would add the following topics: an examination of instances in which it is better to use a number in place of a default of zero, an investigation of faint behavioral trails for nonuse value, and research that more explicitly recognizes uncertainty in the risk management decision that can lead to new valuation measures.

Regarding the use of default values of zero, cost–benefit analysts often are unable to find a number—whether related to quantity, value, or cost—that is exactly designed for the location or other context of the regulatory setting. Analysts often substitute estimates but, not infrequently, may choose to use a zero in the monetized cost–benefit computation because of imprecision or other reasons. In the context of the CWIS analysis, the final monetized cost–benefit analysis used zero values for fish that were not captured or that were not an input into commercial or recreational fishing, as well as for nonuse value. In another setting, the U.S. Army Corps of Engineers chooses not to monetize the probability of a loss of life, although such impacts are typically discussed in the text of Corps documents (GAO 2005). In environmental applications, one aspect of this general issue has been discussed as *benefits transfer* (Freeman 2003), in which means have been sought to improve the accuracy of benefits that are estimated in one location and "transferred" to an analysis for another location. This issue is central to many debates about omitted impacts in which the analyst chooses to use zero in the monetized estimate instead of an estimate transferred from a related study or estimated by other means. Research and improved guidance might exist to help analysts determine when zero is a better estimate than another value. For instance, one can test for a value different from zero both in a statistical sense—via standard statistical testing—and in a decision-analytical sense. One could investigate questions such as, how far away from the true value does an estimate have to be before a value of zero is a better estimate? A preliminary result is that, given a mean squared error loss function, a value of zero is a worse estimator than any number less than two times the (unknown) true value (Farrow 2005).

The valuation of people who may never use a resource, nonuse value, is also a difficult impact to monetize. The authoritative panel that provided guidance on the use of survey-based (contingent)

valuation methods also suggested a search for a faint behavioral trail of revealed behavior (Arrow et al. 1993). In my view, little work has been conducted relevant to this suggestion compared with the work to extend the methods of contingent valuation. For instance, researchers might pursue the thin trail that links observed news gathering behavior to follow-on activity, such as charitable donations or changes in consumer purchases.

Finally, and probably for ease of implementation, regulatory reviews focus on a basic approach requiring "benefits to justify costs." However, the basic decision rules can change substantially in the presence of uncertainty, irreversibility, and an ability to obtain more information (Dixit and Pindyck 1994). In cases where a property right is under dispute and the goal is to maintain a particular level of environmental services, it may be appropriate to spend significantly more than expected benefits (Farrow and Morel 2001). Analytically, such approaches suggest additional, difficult to measure, elements of the problem that are related to uncertainty. These elements are seldom considered, although they are mentioned in OMB guidance (2003).

Economists teach that wants are insatiable. What an economist wants to improve the regulatory process is probably insatiable as well, without consideration of the constraints on agency resources and the value of the economic information in the debate. Finding the analytical and communication level that is as simple as possible but no simpler—as was famously said by Einstein regarding natural science models—remains an art, not a science. Detail that is unlikely to change a decision should not be analyzed, but one should continue to ask, what policy alternative will improve the welfare of society? Economists have evolved their approach for

more than 150 years, and regulations like the CWIS rule continue this evolution. Important questions can be easy to ask and hard to answer.

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Appendix A

Research recommendations by Heal et al. (2005, 258), referred to as "overarching research needs," are as follows:

> Although much is known about the services provided by aquatic ecosystems and methods for valuing changes in these services exist, the committee believes that there are still major gaps in knowledge that limit our ability to incorporate adequately the value of ecosystem services into policy evaluations. Drawing from the preceding major conclusions and overarching recommendations provided above, the committee has identified the following research needs. The committee believes that funding to address these needs is necessary if progress toward improving the use of ecosystem valuation in policy decisions is to be made, and it recommends that such funding be a high priority.
>
> - Improved documentation of the potential of various aquatic ecosystems to provide goods and services and the effect of changes in ecosystem structure and functions on this provision
>
> - Increased understanding of the effect of changes in human actions on ecosystem structure and functions
>
> - Increased interdisciplinary training and collaborative interaction among economists and ecologists
>
> - Development of a more explicit and detailed mapping between ecosystem services as typically conceived by ecologists and the services that people value (and hence to which economic valuation approaches or methods can be applied)
>
> - Development of case studies that show how these links can be established and templates that can be used more generally
>
> - Expansion of the range of ecosystem services that are valued using economic valuation techniques
>
> - Improvements in study designs and validity tests for stated-preference methods, particularly when used to estimate nonuse values
>
> - Development of "cutting-edge" valuation methods, such as dynamic production function approaches and general equilibrium modeling of integrated ecological-economic systems

- Improved understanding of the spatial and temporal thresholds for various ecosystems, and development of methods to assess and incorporate into valuation the uncertainties arising from the complex dynamic and nonlinear behavior of many ecosystems

- Improvements in the methods for assessing and incorporating uncertainty and irreversibility into valuation studies.

Table 1. Scorecard Evaluation of CWIS Cost–Benefit Analysis*

Item number	Variables	CWIS
Estimation of costs		
1	Stated costs exist	Yes
2	Quantified at least some costs	Yes
3	Monetized at least some costs	Yes
4	Monetized all or nearly all costs	Yes
5	Provided point estimate of total costs	Yes
6	Provided range for total costs	Yes
7	Associated costs w/ federal government	Yes
8	Associated costs w/ nonfederal government	Yes
9	Associated costs with producers	Yes
10	Provided best estimate and range for total costs	Yes
Estimation of benefits		
11	Stated benefits exist	Yes
12	Quantified at least some benefits	Yes
13	Monetized at least some benefits	Yes
14	Monetized all or nearly all benefits	No
15	Provided point estimate of total benefits	Yes
16	Provided range for total benefits	No
17	Provided best estimate or range for total benefits	Yes
18	Provided best estimate and range for total benefits	No
Comparison of costs and benefits		
19	Calculated net benefits	Yes
20	Provided a point estimate of net benefits	Yes
21	Provided a range for net benefits	No
22	Calculated cost-effectiveness	Somewhat
23	Provided a point estimate of cost-effectiveness	Yes
24	Provided a range for cost-effectiveness	No
25	Had positive net benefits	No
26	Calculated net benefits or cost-effectiveness	Yes
27	Calculated net benefits and cost-effectiveness	Somewhat
28	Calculated both point estimate and range for net benefits	No
29	Calculated either point estimate or range for net benefits	Yes
Evaluation of alternatives		
30	Gave at least one alt. standard/level	Yes
31	Gave at least one alt. method	Yes
32	Quantified alternatives (costs)	Yes
33	Monetized alternatives (costs)	Yes

Item number	Variables	CWIS
34	Quantified alternatives (benefits)	Somewhat
35	Monetized alternatives (benefits)	No
36	Calculated cost-effectiveness of alternatives	Somewhat
37	Calculated net benefits of alternatives	No
38	Calculated net benefits or cost-effectiveness of alternatives	Somewhat
39	Considered some alternatives	Yes
40	Clarity of presentation	Average/Poor
Consistent use of analytical assumptions		
41	Identified dollar year	Yes
42	Used consistent dollar year	Yes
43	Identified discount rate	Yes
44	Used consistent discount rate	Yes
45	Discount rate = 7 percent	Yes
46	Used consistent costs and benefits	Yes
47	Identified and consistently used discount rate and dollar year	Yes

Notes: Evidence may be in supporting documents and not in summary documents.
**Source:* Scorecard format based on Hahn and Dudley (2007), some item numbers have been omitted because of their original focus on health and safety. CWIS evaluations are by the author.