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Little fish are most valuable when left in the sea, researchers say

By Juliet Eilperin, Published: April 1

The smallest fish in the sea are more than twice as valuable when they're eaten by bigger fish than when they're caught by humans, according to a report released Sunday by a scientific task force.

The 120-page analysis by the Lenfest Forage Fish Task Force — a group of 13 scientists specializing in everything from fish ecology to marine mammals and seabirds — underscores the growing concern researchers have about the fate of forage fish, including anchovies, mehaden, herring and sardines that serve as food for bigger fish, sea birds and marine mammals.

Forage fish account for 37 percent of the world's commercial fish catch, with an annual value of $5.6 billion. (Only 10 percent of forage fish caught are eaten by humans; the remaining 90 percent are processed into fish meal and fish oil, which feed livestock and farmed fish.)

But the team of scientists, who worked for three years on their analysis, concluded that forage fish support $11.3 billion worth of commercial fish by serving as their prey. In the North Sea, for example, sand eels help sustain cod, and tuna in the eastern tropical Pacific Ocean feed on sardines.

The group's economic analysis did not include the value forage fish provide to sea birds and marine mammals, many of which are highly dependent on them. University of Washington conservation biologist Dee Boersma, one of the task force's members, has conducted studies showing that the breeding success of Magellanic penguins is directly related to how far they had to forage for food. If they could find fish between 30 and 50 miles of their colony they produced two chicks; if they had to travel more than 90 miles away, they had one; and if they had to go 125 miles, they had none.

In an interview, Boersma said that with fewer forage fish, seabirds were having to travel farther for less food. "Suddenly, instead of 90 percent, you're settling for 10 percent. That's what's happening to seabirds. When fish is not there, they don't do as well."

Ellen Pikitch, chairman of the task force and executive director of Stony Brook University's Institute for Ocean Conservation Science, said society may need to reassess its reliance on small marine

April 2, 2012

Too Many Small Fish Are Caught, Report Says

By HENRY FOUNTAIN

An international group of marine scientists is calling for cuts in commercial fishing for sardines, herring and other so-called forage fish whose use as food for fish farms is soaring. The catch should be cut in half for some fisheries, the scientists say, to protect populations of both the fish and the natural predators that depend on them.

“The message is, if you cut back on harvesting of forage fish, there will be benefits,” said Ellen K. Pikitch, director of the Institute for Ocean Conservation Science at Stony Brook University and chairwoman of the task force that produced a report on the issue that was released Sunday.

The report, “Little Fish, Big Impact,” financed by the Lenfest Foundation through the Pew Charitable Trusts, details how fishing has increased for these fish, which now account for 37 percent, by weight, of all fish harvested worldwide, up from about 8 percent half a century ago. The consumer market for forage fish is relatively small; most of the fish are ground and processed for use as animal feed and nutritional supplements and, increasingly, as feed for the aquaculture industry, which now produces about half of all the fish and shellfish that people eat.

Forage fish are an important link in the food chain, eating plankton and being consumed, in turn, by large fish like tuna and cod, as well as by seabirds and dolphins and other marine mammals. The task force estimated that as a source of food in the wild for larger commercially valuable fish, forage fish were worth more than $11 billion, or twice as much as their worth when processed for aquaculture and other uses.

“Sometimes the value of leaving fish in the water can be greater than taking it out,” Ms. Pikitch said.

The report cites several cases in which overfishing of forage fish has led to the collapse of populations of larger fish or other predators, and suggests that such cases could increase unless catches are reduced.

ENVIRONMENTAL PROTECTION AGENCY
Attention: Docket ID EPA-HQ-OW-2008-0667

Regulation of Cooling Water Intake Structures at Existing Facilities

Comments by Frank Ackerman, Ph.D., and Elizabeth A. Stanton, Ph.D.[1]

1. Introduction

EPA is proposing requirements under section 316(b) of the Clean Water Act for cooling water intake structures (CWISs) at existing power generation and manufacturing facilities that withdraw more than 2 million gallons per day (MGD) of water. As part of that process, EPA has performed a cost-benefit analysis of four regulatory options. The benefits are developed and presented in EPA's *Environmental and Economic Benefits Analysis for Proposed Section 316(b) Existing Facilities Rule* (EEBA); the costs are developed and presented in EPA's *Economic and Benefits Analysis for Proposed Section 316(b) Existing Facilities Rule* (EA). A number of supporting calculations appear in the *Technical Development Document for the Proposed Section 316(b) Existing Facilities Rule* (TDD).

In these comments we review EPA's analysis of the benefits of regulatory options, and the agency's use of the cost-benefit framework in the regulatory process. In a number of instances we offer more complete estimates of benefits, generally implying that the monetizable benefits of regulation are much greater than EPA's estimates would suggest. In addition, we discuss EPA's calculation of electricity rate impacts and changes in employment resulting from regulation; these calculations, which receive little emphasis in EPA's analysis, imply that electric rate impacts are minimal, while employment is highest under the most stringent regulatory proposal.

We also discuss the importance of the benefits that cannot be monetized, and the meaning of the incompleteness of benefit estimates. Some limitations of the benefit calculations are mentioned by EPA; other limitations are indirectly illustrated by EPA's apparent inability to complete its own agenda of benefit valuation. When important benefits are impossible to monetize in principle, or impossibly expensive to monetize in practice, then the cost-benefit approach is not a useful one; it weighs a relatively complete estimate of costs against an incomplete estimate that represents an unknown fraction of the benefits.

In light of the obstacles to completion of the cost-benefit calculation, other approaches to decision-making are more appropriate. A break-even analysis, showing how large the unmeasured benefits would have to be to outweigh the costs, suggests that the cost of regulation is quite modest. Estimated impacts on electricity bills, calculated but not emphasized by EPA, also show that the cost will be small. EPA offers two methods of calculation of electricity rate impacts; neither is large, and the more complete, sophisticated model estimates rate impacts that are within the noise level (i.e., indistinguishable from zero in practice) for future forecasts.

[1] Senior economists, Stockholm Environment Institute-U.S. Center, 11 Curtis Ave., Somerville, MA 02144; e-mail Frank.Ackerman@sei-us.org, Liz.Stanton@sei-us.org . Our resumes are attached at the end of these comments.

If EPA's recommendation of site-specific decisions is based on concern regarding impacts on smaller facilities, then a better approach would be to adopt a national standard with a higher threshold. Requiring cooling towers for facilities above 500 MGD, for example, would exempt roughly 80 percent of all in-scope facilities, including exemption of all but seven manufacturing facilities – but would still result in 80 percent of the benefits of EPA's Option 3, which requires cooling towers for all facilities.

Because the extraordinary difficulty of benefits calculation is the Achilles heel of the cost-benefit process, recommending site-specific calculations throughout the country will only make things worse. If EPA does not have the resources to complete the benefits calculation at a national level, why should state agencies be more able to do so? If EPA is determined to pass the problem on to the states (an option which we do not support), it should develop standardized procedures, and a set of default values for costs of control technologies, and for all major benefits categories, suitable for use in local analyses. Without such detailed procedural and quantitative guidance, site-specific decisions would lead to hundreds of often mediocre, under-resourced and under-researched repetitions of the analysis EPA has just engaged in at a national level.

2. What's missing from EPA's benefit estimates?

2.1. Overview of EPA's analysis

A brief description of EPA's cost-benefit analysis is needed, in order to frame the discussion of problems in the benefit estimates.

EPA compares costs and benefits for four options for controlling mortality from impingement and entrainment. Impingement controls are almost identical in each case: Options 1-3 require impingement controls everywhere, while Option 4 requires them for facilities with design intake flow (DIF) of more than 50 million gallons per day (MGD) – a threshold that excludes 73 percent of manufacturing facilities, but only 17 percent of electric generators (*TDD*, Exhibit 4-3).

Differences among options are much greater in entrainment controls. While all options require entrainment mortality control for new units at existing facilities, they differ in the more important category of requirements for existing units, as follows:

- *Option 1*: Impingement mortality controls everywhere; entrainment mortality controls on a site-specific basis.
- *Option 2*: Impingement mortality controls everywhere; entrainment mortality controls for existing facilities with DIF greater than 125 MGD
- *Option 3*: Impingement mortality controls everywhere; entrainment mortality controls everywhere
- *Option 4*: Impingement mortality controls for existing facilities with DIF greater than 50 MGD, and best professional judgment for facilities below 50 MGD; entrainment mortality controls on a site-specific basis.

Calculation of impingement and entrainment losses are based on surveys at 97 facilities, including some in each region; values are extrapolated to other facilities within the same region, based on flow rates. All cost and benefit data are calculated on a regional basis, with separate calculations for the Great Lakes, Inland waterways (other than Great Lakes), California, and four East and Gulf Coast regions (North Atlantic, Mid-Atlantic, South Atlantic, and Gulf of Mexico). Most of the facilities covered by the regulation, and most of the total intake flow, are in the Inland region, with many facilities located on major rivers such as the Mississippi, Ohio, Missouri, Delaware, and Illinois Rivers.

Data for power plants in California are excluded, since EPA believes that they are adequately covered by similar state regulation; for this analysis the "California" region consists of four manufacturing facilities in California, and four facilities in Hawaii. The California region is the smallest in many data categories in the analysis, often by a wide margin. There are no in-scope facilities in Oregon, only one in Washington, and no data from Alaska. Thus the analysis virtually excludes the Pacific coast.

Table 1 reproduces the EPA final results, summed across all regions (EBA, Tables 12-2, 13-4):

Table 1: EPA estimates of benefits, costs, and net benefits

Total Benefits and Social Costs by Option (Millions; $2009)						
	Total Monetized Benefits		Total Social Costs		Net Benefits	
Discount rate:	3%	7%	3%	7%	3%	7%
Option 1	$18	$16	$384	$459	-$366	-$443
Option 2	$120	$92	$4,463	$4,699	-$4,343	-$4,608
Option 3	$125	$95	$4,632	$4,862	-$4,507	-$4,767
Option 4	$17	$16	$327	$383	-$309	-$367

Costs are much higher for Options 2 and 3, since their entrainment controls are interpreted as requiring cooling towers at large (Option 2) or all (Option 3) facilities. The small cost difference between Options 2 and 3 shows that the calculations are dominated by costs at large facilities. Likewise, the costs of impingement controls everywhere (Option 1) or only at large facilities (Option 4) are similar, implying that most costs are incurred at large facilities.

Monetized benefits are much lower than costs – indeed, more than an order of magnitude lower in every case. This result, based as it is on extensive, detailed analysis by EPA, could create the erroneous impression that all four options should be rejected. As we will explain, the results shown in Table 1 are misleading in multiple respects. The benefits calculation, the focus of our comments, is incomplete both because it entirely excludes numerous important categories of benefits, and because, even in the included categories, there are analytical errors and arbitrary judgments that lead to unreasonably low benefits estimates.

Questions could be raised about EPA's cost estimates. Research on regulatory cost estimates has shown that costs are typically overestimated in advance, and drop after implementation of regulations (Ackerman 2006; McGarity and Ruttenberg 2002; Harrington, Morgenstern, and Nelson 2000). There are several reasons for this pattern: advance estimates usually ignore the possibility of learning and innovation in regulatory compliance, which often lowers costs in practice; regulators often rely on the regulated industries for empirical data, even though those industries may have a strategic interest in overstating costs; and conservative estimates about high costs may seem prudent in the face of potential court challenges to regulations.

We have focused, however, on the benefits side of the cost-benefit comparison, and have not analyzed EPA's cost estimates. In most of these comments, therefore, we compare EPA's cost estimates to various modified estimates of benefits. A final comparison combines our re-estimate of benefits with a re-estimate of costs developed in a comment letter by Bill Powers – showing positive net benefits for every option at both discount rates.

Our benefits calculations address the same categories of benefits evaluated by EPA, and rely on the estimates of baseline mortality developed by EPA – even though, as we will show, there are reasons to question those mortality estimates. We retain the entire complex apparatus of EPA's benefit calculations, including fractional reductions in baseline mortality under different regulatory options, and the annualized present value calculations at discount rates of 3 percent and 7 percent; we change only selected inputs into those calculations, discussed below. Our "bottom line" calculation shows that better estimates for the benefit categories evaluated by EPA exceed, by far, the costs of Options 1 and 4, and are equal to most of the costs of Options 2 and 3. With a modest estimate for the group of excluded benefit categories as a whole, all four options have benefits greater than EPA's estimate of their costs.

2.2 Excluded benefit categories

EPA presents a hierarchy of categories of benefits that result from reducing impingement and entrainment losses:

- Marketed goods
    - Direct use
    - Indirect use
- Non-market goods
    - Direct use
    - Indirect use
- Non-use values

The benefits calculations, however, include only parts of the two direct use categories and an estimate of non-use values for two regions of the country, as explained in detail in *EEBA*, Table 4.1 (p. 4-3), and summarized more briefly here in Table 2.

Table 2:Benefit categories in EPA analysis

Category		Example of monetary indicator	Estimated by EPA?
Marketed Goods (e.g. salmon)			
	Direct use benefits	Commercial fish sales	Yes
	Indirect use benefits	Sales of commercial fishing equipment	No
Non-Market Goods (e.g. sportfish and preyfish)			
	Direct use benefits	Spending by recreational anglers on travel, licenses, and gear	Significant underestimate
	Indirect use benefits	Spending by hunters and birdwatchers drawn by birds that eat small fish; spending of scuba divers.	No
	Non-use values	Value of existence of fish and aquatic ecosystems, independent of human use; value of saving endangered species	Very incomplete

Direct-use marketed-goods benefits consist of increases in commercial fishery landings, which are valued by EPA. This is the one category where EPA's analysis is most adequate; the resulting benefit estimates are quite small. Indirect-use marketed-goods benefits, none of which are estimated by EPA, include increases in: equipment sales, rental, and repair; bait and tackle sales; consumer choices in stores and restaurants; property values near the water; and ecotourism.

Direct-use benefits from non-market goods include the increased value of recreational fishing trips due to increased catch rates, which is valued (although, we will argue, significantly undervalued) by EPA. Other direct-use benefits from non-market goods include increases in rates of participation in recreational fishing, and the improved value of subsistence fishing, neither of which is estimated by EPA. Indirect-use benefits from non-market goods, which are not valued in EPA's calculations, include the increased value of, and increased participation in, boating, scuba diving, and near-water recreation based on enjoying observation of fish (or of birds catching fish).

The important category of non-use values includes the increase in existence value (or stewardship), altruism, bequest motives, and appreciation of ecological services apart from human uses. A large majority of organisms affected by CWISs have no recreational or commercial uses; non-use value is the only value they have. EPA offers a benefits transfer estimate of non-use values for only two of the seven regions of the country, along with a conceptually mistaken (and quantitatively trivial) estimate of the unique value attached to threatened and endangered species.

As EPA itself concludes,

> While EPA can identify and hypothesize regarding the direction and relative importance of impacts of CWISs on the totality of the aquatic ecosystem …, EPA is currently unable to connect these effects with quantifiable environmental benefits. Thus, it is highly likely

> that the total environmental and monetary impacts of CWISs are significantly underestimated… (*EEBA*, p. 2-22).

In the original version of the proposed rule, prior to editing by the Office of Management and Budget (OMB), EPA's discussion of limitations of the benefits calculations was even more explicit:

> ... the calculation of reduced impingement and entrainment benefits of closed cycle cooling does not account for 97 percent of the direct use A1E [age-1 equivalents] of organisms entrained by cooling water intakes. Moreover, the monetized benefit values do not include the majority of the indirect use and nonuse value of the reductions in I&E [impingement and entrainment] mortality, and completely exclude categories such as the non commercial portion of impacts to threatened and endangered species, the thermal discharge impacts to water quality, and species composition. (Original CWIS rule, p.166)

2.3. Commercial and recreational benefits

Commercial and recreational benefits are based on a common calculation of fishery yields. Impingement and entrainment losses are converted to age-1 equivalents for commercially and recreationally valuable species, and for forage fish consumed by the directly valuable species. These age-1 equivalent losses are converted to forgone fishery yields, including the assumption that 10 percent of the lost biomass of forage species would have been converted into the directly valuable species (*EEBA*, pp.3-2, 3-3). The commercial and recreational fractions of the forgone yields are then analyzed separately.

The assumption of 10 percent "trophic transfer" of biomass from prey to predator species is an average of the findings from numerous studies, calculated in Pauly and Christensen (1995). There is wide variation in trophic transfer rates in different aquatic habitats, ranging from below 2 percent to above 24 percent in studies cited by Pauly and Christensen. The use of a global average may not be appropriate for the individual regions evaluated by EPA; the detailed local data developed for these regions by EPA should be accompanied by local calculations of trophic transfer rates.

For commercial species, EPA calculates losses in pounds of each species and multiplied by market prices to obtain gross revenue losses. They suggest that the appropriate way to value this would be to calculate losses of consumer and producer surplus (*EEBA*, Chapter 6). Due to the small expected change in prices, however, they conclude that changes in consumer surplus would be negligible. The estimated commercial impact, therefore, is solely an estimate of change in producer surplus, calculated in practice as a fraction of gross revenue for each species. That fraction is the estimated ratio of net benefits to gross revenues, or "normal" profits as a percent of sales; it varies by species, but is often 50 percent or more. No commercial impacts were calculated for the Inland region since there is negligible commercial fishing in that region. In practice, the estimated commercial impacts are quite small.

Figure 1. *Source: www.walleye.com*

For recreational species, EPA calculates impingement and entrainment losses in numbers of fish of each species, estimates the number of lost fish that would have been caught by recreational anglers, and then multiplies by an estimate of the marginal recreational value per fish, derived from a meta-analysis of recreational fishing studies developed for a previous phase of the 316(b) rulemaking process (*EEBA*, Chapter 7). Values per fish (i.e., the amount that recreational anglers are assumed willing to pay per fish they catch) range from about $1 for panfish to $13 for salmon.

Other studies have also estimated the impact of CWISs on recreational fishing benefits. A study of the damages caused by impingement and entrainment at the Bay Shore Power Plant (BSPP) in Ohio, a large (650 MGD) facility on Lake Erie, reviewed the research literature on recreational and commercial values per fish, and adopted a set of values for fish species found in that region (Gentner and Bur 2009). For the most important local species, walleye, this study estimated a recreational value of $20.05 (converted to 2009 dollars) per fish, almost five times EPA's estimate of $4.10 (in 2009 dollars) for walleyes in the Great Lakes (Gentner and Bur 2009, Table 8; EEBA Table 7-3). This is indirectly a test of the reasonableness of EPA's intricate methodology for determining what recreational anglers are willing to pay: is catching a walleye a $4 or a $20 experience? Figure 1, from a Lake Erie fishing website, does not look like evidence for EPA's lower estimate; if anything, it suggests consideration of values higher than $20.

The contradictions between EPA's recreational estimates and the BSPP study's estimates are troubling; the differences extend beyond the value per fish. EPA's estimates of baseline mortality of walleyes in the Great Lakes are low, in the hundreds of fish per year. The BSPP study, looking only at one Great Lakes plant, counted impingement of tens of thousands of walleyes per year in the data for that plant, along with entrainment of larvae amounting to hundreds of thousands of adult-equivalent fish.

According to EPA, walleyes are a very small part of the recreational impacts of CWISs in the Great Lakes. According to the BSPP study, they represent the largest recreational damages from impingement and entrainment at this plant in western Lake Erie. An Internet search for "walleye fishing Lake Erie" turns up a number of companies that seem to agree that this is an important industry (including one that is the source of Figure 1).

Nor is the problem limited to walleye: species for which the BSPP study found greater age-1-equivalent baseline mortality at that plant alone than EPA found in the Great Lakes as a whole include channel catfish, freshwater drum, rainbow smelt, and white bass, in addition to walleye.[2] Indeed, the total estimate of age-1-equivalent baseline mortality of all species at BSPP is slightly

[2] EPA includes large numbers of age-1-equivalent mortality not specified by species (identified only as forage species or harvested species), and does not report separate estimates for several of the most numerous species at BSPP. The examples in the text are species for which both studies reported estimates.

greater than EPA's estimate for all species in the Great Lakes (*EEBA*, Table C-11; Gentner and Bur 2009, Table 7).

In short, the BSPP study, based on detailed local data for one important plant, identifies patterns of baseline mortality inconsistent with EPA's estimates, and adopts different estimates of recreational value; the BSPP valuation appears more intuitively plausible, at least in the case of walleye, one much-prized Great Lakes species.

As an alternative approach to valuation of benefits, therefore, we have calculated the BSPP ratio of recreational and commercial benefits to age-1-equivalent baseline mortality, $0.536 (in 2009 dollars) per age-1-equivalent, and applied it to EPA's baseline mortality estimates nationwide. This results in recreational and commercial benefits about 15 times as large as EPA's estimates. Including these benefits, while making no other changes in EPA's cost and benefit estimates, yields the benefits shown in Table 3. Under this scenario, Options 2 and 3 have $500 to $700 million of benefits, and Option 4 is close to having benefits equal to costs.

Table 3: Extrapolating BSPP ratio of recreational and commercial benefits to baseline mortality

Total Benefits and Social Costs by Option (Millions; $2009)						
	Total Monetized Benefits		Total Social Costs		Net Benefits	
Discount rate:	3%	7%	3%	7%	3%	7%
Option 1	$270	$246	$384	$459	-$114	-$213
Option 2	$681	$505	$4,463	$4,699	-$3,782	-$4,194
Option 3	$702	$518	$4,632	$4,862	-$3,930	-$4,344
Option 4	$264	$241	$327	$383	-$62	-$143

Source: Authors' calculations.

2.4. Non-use values

Non-use benefits are an important, large, and imprecise category; they are meant to convey the numerous non-utilitarian meanings and values of nature. Studies repeatedly show that there is substantial willingness to pay for the existence of, or protection of, fish and other species, extending far beyond the limited use values. There is, however, no consensus about exactly how to monetize non-use values.

EPA notes that, "Overall, the public appears to hold substantial nonuse values for ecosystems and species impacted by CWISs...This evidence suggests that the nonuse benefits of 316(b) regulation, although unquantified, are substantial." (*EEBA*, p.8-3). EPA is reportedly developing a survey to estimate total willingness to pay for improvements to fishery resources affected by impingement and entrainment, but has not yet done so. In the absence of such a survey, EPA reviews some of the academic literature on the subject (*EEBA*, Chapter 8), but strangely concludes that only one study, from Rhode Island, is usable for this analysis, and that its values can only be applied to the North Atlantic and Mid-Atlantic regions (i.e., the Atlantic coast from

Maine to Virginia). Thus non-use values in regions located farther from Rhode Island are effectively set to exactly zero. This nonsensical outcome will persist until and unless EPA's broader study is completed, or the agency agrees to use values from the published literature for the other five regions, as it did for the two northeastern ones.

The Rhode Island study estimated household willingness to pay at $0.76 per percentage point increase in the population of migratory, non-harvested fish. On EPA's reading of the study, willingness to pay estimates for different species are not additive; rather, overall willingness to pay should be based on the most affected species (*EEBA*, p.8-12). For the North Atlantic and Mid-Atlantic regions, EPA finds that that species is winter flounder (although this conclusion is based on data on only a few species), with baseline mortality from CWISs of 6.6 percent. So EPA calculates the percent change in winter flounder numbers from each regulatory option, and multiplies this value by $0.76 per household for the 26.4 million households in those two regions. The result, for Option 3, is annual willingness to pay of $112.1 million for the two regions combined; EPA's discounting procedure reduces this to an annualized estimate of $75.5 million at a 3 percent discount rate, or $58.5 million at 7 percent (*EEBA,* Table 8-5, p.8-14). Estimates for Option 2 are slightly lower than for Option 3; estimates for Option 1 are less than $1 million.

These numbers are doubly conservative: they assume that there is no non-use value of fish in the Northeast to households outside the region; and they assume that there is no way to use these numbers to extrapolate non-use values for fish at risk from CWISs in other regions.

The geographic scope of non-use value has been studied by John Loomis – a leading expert in the field, whose work is cited by EPA (Loomis 2000). Loomis writes:

> While benefits per household do exhibit a statistically significant decrease with distance from the wildlife habitat, aggregate benefits are still substantial at 1,000 miles from the public good … on average, measuring only the benefits at the state level would result in just 13 percent of the national total public good benefits… (Loomis 2000, pp.319-320)

Even for valuation of endangered species in California, Loomis found that in-state non-use benefits accounted for less than 20 percent of the national total; for smaller states such as Washington, in-state benefits could be less than 5 percent of the total. In most cases, per-household benefits did not fall as low as 50 percent of the local (within 100 miles) value until 1,500 miles or farther away (Loomis 2000 Figure 1, p.318).

On this basis, it is appropriate to increase EPA's non-use values for impingement and entrainment losses in the North Atlantic and Mid-Atlantic regions, to reflect the reduced but non-zero value per household of this region's fish to the rest of the nation. There were 117.2 million households in the United States in 2009.[3] This implies that there were 90.8 million households outside the North Atlantic and Mid-Atlantic regions. We tested the assumption that this group's non-use value for North Atlantic and Mid-Atlantic fish is on average half as great, per household, as for the households in the region – a conservative estimate, based on Loomis' analysis. The result is that the total non-use values for the North Atlantic and Mid-Atlantic

[3] U.S. Census Bureau, Current Population Survey, 2009, Table H1.

regions should be 2.72 times as large as EPA's estimates[4] – for example, $205 million annualized willingness to pay under Option 3 at a 3 percent discount rate, or $159 million at 7 percent.

The second gap in EPA's estimates is the failure to include anything for non-use values of fish in other regions. Of course, it would be ideal to have locally specific studies of everything – but EPA has prescribed for itself a research agenda that it has not yet been able to complete. In the absence of locally specific numbers, zero does not seem like a sensible estimate of non-use values elsewhere. In reality, fish elsewhere are not less valuable simply because EPA has not yet studied them.

A better estimate, for use until regionally specific numbers become available, is that non-use benefits might be roughly proportional to age-1-equivalent (A1E) baseline mortality. The North Atlantic and Mid-Atlantic regions together account for 1,050 million, or 48 percent, of the national total of 2,189 million A1E baseline mortality (*EEBA*, Appendix C). Thus the extrapolated national total of non-use benefits is 2,189/1,050 = 2.085 times the two-region total. The results of applying this benefits transfer method to non-use benefits in all regions, leaving all other aspects of EPA's costs and benefits unchanged, are reported in Table 4.

Table 4: Benefits transfer estimate of non-use values

Total Benefits and Social Costs by Option (Millions; $2009)						
	Total Monetized Benefits		Total Social Costs		Net Benefits	
Discount rate:	3%	7%	3%	7%	3%	7%
Option 1	$20	$18	$384	$459	-$364	-$440
Option 2	$454	$351	$4,463	$4,699	-$4,009	-$4,348
Option 3	$473	$365	$4,632	$4,862	-$4,159	-$4,497
Option 4	$20	$18	$327	$383	-$307	-$365

Source: Authors' calculations.

EPA itself presents an alternative method, valuing the amount of habitat needed to offset impingement and entrainment mortality (*EEBA*, Chapter 9). This yields values greater than our corrections of EPA's Rhode Island-based estimates. EPA seems more comfortable with this methodology: it is consistent with the approach adopted in some other regulatory proceedings; and studies of willingness to pay are apparently more readily available for habitats than for fish, making this method easier to implement. EPA calculates that there would be large willingness to pay for the habitat-equivalent of fish lost to CWISs.

Non-use value calculated with the "habitat restoration area equivalent" methodology for Option 1 would be about $500 million per year; under Options 2 and 3, it would be a little over $2.0 billion per year at a 3 percent discount rate, or a little over $1.5 billion at a 7 percent discount rate (*EEBA*, Table 9-5, p.9-16). Use of this value would close the entire gap between estimated

[4] The 90.8 million households elsewhere, with average willingness to pay half as great as the in-region households, contribute the same amount as 45.4 million in-region households. The region actually includes 26.4 million households; thus the national total is equivalent to (45.4 + 26.4) million in-region households, which is 2.72 times as large as 26.4 million.

costs and benefits under Option 1, or about half the gap under Options 2 and 3. Yet it is not included in EPA's best estimate of costs and benefits. Applying EPA's habitat area restoration benefits to non-use benefits in all regions, making no other changes to EPA's cost and benefit estimates, yields the results shown in Table 5. This modification yields positive net benefits in Options 1 and 4 at both discount rates.

Table 5: Habitat area restoration method for non-use benefits in all regions

Total Benefits and Social Costs by Option (Millions; $2009)						
	Total Monetized Benefits		Total Social Costs		Net Benefits	
Discount rate:	3%	7%	3%	7%	3%	7%
Option 1	$531	$493	$384	$459	$147	$34
Option 2	$2,116	$1,579	$4,463	$4,699	-$2,347	-$3,120
Option 3	$2,145	$1,601	$4,632	$4,862	-$2,486	-$3,261
Option 4	$530	$492	$327	$383	$204	$109

Source: Authors' calculations.

2.4. Threatened and endangered species

A fourth category listed by EPA, the value of threatened and endangered species, receives a particularly incomplete treatment. Threatened and endangered species are often thought to have large non-use values; that is, people value their existence, and are willing to pay to prevent extinction. EPA notes that there are significant impacts on threatened and endangered species from CWISs (*EEBA*, Chapter 5), but then claims inability to come up with any reasonable estimates for the value of these impacts.

Instead, EPA includes only the impacts on recreational use of two of the 88 threatened and endangered species affected by CWIS in its benefits estimates. That is, the agency includes recreational benefits to anglers who catch two of the threatened and endangered species (*EEBA*, Chapter 5, pp.5-12, 5-13.) EPA reports on an earlier regulatory analysis that estimated a recreational value of $70 per California sturgeon, a value which is transferred to anglers for pallid sturgeon and paddlefish in the Inland region. This analysis makes no use of the threatened or endangered status of the fish in question, except insofar as that contributes to the high value per fish. Instead, it estimates the value of letting anglers break the laws protecting these species, and catch the fish that would otherwise have been killed by impingement and entrainment.

Analogously, one could estimate the value of endangered African wildlife on the basis of the amount that poachers get for illegal sales of rhinoceros horns. Valuation based on poaching, however, misses something essential about the values that people place on the existence of threatened and endangered species. Indeed, the laws protecting these species reflect the fact that society assigns a value to them that is far above (or more precisely speaking, categorically different from) their market price.

Oddly enough, despite this absurdity, EPA appears to be aware of the research literature on the non-use value of threatened and endangered species. The same chapter of the EEBA applies the meta-analysis model of threatened and endangered species valuation developed by Richardson and Loomis (2009) to a possible change in the Inland region's threatened and endangered species (*EEBA*, pp. 5-13), and discusses at length valuation of sea turtle mortality (*EEBA*, pp.5-14 – 5-17). Both of these calculations rely on hypothetical, unsupported estimates of the change in affected populations attributable to baseline impingement and entrainment: 0.25 percent or 0.5 percent reduction in the Inland region threatened and endangered species; and a 1 percent reduction in endangered sea turtle populations.

The results of these calculations, which are not included in EPA's overall estimates of values affected by CWISs, are crucially dependent on the assumed percentage of the affected population that is lost under baseline conditions. For Inland region threatened and endangered species, a 0.25 percent change in population size is said to be worth $1.02 per household; a 0.5 percent change is worth $1.85. But why does EPA select these percentages rather than others? No evidence or argument is presented on this question. Elsewhere, EPA considers 1 percent losses for sea turtles, and uses estimates as high as 6.6 percent baseline losses for winter flounder in the North Atlantic and Mid-Atlantic, as seen in the previous section. In the absence of any empirical information about Inland region losses, we suggest using numbers that fall between the sea turtle and winter flounder loss estimates, such as 2 percent or 4 percent losses of Inland region threatened and endangered species. The very fact that species are classified as threatened or endangered implies that their numbers are limited; annual mortality of a few percent due to cooling water intake does not seem impossible.

The same methodology used by EPA would value 2 percent losses at $6.18 per household, and 4 percent losses at $11.31.[5] EPA applies its estimate per household to 59.6 million households in the affected states. Following the methodology explained in the previous section, we apply our estimates, $6.18 or $11.31 per household, to those 59.6 million households, plus half of that amount, $3.09 or $5.66 per household, to the 57.6 million households in the rest of the country. The result is a nationwide non-use value for Inland region threatened and endangered species of $546 million at 2 percent losses, or $999 million at 4 percent losses.

Again following the model of the previous section, we then scale this up in proportion to A1E baseline mortality, for an approximation to national threatened and endangered values. Since the Inland region accounts for 879 million of the 2,189 million nationwide A1E baseline mortality, we multiply our Inland estimates by 2,189/879 = 2.49 to obtain national estimates. Table 6 presents the results of applying this benefits transfer method, using 2 percent losses, to the threatened and endangered species benefits in all regions; all other aspects of EPA's cost and benefits are unchanged. This calculation alone is enough to make net benefits positive for Options 1 and 4, and significantly reduces the negative net benefits for Options 2 and 3.

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[5] The Richardson and Loomis equation used to estimate these values, presented in *EEBA*, Appendix F, is a logarithmic relationship. This means that each doubling of the percentage losses increases household willingness to pay by the same factor, which turns out to be 1.83. Multiplying EPA's estimate at 0.5 percent losses by this factor, twice, yields $6.18 – the appropriate estimate for four times EPA's loss percentage, i.e. 2 percent losses. Multiplication of this value by 1.83 yields $11.31, the appropriate estimate for 4 percent losses.

Table 6. Benefits transfer estimate of threatened and endangered benefits, assuming 2% loss

Total Benefits and Social Costs by Option (Millions; $2009)						
	Total Monetized Benefits		Total Social Costs		Net Benefits	
Discount rate:	3%	7%	3%	7%	3%	7%
Option 1	$564	$514	$384	$459	$180	$55
Option 2	$909	$707	$4,463	$4,699	-$3,554	-$3,993
Option 3	$911	$697	$4,632	$4,862	-$3,721	-$4,165
Option 4	$563	$514	$327	$383	$237	$131

Source: Authors' calculations.

Table 7 presents the equivalent calculation, assuming 4 percent losses. Under this assumption, net benefits are larger for Options 1 and 4, and represent smaller negatives for Options 2 and 3.

Table 7. Benefits transfer estimate of threatened and endangered benefits, assuming 4% loss

Total Benefits and Social Costs by Option (Millions; $2009)						
	Total Monetized Benefits		Total Social Costs		Net Benefits	
Discount rate:	3%	7%	3%	7%	3%	7%
Option 1	$1,018	$928	$384	$459	$634	$469
Option 2	$1,564	$1,218	$4,463	$4,699	-$2,899	-$3,482
Option 3	$1,565	$1,198	$4,632	$4,862	-$3,067	-$3,664
Option 4	$1,017	$928	$327	$383	$691	$545

Source: Authors' calculations.

Next, we summarize our recalculations with a combined estimate, using the BSPP-based estimate of recreational and commercial benefits, the habitat area valuation for non-use values, and the benefits transfer estimate of threatened and endangered species benefits assuming 4 percent losses. The combined result of these recalculations is shown in Table 8. Options 1 and 4 have net benefits in excess of $1 billion per year. Options 2 and 3 still have negative net benefits, but the amounts are much reduced; at the 3 percent discount rate, benefits are equal to 92 percent of costs for Option 2, and 90 percent for Option 3.

Table 8. Combined effect of benefits recalculations

Total Benefits and Social Costs by Option (Millions; $2009)						
	Total Monetized Benefits		Total Social Costs		Net Benefits	
Discount rate:	3%	7%	3%	7%	3%	7%
Option 1	$1,783	$1,635	$384	$459	$1,399	$1,176
Option 2	$4,121	$3,118	$4,463	$4,699	-$342	-$1,581
Option 3	$4,163	$3,127	$4,632	$4,862	-$468	-$1,735
Option 4	$1,777	$1,629	$327	$383	$1,451	$1,246

Source: Authors' calculations.

Finally, we examine an alternative estimate of the costs of Options 2 and 3, based on the comment letter submitted in this case from Bill Powers of Powers Engineering. Powers identifies numerous technical problems in EPA's estimates of cooling tower costs, and concludes that the annualized national pre-tax compliance costs for power plants under Option 2 and Option 3 would be $3,029 million and $3,104 million annually (compared to $4,933 million and $5,079 million in EPA's estimates, as shown in *EBA*, Table 3-8). Assuming no change in EPA's estimates of costs to manufacturers, the Powers corrections imply that the total cost of Option 2 is 62.8 percent, and the total cost of Option 3 is 62.9 percent, of the corresponding EPA figures. (There is no change to the costs of Options 1 and 4.)

Table 9 compares the Powers cost estimates to our combined benefit estimates, from Table 8. The result is that net benefits are positive for every option, at both the 3 percent and 7 percent discount rates. In fact, net benefits are relatively similar, roughly $1,200 to $1,500 million, in six of the eight cases shown (Options 1 and 4 at both discount rates, and Options 2 and 3 at 3 percent); they are much smaller, but still positive, for Options 2 and 3 at 7 percent.

Table 9. Powers cost estimates and our combined benefits estimates

Total Benefits and Social Costs by Option (Millions; $2009)						
	Total Monetized Benefits		Total Social Costs		Net Benefits	
Discount rate:	3%	7%	3%	7%	3%	7%
Option 1	$1,783	$1,635	$384	$459	$1,399	$1,176
Option 2	$4,121	$3,118	$2,803	$2,951	$1,318	$167
Option 3	$4,163	$3,127	$2,913	$3,058	$1,250	$69
Option 4	$1,777	$1,629	$327	$383	$1,451	$1,246

Source: Authors' calculations.

In summary, reasonable recalculation of the estimated value of benefits, combined with an expert reassessment of the costs of cooling towers, imply that the monetized portion of benefits could exceed the costs for every option considered by EPA, either at a 3 percent or a 7 percent discount rate.

3. Interpreting the incompleteness of benefit valuations

Cost-benefit analysis is designed to weigh the relevant costs of a proposal against the corresponding benefits. This process cannot yield a meaningful result unless the calculations of costs and benefits are equally complete. In the private sector, a balance sheet that weighs all of a company's income against *some* of its expenditures does not provide a useful picture of the company's true financial condition. Likewise, in the public sector, a comparison of complete costs and incomplete benefits does not provide an accurate picture of net benefits to society.

Yet a comparison of complete costs and incomplete benefits is exactly what EPA has produced in this case. The costs of compliance with regulation of CWISs are the monetary costs of constructing and operating cooling towers and other control technologies. Such costs are backed up by detailed engineering analyses, and often by recent experience in building similar facilities, or buying and installing similar equipment. These costs are well understood, and are well defined in monetary terms. While there may be disputes about whether the costs have been correctly estimated (such as the questions raised by Bill Powers), these are straightforward questions of fact, resolvable in principle by empirical evidence. There are no large cost categories that are omitted for lack of clarity about how to measure or monetize them.

Contrast this with the calculation of the benefits of regulating CWISs. These benefits consist, in large part, of reduced numbers of deaths of fish and other marine organisms, caused by reduction in impingement and entrainment. How should such benefits be measured and monetized? Measurement is itself a complex undertaking, with far fewer standardized answers than on the cost side. Monetization can be even more challenging, or, in principle, even impossible. Categories that cannot be both measured and monetized are typically excluded, effectively valuing them at zero – as is the case for non-use benefits for five of the seven regions in this rule.

In short, the difficulties of both measurement and monetization ensure that the benefit estimates are incomplete, and that only a fraction of these benefits are awkwardly or indirectly expressed in monetary terms. Thus there is a built-in bias in the completeness of coverage: regulatory costs are more thoroughly measured and more meaningfully expressed in monetary terms; regulatory benefits are much less completely measured, and much less adequately monetized.

So imagine finding (as in some scenarios in this case) that EPA's estimate of the costs of regulation exceeds the estimated, monetized benefits. This is comparable to a business discovering that an exact tally of monthly expenses exceeds its best guess at some unspecified fraction of the month's revenues. This does not prove that the bottom line for the month is a loss; on many reasonable assumptions about the missing data, the business actually ends the month in the black.

The problem is more difficult because the missing data in the CWIS cost-benefit analysis may not be susceptible to quantification or monetization. This case is centrally dependent on the non-use value of aquatic ecosystems in general, including (but not limited to) the heightened non-use value of threatened and endangered species. Ethical statements about nature, environmental integrity, and obligations to protect ecosystems and biodiversity, which are at stake for many people, are only awkwardly translated into the language of monetized non-use values. The beliefs of many stakeholders may be distorted beyond recognition in this process (or ignored for lack of research meeting rigid specifications) – which is why cost-benefit analysis is poorly suited for this case.

4. Other methods of decision-making

4.1 Breakeven analysis

EPA's breakeven analysis in *EEBA*, Section 10.5 finds that non-use values would have to be $3 to $4 per household under Option 1, and about $40 per household under Options 2 and 3, for benefits to breakeven with costs. This calculation assumes that only households in states with in-scope facilities care about the fish affected by these facilities (although those states encompass almost all of the population), and uses 2000 Census data on the number of households. Using the Census Bureau estimate of the number of households in the country in 2009, the non-use value for breakeven would drop by 12 percent, to about $35 per household under Options 2 and 3.

A similar breakeven analysis can be applied to our calculations, as presented above. Using the combined benefits estimates in Table 8, EPA's cost estimates, and the number of households in 2009, Option 3 would break even if the value of all excluded benefit categories was $4 per household per year at a 3 percent discount rate, or $15 at 7 percent. The corresponding figures for Option 2 are $3 and $13.50. (Using the Powers cost estimates, as shown in Table 9, this analysis becomes moot, since the breakeven value for excluded benefits is negative.)

These relatively comprehensible numbers – a $35 to $40 per household gap between total costs and monetized use-value benefits in EPA's original analysis, or a $3 to $15 per household value for omitted benefits in our Table 8 analysis – could be used in a more straightforward approach to valuation: describing the benefits of not killing large numbers of fish, shellfish, etc., and asking whether people are willing to pay the indicated amount in higher electricity bills. This provides what might be called a "holistic" comparison of costs and benefits (see Ackerman and Heinzerling (2004), Chapter 9). It is more meaningful and accessible than a complex academic analysis of what we infer people must be willing to pay; instead, it involves asking them directly, with the question tailored to this decision in particular.

EPA also analyzes two other important economic indicators: the expected impacts on electricity costs, and on employment. In brief, their analyses show that changes in electricity rates will be minimal, while economic benefits are greatest with Option 3.

4.2. Simple electricity model finds small effects

EPA does its electricity impacts analysis twice, at different levels of complexity. First, a relatively simple model (in *EBA*, Chapter 5) assumes 100 percent pass-through of compliance costs into electricity prices.

As EPA has noted earlier (*EBA*, Chapter 2H), however, 100 percent pass-through of compliance costs is far from being a likely outcome of new CWIS regulation nationwide. In states that still have traditional cost-of-service rate regulation, utilities would be entitled to recover 100 percent of their increased costs, plus appropriate interest; but in states that have deregulated electricity prices, cost recovery is more doubtful. In deregulated states, the marginal cost of electricity supply, which determines prices, may be based on costs at facilities that already have cooling towers, or on facilities that are exempt – in which case there will be little or no effect of new CWIS requirements on rates. In an analysis of closed cycle cooling requirements for 25 steam generators in New York, a deregulated state, Robert McCullough finds that the affected plants are almost never on the margin, so the price of electricity is almost never based on their costs, and closed cycle cooling requirements will have almost no effect on state electricity rates (McCullough 2010).

There are 14 states, plus the District of Columbia, where electricity deregulation is in effect (see map, *EBA* Figure 2H-6, p. 2H-21). These deregulated jurisdictions include 43 percent of in-scope electric generators, 43 percent of in-scope capacity, and 41 percent of in-scope generation (*EBA*, p.2H-20). Traditional cost-of-service regulation, allowing full pass-through of costs, applies to less than 60 percent of electricity production that is affected by CWIS regulation.

The states with electricity deregulation roughly correspond to the North American Electricity Reliability Council (NERC) regions NPCC, RFC, and TRE (compare the map of deregulated states, *EBA* Figure 2H-6, p. 2H-21, with the map of NERC regions, *EBA* Figure 6-1, p. 6-3) – or in the older NERC regional map which EPA sometimes uses, NPCC, ECAR, MAAC, MAIN, and ERCOT.[6] Of the $6.22 billion in annualized compliance costs under Option 3, these deregulated regions account for $3.56 billion, or 57 percent of the total (*EBA*, Table 5-6, p. 5-16). Thus only 43 percent of compliance costs occur in the traditionally regulated NERC regions, where full pass-through of these costs to customers is assured.

The simple model, with 100 percent pass-through of costs, projects average annual increases in electricity bills as of 2015 amounting to $1.41 per household under Option 1, $17.09 under Option 2, and $17.60 under Option 3 (*EBA*, Table 5-5, p. 5-14). The largest increase in any NERC region, under any of the options, was $27.88 per household. Electricity price increases average less than $1.57 per MWh (0.157¢ per kWh) under Option 3. The national average percentage increase in electricity rates under Option 3 is 1.40 percent for the residential sector, and 1.68 percent for all sectors. (In all cases, impacts under Option 2 are slightly smaller than under Option 3; and impacts under Option 1 are imperceptibly small – e.g., 0.13 percent increase in electricity rates for all sectors.) Moreover, the deregulated NERC regions all have moderately greater than average price increases in this model; hence the average for the traditionally regulated regions, where prices will be passed on in full, is even lower.

Again, it should be noted that the Powers cost estimates are less than two-thirds of EPA's estimates for Options 2 and 3, implying that the resulting electricity rate impacts would be proportionally smaller.

4.3. Sophisticated electricity model finds smaller effects

Second, EPA repeats the analysis of electricity impacts, using the Integrated Planning Model (IPM), a more complex and sophisticated model (*EBA*, Chapter 6). The IPM results are lengthy and are not easy to summarize, but the projected impacts on electricity prices are consistently smaller than in the simple model.

IPM models electricity supply and demand in much greater detail, including individual facility-level detail on almost all of the in-scope facilities. It considers existing environmental regulations affecting facilities, and models the dispatch order of electricity supply options. EPA focuses on IPM projections for 2028, after in-scope facilities are all assumed to be in compliance with any new regulations. Compared to a baseline projection without new CWIS regulation, Option 3 causes small changes in 2028 electricity prices: five of the eight NERC regions have price increases, ranging up to only 0.5 percent; the other three regions have decreases, ranging down to a 1.7 percent drop (*EBA*, Table 6-2, pp. 6-12 – 6-15). Again, impacts are almost as large under

[6] *EBA* mentions several times that NERC regions have "recently" changed, but never explains the change. In 2006, the former ECAR, MAAC, and MAIN regions were combined into RFC (Mid Atlantic-Great Lakes), ERCOT was renamed TRE (Texas), and MAPP was renamed MRO (Upper Midwest). Other regions remained unchanged, including NPCC (New York-New England). *EBA* uses both the pre-2006 and current NERC regions at different points in the electricity analysis in Chapter 5.

Option 2, and minute under Option 1. EPA reports that in the IPM analysis for 2028, Option 3 "would not be expected to have a material ongoing effect on capacity availability and supply reliability" (*EBA*, p. 6-17), and that "the net change in generation is essentially zero. No NERC region records a consequential change in total generation" (*EBA*, p.6-18).

4.4. Output and employment impacts look best with Option 3

EPA also analyzes the output and employment impacts of Options 1, 2, and 3 (*EBA*, Chapter 10). To simplify a complicated story, there are two somewhat offsetting effects. On the one hand, EPA models the impacts of the substantial one-time costs of compliance, such as construction of cooling towers, and the recurring costs of compliance, primarily the energy penalty for the use of cooling towers. These costs increase expenditures, creating jobs and incomes. On the other hand, EPA assumes that electric utilities will raise prices to recover their increased costs; higher electricity prices reduce the supply and demand for other goods and services. In effect, higher electricity prices transfer spending from other sectors of the economy into electric utilities and their suppliers. Since electric utilities and the petroleum and coal industry create much less employment, per million dollars of spending, than manufacturing, construction, and other sectors (*EBA*, Table 10-1, p. 10-4), this tends to reduce overall employment.

The employment-reducing aspect of the analysis is overstated in two ways. First, EPA again assumes that all electric generators will be able to achieve complete cost recovery, as is the case under traditional cost-of-service utility regulation (see *EBA*, p. 10-17). Yet as noted above, 43 percent of in-scope capacity and 41 percent of in-scope generation are located in jurisdictions where electricity rates have been deregulated, and full cost recovery is not guaranteed.

Second, despite considerable attention to details of timing in the analysis of compliance costs, EPA arbitrarily assumes that cost recovery occurs at a constant annual rate from 2013 through 2056, noting that "To the extent that the rate increase from compliance costs would phase in before reaching the "steady state" constant value, this analysis will overstate the economic impact from the electricity rate increase." (*EBA*, p. 10-7.) This is not just a theoretical possibility: Since compliance costs will phase in over more than a decade following the effective date of the regulation, traditional utility rate regulation would impose a similar phase-in period for cost recovery. Thus EPA's failure to model the timing of cost recovery has exaggerated the employment impacts of electricity rate increases.

EPA introduces another needless complication into the analysis, considering the results obtained by accounting for only part of the price impacts of electricity, as well as the whole effect (described as "Case 1" and "Case 2", see *EBA*, p. 10-11). It is perhaps of academic interest that Case 1, defined as including only part of the anticipated price impacts, makes the regulatory options look worse than Case 2, defined as including the full price impacts. This does not translate into real-world significance, however: No argument for basing decisions on Case 1 is made in *EBA*; the more comprehensive Case 2 (often described as "with supply elasticity" in tables) appears to be EPA's best estimate.

In terms of output effects, EPA's findings are unambiguous: the stronger the regulation, the greater the boost to GDP. The average annual effect on output, from 2012 through 2056, is -$194 million from Option 1, +$768 million from Option 2, and +$4,258 million from Option 3 (*EBA*, Table 10-9, p. 10-15). In terms of employment effects, EPA reports the opposite, finding job losses becoming greater as regulation becomes stricter. As noted above, however, EPA overstates the employment-reducing effects in its analysis. If electric generators in deregulated jurisdictions are able to pass on roughly half of their cost increases, then EPA's net employment impacts would be reversed, as shown in Table 10. Under this assumption, Option 2 creates a net increase in employment, and Option 3 creates even more jobs.

Table 10: Average annual employment effects of regulatory options, 2012-2056

	full-time equivalent jobs, national totals	
	EPA version	50% pass-through in deregulated states
Option 1	-2,475	-1,161
Option 2	-12,251	+2,116
Option 3	-12,441	+2,374

Source: "EPA version" from EBA, *Table 10-10, p. 10-16. "50% pass-through" assumes that only half of the roughly 40% of national total costs incurred in deregulated states can be recovered from customers; it therefore assumes a 20% reduction in the job losses due to electricity price impacts on households and other product markets, in* EBA, *Table 10-10.*

Even without this correction for deregulated states, EPA presents a view of employment impacts that favors Option 3, based on calculations analogous to those used throughout the analysis of costs and benefits. EPA calculates the present value of the future stream of jobs at discount rates of 3 percent and 7 percent, and then annualizes this present value at the same discount rate (*EBA*, Table 10-11, p. 10-17). Because so many of the new jobs created by regulation occur relatively soon, in the wave of construction required for compliance, the regulatory options all look better at 7 percent than at 3 percent. At either discount rate, Option 3 is the best for employment: at 7 percent, it creates an annualized increase of 10,102 jobs, better than Options 1 and 2; at 3 percent, it creates an annualized loss of 319 jobs, a smaller loss than either of the other options.

In short, the annualized present value calculation confirms the finding of our (perhaps more transparent) 50 percent pass-through scenario in Table 10: Stricter regulation is better for employment, as well as output. The numbers of jobs are not large, relative to the U.S. economy as a whole; this is to be expected, given the generally small size of the regulatory costs involved in this case. (The Powers cost estimates would reduce the already small employment and output impacts by more than one-third.) Remember that EPA's estimates of total costs are small in macroeconomic terms: annualized costs of a few billion dollars are an insignificant percentage of a $14 *trillion* economy. The annualized total cost of Option 3 at a 7 percent discount rate, the highest cost estimate in the analysis, is $4.86 billion, or 0.033 percent (1/30 of one percent) of US GDP. As the employment estimates, electricity rate impacts, and breakeven calculations all demonstrate, there is no basis for arguing that CWIS regulation, as proposed in any of the options in this case, would be harmful to the economy.

5. Alternative thresholds

In our final comparison of the Powers cost estimates and our combined benefits estimates, in Table 9, the monetized benefits exceed the costs even for Option 3, the most stringent regulation under consideration. Thus we see no need to propose alternatives. If however, the interest in other options is driven by concern for specific categories, such as small facilities, it would be better to exempt those categories than to advocate site-specific calculations everywhere; the latter alternative would cause a huge increase in regulatory burdens, as discussed in the next section.

Facilities below 500 MGD, for example, represent roughly 80 percent of all facilities, but only 19 percent of the total water flow and 25 percent of the pre-tax compliance costs of Option 3 (our calculations from *TDD*, Exhibits 7-1, 7-2). Thus a proposal structured like Option 2, but with a 500 MGD threshold for the cooling tower requirement, would exempt most of the in-scope facilities – including all but seven of the manufacturers – while still regulating 81 percent of the water flow, and presumably achieving 81 percent of the benefits. In other words, such an approach would still achieve most of the total benefits, while reducing rather than increasing the regulatory analysis requirements.

6. Site-specific calculations

Cost-benefit analysis, even at the national level, is an ambiguous process that offers only weak and incomplete guidance to public policy decisions. On the theoretical level, it is stymied by the asymmetry between well-defined, monetized costs versus qualitatively important but partially unquantifiable or unmonetizable benefits, as discussed in section 3. In practice, the claimed objectivity and transparency of the cost-benefit process dissolves in the face of staggering technical complexity and dependence on arbitrary, potentially subjective judgment calls, as seen in section 2.

A switch to site-specific calculations would magnify all of these problems, and force them to be analyzed and debated again and again in underfunded local proceedings throughout the country. The tasks involved are formidable: full calculation of monetary benefits in this case is evidently more than EPA can handle at the national level. The agency's failure to produce any estimate whatsoever of non-use benefits for 5 of the 7 regions, and failure to produce any sensible, non-trivial estimate of the benefits of protecting threatened and endangered species nationwide, suggests that valuation of benefits is a challenging undertaking. For state and local agencies with far more limited time and budgets for analysis, it will simply prove impossible.

Thus we recommend strongly against site-specific calculations. If, however, it is decided to require site-specific calculation of costs and benefits for individual facilities, there will be a need for a reproducible, localizable version of this analysis, requiring standardized approaches to both costs and benefits. To that end, EPA should start by making four important changes to the site-specific cost-benefit analysis process envisioned in the Proposed Rule.

First, EPA should clarify how costs and benefits are to be compared. EPA's novel formulation in the Section 316(b) context that benefits should "justify" the costs of entrainment controls is unclear; some states may interpret it as a departure from the "wholly disproportionate" standard used under the Clean Water Act. It is likely that states will disagree sharply on the point at which the costs of closed-cycle cooling are justified, and how this comparison is to be made.

Some states may conclude that the benefits of more protective standards are not justified unless an applicant conducts a fine-grained analysis, similar to EPA's, and determines that the monetizable social benefits are larger than the monetized social costs. Given the extreme difficulty of conducting such an analysis, this approach would effectively determine in advance that more protective standards could never be justified. Other states may conclude that properly monetizing the non-use values of aquatic ecosystems is impossible (after all, the task is beyond EPA's capacity) and, therefore, the costs of entrainment controls are justified so long as they are not wholly disproportionate to the non-monetized benefits of the rule.

A clear interpretive standard set by federal regulation would prevent states from making cost-benefit comparisons under disparate standards. It would also prevent states from relying on cost-benefit considerations in a manner that is inconsistent with the limits that Congress placed on the use of cost-benefit comparisons. Therefore, EPA should establish that the new "benefits justify the costs" standard is consistent with its existing Clean Water Act guidance: the costs of a protective measure are justified so long as they are not wholly disproportionate to the benefits conferred by that measure.

Second, EPA should ensure that government employees or contractors are the sole arbiters of the technical adequacy of all cost-benefit analyses. The current study process is deeply flawed because consultants and peer reviewers hired by the applicant will generally become advocates for the applicant's position rather than impartial adjudicators. This risk is greatest where, as here, most applicants are repeat players: a parent company that owns or operates multiple facilities can provide pliant consultants and reviewers with a steady stream of work. Even if applicants pay for the cost of conducting studies and peer reviews, the integrity of the analytical process can only be assured if the State, not the applicant, selects the contractors and oversees the studies.

Third, because cost-benefit analyses are complex and require analysts to make considerable assumptions, applicants require additional guidance on how they should be performed. Therefore, EPA should restore a number of guidance statements that were deleted by OMB. For example, OMB deleted EPA's explanation of the difference between the social costs and the private costs to facilities of installation downtime and energy penalties, and how these costs should be calculated to avoid overestimating the social costs.[7] OMB also removed EPA's guidance on discount rates. EPA had called for facilities to use a "social discount rate . . . reflecting society's rate of time preference as opposed to a facility's cost of capital," and suggested 3 percent, as per existing OMB guidance.[8] EPA should restore both of these guidance statements to the rule text.

Finally, EPA should provide standardized default values and valuation methodologies for costs of control technologies, and for all major benefits categories, suitable for use in local analyses. In particular, EPA should require:

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[7] *See* redlined version of original CWIS rule, p. 338-339.
[8] *See* redlined version of original CWIS rule, p. 340.

- *Estimates of national, not regional, non-use values* – As noted above, economic studies have repeatedly shown that people place a high value on preserving and protecting ecosystems even if they do not live close to them. A complete benefits analysis must include the value that all Americans derive from protecting wildlife, not just the benefits to those people who live close to a particular waterbody.

- *A clear explanation of how the heightened value of protecting threatened and endangered species is included in the benefits analysis* – Americans place a particularly high value on protecting and preserving threatened and endangered species. This additional value must be reflected in the benefits analysis.

- *Quantified uncertainty estimates* – EPA generally promotes transparent and (where possible) quantified disclosure of scientific and economic uncertainties in its analysis. Uncertainty is particularly problematic in this rulemaking because it is asymmetric: the costs of entrainment controls are well quantified, but the benefits are incompletely quantified and systematically underestimated. Thus, EPA should require anyone conducting a cost-benefit analysis to disclose the uncertainty in their estimates of the number of fish and other organisms affected by this rule, and in the economic benefits of protecting these organisms. EPA stated repeatedly in the preamble to the proposed rule that it underestimated the economic benefit to society of saving the more than one trillion fish and other organisms currently killed each year in cooling water intakes. Yet even with these caveats, EPA's numbers take on a false air of precision since they are unaccompanied by quantified error estimates. EPA should require that all cost-benefit studies include a quantitative measure of the uncertainty in the different estimates so that regulators understand the error range associated with the estimates they have received.

- *A buffer or margin of safety for threatened and endangered species* – The difference between killing 1 percent and 2 percent of all the individuals in an endangered population can be the difference between survival and extinction for that species. Threatened and endangered species should not be required to bear the risk that an applicant has erred in its cost-benefit calculations. Because estimates of both the physical and economic benefits of entrainment controls are uncertain, where threatened or endangered species, or species of concern are involved, EPA should require that applicants do their utmost to quantify the uncertainties in their benefits estimate, and then base their benefits calculations on the upper end of the error range.

- *Non-use value estimates no lower than those found by EPA* – Contingent valuation of environmental goods is a difficult undertaking. Such studies must be done with care and transparency because an applicant can significantly alter the results of a site-specific cost-benefit analysis by manipulating estimates of non-use values. Presently, EPA is conducting a national willingness to pay study to develop accurate and transferable estimates of the non-use benefits of wildlife. If applicants or regulators can document a substantial basis to deviate upwards from EPA's estimates, this should be permitted. But as a safeguard against inaccurate estimation studies, EPA should not allow applicants to present non-use values for fish and aquatic ecosystems that are lower than those found in EPA's forthcoming study.

The difficulty of imagining success in this agenda is a reason why the issue should continue to be addressed and resolved at a national level, where much greater resources are available for analysis.

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Vertically Summing Public Good Demand Curves: An Empirical Comparison of Economic versus Political Jurisdictions

John B. Loomis

ABSTRACT. *Fiscal equivalence for efficient provision of a public good requires perfect correspondence between political and economic jurisdictions. However, the spatial extent of the economic jurisdiction is an empirical question. Drawing on four survey-based valuation studies, we measure the "relative public good benefit gradient" as a function of residential location from six natural resource public goods. The results indicate commonly used state political jurisdictions reflect an average of 13% of total benefits in the economic jurisdiction, although with a logarithmic form for distance the upper confidence interval of state benefits can include 100% for some species.* (JEL H41; D61)

I. INTRODUCTION

As formalized by Samuelson (1954) the benefits of public goods are non-rival in consumption and non-excludable. Allocative efficiency in a second best world of distortionary taxes, between a public good, (y) and a purely private good (x) requires:

$$\sum_{i=1}^{n} \text{MRS}_{xy}^{i} = \text{MRT}_{xy} * \text{MCF} \qquad [1]$$

where MCF is the marginal cost of public funds (Atkinson and Stiglitz 1980; Ballard and Fullerton 1992).

A natural question that should arise in economic analysis of public goods is the size of "n." That is, how broadly should we vertically sum individuals' marginal benefit schedules? Should it be just residents in the immediate area where the public good is located, the entire country that may (or may not) care about the services of the public good, or the entire world? Implicitly we make this judgment when we distinguish between "local public goods" and national public goods. This distinction is far more than semantics, however, as it ties directly to determining the appropriate level of government financing and provision. This is the heart of fiscal federalism (Oates 1972) and concerns for coordination of environmental policies in a federal system or transboundary public good or bad. If the public good provides benefits well beyond the immediate jurisdiction where the good is located, then either federal grants-in-aid or even federal provision may be needed to improve the allocation of resources involving the public good. Comparing only the local public benefits to marginal cost of supply will result in underprovision if substantial spillover benefits to other non-payers are ignored.

What guidance does economic theory provide in the search for answers regarding the geographic extent of the public good? Cornes and Sandler (1996) draw upon Olson's concept of *fiscal equivalence* to state that optimality will be more likely when the *political jurisdiction* and the *economic jurisdiction*, correspond. The political jurisdiction is the level of government making the provision decision. The economic jurisdiction "includes all individuals receiving the good's benefits" (Cornes and Sandler 1996, 33). Fiscal equivalence is similar to internalizing the *positive* externality provided by provision of a public good.

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This issue is of some recent policy relevance in the debates over reauthorization of the federal Endangered Species Act (ESA) and proposed federal excise taxes to fund state agency nongame wildlife programs. Critics of ESA contend protection of endangered species would be best handled at the local level. Environmentalists not only oppose this, but have been prime supporters of the Fish and Wildlife Conservation Act to provide federal grants-in-aid to *state* nongame wildlife programs. Which of these conflicting directions in the fiscal federalism debate is appropriate might profit from some empirical analysis.

Viewed in terms of "who's benefits count" the issue has been a recurring theme in discussions about benefit-cost analysis. Howe (1971) clarified the question with the concept of *accounting stance,* although other authors refer to it as an issue of who has *standing* in benefit-cost analysis (Whittington and MacRae 1986; Trumbull 1990, Zerbe 1991). The accounting stance defines the relevant political jurisdiction for including benefits and costs. As noted by Whittington and MacRae (1986, 666) which individuals should be included is a crucial but rarely addressed issue in the application of benefit-cost analysis. Of course the essence of economics, as compared to financial analysis, is that for efficiency in resource allocation to prevail, the accounting stance should be large enough to capture all Pareto-relevant spillovers (Trumbull 1990).

Oakland's *Handbook of Public Economics* chapter on Public Goods as well as Cornes and Sandler's recent book on public goods, do not go beyond this conceptual level of discussion. Musgrave (1997, 66) suggests that various public goods will have different "spatial ranges." Thus, it appears to be an empirical question. Unfortunately studies of the benefits of environmental public goods continue to predetermine the measurement of benefits by limiting the sample to only residents of the state where the public good is located (Walsh, Loomis, and Gillman 1984, Boyle and Bishop 1986; Loomis 1987; Sanders, Walsh and Loomis, 1990; Carson et al. 1994; Wegge, Hanemann, and Loomis 1996). As noted by V. Kerry Smith (1993, 21) "Definitions of the extent of the market are probably more important to the values attributed to environmental resources as assets than any changes that might arise from refining our estimates of per unit values." In one of the few (unpublished) papers to address this question, Smith, Schwabe, and Mansfield (1997) use a single case study to investigate the relationship between the extent of environmental spillovers and the size of the "regulatory market". These authors conclude that there can be cases where nature will dictate the appropriate level of government. The only published study to address this question found there were passive use values received by households living in states adjacent to Flathead Lake in Montana (Sutherland and Walsh 1985).

The purpose of this paper is to use a variety of public goods to empirically estimate the economic jurisdiction over which to vertically sum public good benefits. From the survey data we empirically estimate a "*relative* benefit gradient" relating the percent of local willingness to pay (WTP) at varying distances from the resource being protected. A relative benefit gradient is used since there is some controversy regarding the accuracy of contingent valuation for measuring public good values of households (see Portney 1994; Cummings, Harrison, and Rutstrom 1995; Hanemann 1994). We expect that whatever hypothetical bias might be present in the absolute dollar magnitude of WTP, as long as this bias is invariant to distance from the natural resource, our percent benefit gradient should be a credible relative measure. We believe this to be the case because contingent valuation has been shown to repeatedly yield reliable measures of WTP in several test-retest reliability studies (Loomis 1990; Reiling et al. 1990; Carson et al. 1997). To explicitly evaluate the degree of fiscal equivalence, we calculate the percentage of nationwide public good benefits that are reflected in typical political jurisdictions commonly used in benefit-cost or policy analyses.

II. HYPOTHESIS TESTS

The benefits of increasing the quantity of a public good beyond the current level can be measured by compensating surplus or willingness to pay (WTP). Testing whether public good benefits fall with distance and providing an empirical limit for the economic jurisdiction is facilitated by including distance from the respondent's home to the public good under study in the WTP function. For the purpose of illustration, assume for the time being a linear relationship between individual i's WTP and the following set of explanatory variables:

$$WTP_i = Bo + B_1Q + B_2T_i - B_3DISTANCE_i + B_4INCOME_i, \quad [2]$$

where Q is the quantity of public good being offered; T_i is a variable(s) reflecting an individual's tastes and preferences; $DISTANCE_i$ is miles the individual lives from the particular natural resource being protected.

To determine whether there is any spatial or geographic limit to the market, one might test the null hypothesis Ho: $B_3 = 0$ versus the alternative hypothesis Ha: $B_3 < 0$. If the null is accepted, then in principle the economic jurisdiction would be at least nationwide and could be worldwide, if similarity of preferences are likely as might be the case for clean air or prevention of stratospheric ozone depletion. However, the specific nature of the public good may allow us to determine whether Ho or Ha is likely to hold. Specifically, some public goods studied in this paper provide both on-site use values as well as off-site, non-use values such as existence value. Following the logic of the travel cost method for estimating recreation demand curves, the use benefits would fall with distance, causing total economic value (the sum of use and non-use) to fall rapidly. In contrast, protection of endangered plants would primarily have non-use value, and the total economic value might fall very slowly, if at all, with distance. In addition, one could test whether there is a discontinuous jump in the WTP function or change in slope for residents within the state where the resource is located versus non-residents. This could be done by adding a resident intercept shifter and/or resident-distance interaction term. As in any demand relationship, the availability of substitute public goods may also change with distance and influence the WTP distance-decay function.

If we reject the null hypothesis in favor of the alternative that $B_3 < 0$, then to calculate the distance where WTP = 0, one can rearrange equation [2] to [3] to solve for DISTANCE:

$$DISTANCE_0 = (Bo + (B_1 * Q_m) + (B_2 * T_m) + (B4Income_m))/B_3 \quad [3]$$

where subscript m indicates variable sample means.

In principle, the economic jurisdiction extends to the point where WTP = 0. One measure of the divergence of political and economic jurisdictions can be made by comparing the distance covered by the political jurisdiction relative to the distance where WTP = 0. The economic efficiency bias from using a political jurisdiction smaller than the distance to where WTP = 0 can made by comparing benefits within the political jurisdiction to the total public good benefits. In this paper we "test" the null hypothesis of state level government fiscal equivalence for wildlife protection. The test is carried out by comparing the computed percentage of benefits within the state political jurisdiction to the economic jurisdiction of the public good. If the upper confidence interval for the percentage of benefits in the political jurisdiction is less than 100%, we would reject the null hypothesis of state level fiscal equivalence.

III. SPECIFIC METHODS ADOPTED FOR VALUING PUBLIC GOODS

While equation [2] is the general form of a WTP equation, most contingent value method (CVM) surveys no longer directly elicit WTP. Rather, the WTP question is framed as a referendum in which the individual is asked whether they would vote in favor of the program at a cost of $X per household, where $X varies across households. There are numerous advantages of this dichotomous choice referendum format over directly asking WTP (see Hoehn and Randall 1987). The referendum question format has also been recommended by the "blue ribbon" panel on CVM (Arrow et al. 1993), although Cummings, Harrison, and Rutstrom et al. (1995) presents empirical evidence questioning this recommendation. Hanemann (1984) provided a utility-theoretic basis for the dichotomous choice question format in terms of a utility difference model. If the utility difference from paying \$X and receiving the public good versus not paying \$X and foregoing the public good is distributed logistically, then a standard binary logit model can be used (Hanemann 1984). The basic form of the logit model is:

$$\text{Prob}\ [Y = 1] = \frac{e^{\beta_0+\beta_1(\$X)+\beta_2 \text{DISTANCE}}}{1 + e^{\beta_0+\beta_1(\$X)+\beta_2 \text{DISTANCE}}} \quad [4]$$

where Y is a binary indicator variable, taking on a value of 1 if the respondent answers "Yes, [they] would pay."

Cameron (1988) showed that [4] could be converted to a WTP equation like [2], by reparameterizing the logit equation [4] by dividing the coefficients ($\beta 2$ and βn) through by the coefficient on bid ($\beta 1$). For computational convenience we adopt this reparameterization approach here. Using Cameron's approach, the logit coefficients are rescaled into units with a conventional regression interpretation (e.g., change in WTP for one additional mile).

IV. DATA

The data for testing the geographic extent of public good benefits comes from three nationwide CVM surveys and one survey of California, Oregon, and Washington residents. The first two surveys are mail surveys of U.S. households.

Washington State Salmon

The first is a survey regarding WTP to remove two dams from the Elwha River in the State of Washington and restoration of the river back to its natural pre-dam condition and associated increases in four species of salmon and steelhead. The survey booklet was the result of several focus groups and pre-tests with residents of the state of Washington and of Boston, Massachusetts. The dichotomous choice WTP question was worded "If an increase in your federal taxes for the next 10 years costs your household \$X each year to remove the two dams and restore both the river and fish populations would you vote in favor? YES NO" The questionnaire was sent to a random sample of 900 Washington households (the dams are located in Washington.) One thousand surveys were sent to U.S. households to provide enough spatial detail to test the extent of the U.S. market. After two mailings, 523 surveys were received from residents of the State of Washington, and 482 surveys from the rest of the U.S. The response rate for deliverable surveys was 68% in Washington and 55% for the rest of the U.S. More details on the survey can be found in Loomis (1996).

Mexican Spotted Owl and 62 Threatened and Endangered (T&E) Species

We designed and sent two versions of a mail survey to a random sample of U.S. households provided by Survey Sampling, Inc. Each survey contained detailed maps showing the location of the Critical Habitat Units in states of Arizona, Colorado, New Mexico, and Utah that form what is known as the Four Corners Region along with a description of the current recovery effort. This was followed by proposals to reduce the protection for the Threatened Mexican spotted owl (or 62 T&E species) to allow for increased economic activity and reduce federal management expenditures. The survey then proposed a Mexican Spotted Owl Recovery Trust Fund (or Four Corners Region T&E Species Trust Fund) to continue the current recovery program. Households were told if they agreed to pay, the program would continue, with the likelihood the Mexican spotted owl would recover in 15 years and could be delisted. They also were told if they did not pay then it was likely the Mexican spotted owl would become extinct in 15 years. Similarly for the 62 T&E species, they were told that payment would result in delisting of 25 species and lack of payment would result in half the species becoming extinct within

15 years. After two mailings the overall survey response rate was 54.4% of deliverable surveys. The exact wording of the Mexican Spotted Owl WTP question was: "If the Mexican Spotted Owl Recovery Trust Fund was the only issue on the next ballot and it would cost your household $X every year, would you vote in favor of it? YES NO"

California Wetlands and Agricultural Contamination

The sample frame was households in California, Nevada, Oregon, and Washington. Random-digit dialing was used to generate the sample frame. Households were then sent a 16-page booklet that described the two programs: (1) increasing the acres of wetlands for waterfowl in the San Joaquin Valley of California by 40,000 acres; and (2) reducing the percentage of waterbirds exposed to contaminated agricultural drainage waters. The interviews were conducted over the phone with the respondent reading along in the survey booklet. The exact wording of the wetlands question was "Improving habitat conditions and increasing wildlife populations above current levels is more costly than just maintaining the existing conditions. If the improvement program was the only program you had an opportunity to vote on and it cost every household $XX each year in taxes, would you vote for it? YES NO."

The response rate was 51% of those initially contacted during the random digit dialing.

California Spotted Owl

A survey booklet and telephone script was administered to California and New England residents. The sample was derived from random-digit dialing. The program was protection of California Spotted Owl habitat from catastrophic fire. The survey booklet contained both text and graphics to portray the effect of the program in reducing the number of acres of habitat that would burn each year. Households were told that there was inadequate funding to pay for the improved fire prevention and control programs. The text of the script read to the respondent was "While fire control programs such as Programs A and B have been proven to protect old-growth forests and associated wildlife habitat there is not sufficient funding available to apply either Program A or B on the 5 million acres of old-growth forests in California. Thinking about Program B which reduces the proportion of high intensity fires and also includes a 20% reduction in the acreage of old-growth forests that burns each year: If Program B were the only program available and your household was asked to pay $XX each year to help pay for Program B would you pay this amount? YES NO"

The response rate of deliverable surveys for California was 49%, and 44% for New England.

V. RESULTS

Table 1 provides the reparameterize coefficients calculated from the logit equations using the technique of Cameron 1988. For several programs we estimated a coefficient on miles in the linear and log form if the t-statistics and pseudo R squares (defined as 1 − [max log likelihood/restricted log likelihood]) did not indicate one functional form was particularly superior to the other. In terms of our hypothesis, respondent's distance from the wildlife habitat is negative in all of the seven regressions and statistically significant at the .05 level for six of the seven regressions (it is significant at the .1 level in the seventh). For the WA salmon enhancement program we tested whether there was either an intercept shift or slope change in the WTP function when one crosses the state boundary. We found neither significant individually ($t = 1.34$ for WA Resident dummy; $t = 1.42$ for WA resident × distance) or used in combination ($t = .72$ for WA Resident dummy; $t = .86$ for WA resident × distance).

Using the coefficients in Table 1 we calculated the per household WTP at 100 mile distance intervals from 100 miles to 2,500 miles. The benefits received by local households (defined as those living within 100 miles of the resource) was set at 100%. Figure 1 plots the percent of this local household WTP for respondents living at the other dis-

TABLE 1
REPARAMETERIZED RESULTS FOR LOGIT WTP EQUATION

	Mex Spotted Owl		62 T&E Species		CA Wetlands	CA Contamination	WA Salmon
Model	Linear	Log	Linear	Log	Log	Log	Linear
Constant	61.38	93.07	76.56	86.53	480.75***	452.5***	−155.85***
Miles	−0.0343**	−16.84***	−0.031*	−13.38**	−32.71*	−45.62**	−0.0101***
Protect	22.68***	22.51***	24.05***	23.88***			
Projob	−35.45***	−35.48***	−38.64***	−38.46***			
Tknow		21.32**		24.09**			
Member					85.99***	136.34***	
Age					−2.64***	−2.97***	
Recreation Expend					0.018**	0.021**	
Fish Importance							69.51***
Electricity Importance							−35.73***
Native Am. Imp.							28.80***
D.O.F.	671	668	671	667	998	998	946
Pseudo R^2	.286	.297	.307	.318	.05	.04	.20
% Correct	77	76	78	77	67	65	71

Note: Protect: importance of protecting endangered species.
Projob: importance of using public lands for commercial uses and jobs.
Member: dummy variable equal to one, if individual was member of environmental or hunting/fishing organization.
Tknow: is the knowledge of the respondent regarding T&E, owls, and fish species.
Fish Importance: importance of rivers as habitat for fish.
Native Am. Imp: importance of providing Native Americans with their traditional fishing areas.
* = significant at 0.10; ** = significant at 0.05; *** = significant at 0.01.

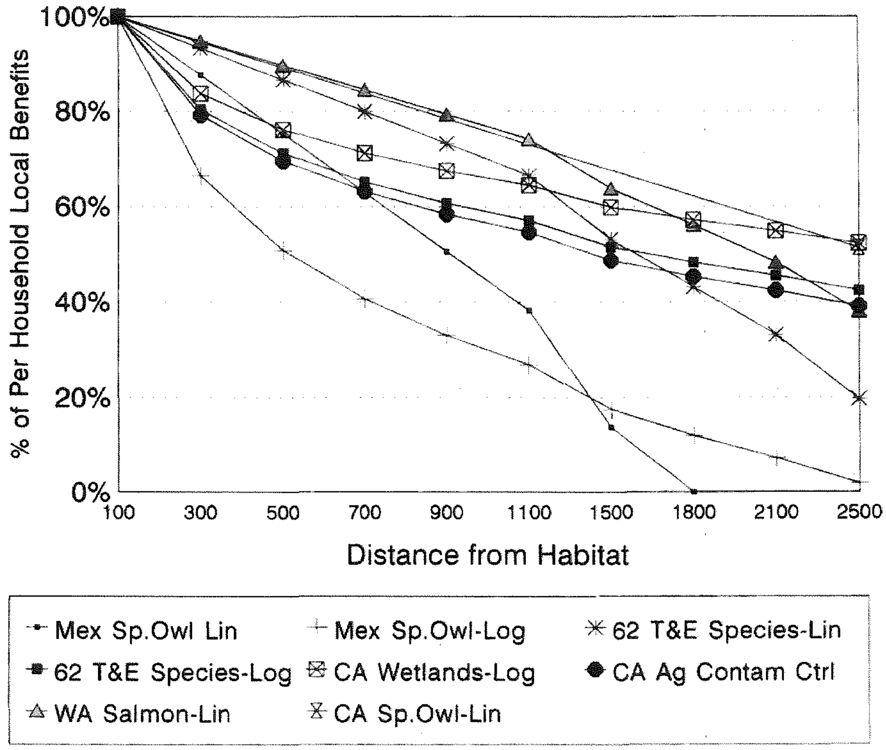

FIGURE 1
PER HOUSEHOLD BENEFIT GRADIENTS FOR PUBLIC GOOD VALUES OF WILDLIFE: PERCENT OF LOCAL WTP AS A FUNCTION OF DISTANCE FROM HABITAT

tances from the natural resource in question. The percent of household benefits drop the fastest for the Mexican Spotted Owl, implying very low benefits per household beyond 1,500 miles from the species four corner states habitat (e.g., households in the eastern seaboard appear to receive almost no benefit per household). However, for the other wildlife protection programs, more distant residents receive benefits per household that are about half the benefits received by local households. Even households 2,500 miles away receive nearly 40% of the local household benefits. Figure 1 also suggests there may often be large benefits to residents in other countries, as the percentage WTP remains sizeable for these species as one moves north to Canada or south to Mexico, although there may be cultural differences in WTP.

Figure 1 however, abstracts from the uneven population distribution surrounding the wildlife habitat areas. With the exception of California and Washington, very little of the nation's population lives within 100 miles of the protected wildlife habitat areas. Thus, while benefits per household may fall off rapidly for the Mexican Spotted Owl, only about 4% of the U.S. population lives in the four corner states of Arizona, Colorado, New Mexico, and Utah. Thus, to determine the degree of error from using state level political jurisdictions commonly employed in policy analyses, one must account for benefits per household *and* the number of households at varying distances from the natural resource. The total public good benefits were calculated by multiplying the benefit per household times the population living at various distance increment from the resource. To calculate the percent of economic benefits reflected in the political jurisdiction (Table 2) the amount of the public good benefits received by state residents was divided by the

TABLE 2
PERCENTAGE OF TOTAL ECONOMIC BENEFITS REFLECTED IN STATE OR REGIONAL POLITICAL JURISDICTIONS FOR SIX WILDLIFE PROTECTION PROGRAMS

WA	Mex Spotted Owl		62 T&E Species		CA	CA	CA
Salmon	Linear	Log	Linear	Log	Wetlands	Contamination	Cal Sp. Owl
4.6% (2.3–24)	16.0% (4.3–38)	13.5% (4.4–100)	6.7% (4.3–19)	6.4% (4.1–100)	17.9% (11.6–100)	18.7% (13.3–100)	17.4% (15.8–20.3)

Note: 90% confidence intervals in parentheses.

national benefits. For example, the vast majority of Washington's population lives within 100 miles of the Elwha River. A state of Washington distance weighted WTP was $73.63 million. The distance weighted WTP for the U.S. as a whole is $1,577 million. Dividing the Washington state benefits by U.S. benefits yields 4.6% shown in Table 2. For the Mexican Spotted Owl and 62 T&E species, we used the sum of benefits to the four corner states (AZ, CO, NM, UT) as the political jurisdiction.

Table 2 summarizes the percent of national public good benefits reflected in commonly employed state or regional accounting stances. Even when the resource being protected is in the most populous state in the country (California), this political jurisdiction, accounts for less than 20% of the economic benefits to the U.S. for increased wetlands and protection of California Spotted Owl habitat. For resources located in small population states such as Washington, only about 5% of the total public good benefits are reflected in the state political jurisdiction. Table 2 also presents the upper and lower confidence intervals on the percent of economic benefits within the political jurisdiction. In all of the linear in distance models, we reject the null hypothesis of state level fiscal equivalence for these wildlife protection programs (the tight confidence interval on the California Spotted Owl program is due to use of the double-bounded dichotomous choice method, rather than single-bounded as in all of the other programs). However, with the log of distance functional form, the exponential decline in WTP with distance and large standard errors (although the log of distance is significant at the 5% alpha level in all but one of these log of distance models) results in an upper limit on the confidence interval including 100% of the economic benefits within the political jurisdiction. This suggests an important area of future research may be to apply Box-Cox functional form tests to allow for more flexible functional forms.

For the California Spotted Owl and Washington salmon programs *lack* of fiscal equivalence would result in serious underprovision of wildlife protection if these programs relied solely upon state funding or state level decisionmaking. In terms of fiscal federalism, the proposed grants-in-aid programs to state fish and game agencies funded by federal excise taxes on recreational equipment embodied in the Fish and Wildlife Conservation Act of 1980 may be welfare improving. Further, devolution of protection of endangered species from the federal level down to the state level could worsen fiscal equivalence. Since the benefits of the salmon and California Spotted Owl programs are nationwide, federal decisionmaking and funding internalizes the positive externalities of the program.

VI. CONCLUSION

This paper illustrates the national and international economic jurisdiction for protection of the California Spotted Owl and salmon. While benefits per household do exhibit a statistically significant decrease with distance from the wildlife habitat, aggregate benefits are still substantial at 1,000 miles from the public good with linear in distance models. While the upper confidence interval on state benefits is 100% with the logarithmic functional form for three of the six natural resources, on average, measuring only the benefits at the state level would result in just 13% of the national total public good benefits and an even smaller percentage of world-wide benefits. As noted by Smith (1993) this type of error dwarfs previously researched concerns regarding differences in WTP due to divergences in revealed versus stated preferences. While it is important to reflect the local area in benefit-cost analysis, since in some cases it may bear a disproportionate share of the costs, the benefits are often nationwide and can even be world-wide. Olson's fiscal equivalence suggests continued federal financing and federal decisionmaking for protection of threatened and endangered species in the U.S. as well as federal grants-in-aid to state non-game wildlife programs.

What guidance does this research offer to practicing economists? If additional research on a wider range of environmental programs substantiates what we have found for wildlife and wetlands programs, then it appears that economists should look more broadly when estimating the benefits of public goods. Additional investigation with national sample frames to test whether WTP for other environmental quality programs exhibit a similar distance-decay pattern is clearly needed before we can recommend national sampling. Given the limited analysis in this paper and the sensitivity of results to functional form, we suggest that during the scoping of a public goods analysis, pre-testing of surveys over a wide geographic region should be performed to determine just how geographically widespread the benefits are. The results of this pre-test data, can then be used to determine the economic jurisdiction for final analysis.

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