Chapter A9: Economic Benefit Categories and Valuation

INTRODUCTION

CHAPTER CONTENTS

Changes in cooling water intake structure (CWIS) design or operations resulting from the final section 316(b) rule for existing facilities are expected to reduce impingement and entrainment (I&E) losses of fish, shellfish, and other aquatic organisms and, as a result, the rulemaking is expected to increase the numbers of individuals present, increase local and regional fishery populations, and ultimately contribute to the enhanced environmental functioning of affected waterbodies (rivers, lakes, estuaries, and oceans) and associated ecosystems. The economic welfare of human populations is expected to increase as a consequence of the improvements in fisheries and associated aquatic ecosystem functioning.

The aquatic resources affected by cooling water intake structures provide a wide range of services. Ecosystem services are the physical, chemical, and biological functions performed by natural resources and the human benefits derived from those functions, including both ecological and human use services (Daily, 1997; Daily et al., 1997). Scientific and public interest in protecting ecosystem services is increasing with the recognition that these services are vulnerable to a wide range of human activities and are difficult, if not impossible, to replace with human technologies (Meffe, 1992).

In addition to their importance in providing food and other goods of direct use to humans, the organisms lost to I&E are critical to the continued functioning of the ecosystems of which they are a part. Fish are essential for energy transfer in aquatic food webs, regulation of food web structure, nutrient cycling, maintenance of sediment processes, redistribution of bottom substrates, the regulation of carbon fluxes from water to the atmosphere, and the maintenance of aquatic biodiversity (Peterson and Lubchenco, 1997; Postel and Carpenter, 1997; Holmund and Hammer, 1999; Wilson and Carpenter, 1999). Examples of ecological and public services disrupted by I&E include:

- decreased numbers of ecological keystone, rare, or sensitive species;
- decreased numbers of popular species that are not fished, perhaps because the fishery is closed;
- decreased numbers of special status (e.g., threatened or endangered) species;
- increased numbers of exotic or disruptive species that compete well in the absence of species lost to I&E;
- disruption of ecological niches and ecological strategies used by aquatic species;
- disruption of organic carbon and nutrient transfer through the food web;
- disruption of energy transfer through the food web;
- decreased local biodiversity;
- disruption of predator-prey relationships;
- disruption of age class structures of species;
- disruption of natural succession processes;
- disruption of public uses other than fishing, such as diving, boating, and nature viewing; and
- disruption of public satisfaction with a healthy ecosystem.

Many of these services can only be maintained by the continued presence of all life stages of fish and other aquatic species in their natural habitats.

The traditional approach of EPA and other natural resource agencies to quantifying the environmental benefits of proposed regulations has focused on active use values, particularly direct use values such as recreational or commercial fishing. Nonconsumptive uses (such as the importance of fish for aquatic food webs), and passive use or non-use values (including the value of protecting a resource for its own sake), are seldom considered because they are difficult to monetize with available economic methods. However, even though economists debate methods for indirect and non-use valuation, there is general agreement that these values exist and can be important.

This chapter first identifies the types of economic benefits that are likely to be generated from improved ecosystem functioning resulting from the final section 316(b) rule for existing facilities. Then, the basic economic concepts applicable to the economic benefits, including benefit categories and benefit taxonomies associated with market and nonmarket goods and services that are likely to flow from reduced I&E, are discussed. Sections in this chapter refer to the chapter in this report that details the methods used to estimate the values of reductions in I&E. These methods are in turn applied in the regional studies described in Parts B through H of this document.

A9-1 Economic Benefit Categories Applicable to the Final Section 316(b) Rule

The term "economic benefits" for our purposes refers to the dollar value associated with all the expected positive impacts of the final section 316(b) rule. The basic approach for estimating the benefits of a policy event is to evaluate changes in social welfare realized by consumers and producers. These surplus measures are standardized and widely accepted concepts within applied welfare economics, and reflect the degree of well-being derived by economic agents (e.g., people and/or firms) given different levels of goods and services, including those associated with environmental quality.[1] For the case of market goods, analysts typically use money-denominated measures of consumer and producer surplus, which provide an approximation of exact welfare effects (Freeman, 2003). For nonmarket goods, such as aquatic habitat, values must be assessed using non-market valuation methods. In such cases, valuation estimates are typically restricted to effects on individual households (or consumers), and either represent consumer surplus or analogous exact Hicksian welfare measures (e.g., compensating surplus). The choice of welfare (i.e., value) measures is often determined by the valuation context. The theory and practice of nonmarket valuation is well developed, and typically plays a pivotal role in benefit-cost analysis conducted by public and private agencies (Freeman, 2003).

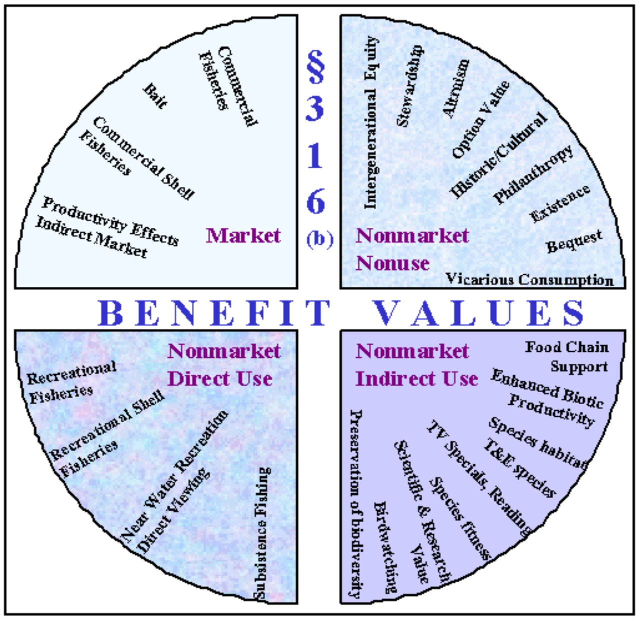
Estimating economic benefits of reducing I&E at existing CWIS can be challenging. There are many steps needed to analyze the link between reductions in I&E and improvements in human welfare. The changes produced by the new regulations on fisheries and other aspects of relevant aquatic ecosystems must be determined, and then linked in a meaningful way to the associated environmental goods and services that ultimately produce increased benefits. Key challenges in environmental benefits assessment include uncertainties, data availability, and the fact that many of the goods and services beneficially affected by CWIS are not traded in the marketplace (i.e., monetary values can not be established based on observed market transactions for some of the important beneficial outcomes). In this case, several types of benefits need to be estimated using nonmarket valuation techniques. Where this cannot be done in a reliable manner, the benefits need to be described and considered qualitatively.

For the final section 316(b) rule for existing facilities, the benefits are likely to consist of several categories; some are linked to direct use of market goods and services, and others pertain to nonmarket goods and services. Figure A9-1 outlines the most prominent categories of benefit values for the final section 316(b) rule. The four quadrants are divided by two principles:

- whether the benefit can be tracked in a market (i.e., market goods and services); and
- how the benefit of a nonmarket good is received by human beneficiaries (either from direct use of the resource, from indirect use, or from non-use).

[1] Technically, consumer surplus reflects the difference between the "value" an individual places on a good or service (as reflected by the individual's "willingness-to-pay" (WTP) for that unit of the good or service) and the "cost" incurred by that individual to acquire it (as reflected by the "price" of a commodity or service, if it is provided in the marketplace). See Chapter A10 for a more detailed discussion of consumer and producer surplus.

Figure A9-1: Benefits Categories for the Final Section 316(b) Rule



The best example of market benefits for the final section 316(b) rule are commercial fisheries, where a change in fishery conditions will manifest itself in the price, quantity, and/or quality of fish harvests. These fishery changes result in changes in the marketplace, and can be evaluated based on market exchanges. A discussion of commercial benefits can be found in Chapter A10 of this document.

Direct use benefits also include the value of improved environmental goods and services used and valued by people (whether or not these services and goods are traded in markets). A typical nonmarket direct use would be recreational angling. Recreational fishing studies of sites throughout the United States have shown that anglers place high value on their fishing trips and that catch rates are one of the most important attributes contributing to the quality and, as a result, value of their trips. Higher catch rates resulting from reduced I&E of fish species targeted by recreational anglers may translate into two components of recreational angling benefits: (1) an increase in the value of existing recreational fishing trips resulting in a more enjoyable angling experience, and (2) an increase in recreational angling participation. A discussion of methodology used in valuation of recreational benefits can be found in Chapter A11.

Indirect use benefits refer to changes that contribute indirectly to an increase in welfare for users (or non-users) of the resource. An example of an indirect benefit would be when the increase in the number of forage fish enables the population of valued predator species to improve (e.g., when the size and numbers of prized recreational or commercial fish increase because their food source has been improved). In such a context, reducing I&E of forage species will indirectly result in welfare gains for recreational or commercial anglers. See Chapter A5 for a discussion on the indirect influence of forage fish.

Non-use benefits, often referred to as passive use benefits, arise when individuals value improved environmental quality apart from any past, present, or anticipated future use of the resource in question. Such passive use values have been categorized in several ways in the economic literature, typically embracing the concepts of existence, altruism, and bequest motives. Existence value is the value that individuals may hold for simply knowing that a particular good exists regardless of their present or expected use.[2] This motive applies not only to protecting endangered and threatened species (i.e., avoiding an

[2] The term "existence value" is sometimes used interchangeably with or in place of "non-use value." In this case, where the whole of non-use benefits is represented, existence value has been described as including vicarious consumption and stewardship values. Vicarious consumption reflects the value individuals may place on the availability of a good or service for others to consume in the current time period, and stewardship includes inherent value as well as bequest value. In this case inherent value may be considered the existence value individuals hold for knowing that a good exists (described above), and bequest value is the value individuals place on preserving or ensuring the availability of a good or service for family and others in the future.

irreversible impact), but also applies (though perhaps the values held may be different) for impacts that potentially are reversible or that affect relatively abundant species and/or habitats.[3] Bequest value exists when someone gains utility through the knowledge that an amenity will be available for others (family or future generations) now and in the future (Fisher and Raucher, 1984). Altruistic values arise from interpersonal concerns (valuing the happiness that others get from enjoying the resource). Non-use values also may include the concept that some ecological services are valuable apart from any human uses or motives. Examples of these ecological services may include improved reproductive success for aquatic and terrestrial wildlife, increased diversity of aquatic and terrestrial species, and improved conditions for recovery of I&E species.

In older published studies, option value, which may exist regardless of actual future use, has been classified as either non-use value, use value, or as a third type of value, apart from both the use and non-use components of total value. Fisher and Raucher (1984) define *option price* for such an individual as "the sum of the expected value of consumer surplus from using the resource plus an *option value* or risk premium that accounts for uncertainty in demand or in supply." Mitchell and Carson (1989) argue that on theoretical grounds this risk premium should be small for non-unique resources. It is increasingly recognized, however, that option value "cannot be a separate component of value" (Freeman, 2003; p. 249). As noted by Freeman (2003; p. 250), option value is "not mentioned in EPA's most recent set of guidelines for economic assessment." Accordingly, the following analysis does not assess option value as a distinct component of value.

Although different benefit categories can be developed, it makes little difference where specific types of benefits are classified as long as the classification system captures all of the types of beneficial outcomes that are expected to arise from a policy action, while at the same time avoiding any possible double counting. Some valuation approaches may capture more than one benefit category or reflect multiple types of benefits that exist in more than one category or quadrant in the diagram. For example, habitat restoration may enhance populations of recreational, commercial, and forage species alike. Thus, for the habitat-based analysis, decision makers need to be careful to account for the mix of direct and indirect uses included in the benefits estimates, including both market and nonmarket goods and services as well as non-use values.

A9-2 DIRECT USE BENEFITS

Direct use benefits are the simplest to envision. The welfare of commercial, recreational, and subsistence fishermen is improved when fish stocks increase and their catch rates rise. This increase in stocks may be induced by reduced I&E of species sought by fishermen, or through reduced I&E of forage and bait fish, which leads to increases in the number of commercial and recreational species that prey on the forage species. For subsistence fishermen, the increase in fish stocks may reduce the amount of time spent fishing for their meals or increase the number of meals they are able to catch. For recreational anglers, more fish and higher catch rates may increase the enjoyment of a fishing trip and may also increase the number of fishing trips taken. For commercial fishermen, larger fish stocks may lead to increased revenues through increases in total landings and/or increases in the catch per unit of effort (i.e., lower costs per fish caught). Increases in catch may also lead to growth in related commercial enterprises, such as commercial fish cleaning/filleting, commercial fish markets, recreational charter fishing, and fishing equipment sales.[4]

Evidence that the use value of fishery resources is considerable can be seen in the market and other observable data. For example, in 1996, over 35 million recreational anglers spent nearly $38 billion on equipment and fishing trip related expenditures (U.S. DOI, 1997), and the 1996 GDP from fishing, forestry, and agricultural services (not including farms) was about $39 billion (BEA, 1998). Americans spent an estimated 626 million days engaged in recreational fishing in 1996, an increase of 22 percent over the 1991 levels (U.S. DOI, 1997). If the average consumer surplus per angling day were only $20

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[3] Some economists consider option values to be a part of non-use values because the option value is not derived from actual current use. Alternatively, some other writers place option value in a use category, because the option value is associated with preserving opportunity for a future use of the resource. Both interpretations are supportable, but for this presentation EPA places option value in the non-use category in Figure A9-1.

[4] Increased revenues are often realized by commercial ventures whose businesses are stimulated by environmental improvements. These revenue increases do not necessarily reflect gains in national level "economic welfare" and, therefore, are not usually included in a national benefit-cost analysis. However, these positive economic impacts may be sizable and of significance to local or regional economies — and also of national importance — in times when the economy is not operating at full capacity (i.e., when the economic impacts reflect real gains and not transfers of activity across regions or sectors).

— a conservative figure relative to the values derived by economic researchers over the years (Walsh et al., 1990)[5]— then the national level of consumer surplus based on these 1996 levels of recreational angling would be approximately $12.6 billion per year (and probably is appreciably higher).

However, these baseline values do not provide a sense of how benefits change with improvements in environmental quality, such as due to reduced I&E and increased fish stocks. If the improvement resulted in a aggregate increase of 1.0 percent in recreational angling consumer surplus, it would translate into potential recreational angling benefits of approximately $100 million per year or more, based on the limited metrics in the previous paragraph.

Methodologies for estimating use values for recreational and commercial species are well developed, and some of the species affected by I&E losses have been extensively studied. As a result, estimation of associated use values is often considered to be straightforward. However, the portion of I&E losses consisting of fish that are recreationally and commercially landed represents only a very small fraction of the total age one equivalent I&E losses and, as a result, changes in direct use values resulting from the final section 316(b) rule provide an incomplete estimate of the regulation's benefits.

The following bullets discuss techniques of estimating direct use value for I&E losses of harvested fish.

❖ ***Commercial fisheries***

The social benefits derived from increased landings by commercial fishermen can be valued by examining the markets through which the landed fish are sold. The first step of the analysis involves a fishery-based assessment of I&E-related changes in commercial landings (pounds of commercial species as sold dockside by commercial harvesters). The changes in landings are then valued according to market data from relevant fish markets (dollars per pound) to derive an estimate of the change in gross revenues to commercial fishermen. The final steps entail converting the I&E-related changes in gross revenues into estimates of social benefits. These social benefits consist of the sum of the producers' and consumers' surpluses that are derived as the changes in commercial landings work their way through the multi-market commercial fishery sector. Each step is described in detail in Chapter A10.

❖ ***Recreational fisheries***

The benefits of recreational use cannot be tracked in the market, since much of the recreational activity associated with fisheries occurs as nonmarket events. However, a variety of nonmarket valuation methods exist for estimating use value, including both "revealed" and "stated" preference methods (Freeman, 2003). Where appropriate data are available or may be collected, revealed preference methods may represent a preferred set of methods for estimating use values. These methods use observed behavior to infer users' value for environmental goods and services. Examples of revealed preference methods include travel cost, hedonic pricing, and random utility models (RUM). Compared to non-use values, use values are often considered relatively easy to estimate, due to their relationship to observable behavior, the variety of revealed preference methods available, and public familiarity with the recreational services provided by surface waterbodies.

EPA used a random utility model (RUM) to estimate welfare gain to recreational anglers from improved recreational opportunities resulting from reduced I&E of fish species. This method has been applied frequently to value recreational fisheries and is thought to be quite reliable because it is based on people's demand for nonmarket goods and services through observable behavior.[6] The RUM approach has been applied in six of the regional studies. Chapter A11 provides greater detail on specific models used in the regional analyses.

For the Inland region, EPA used a benefit transfer approach to value recreation fishing benefits from reduced I&E. Benefits transfer is a secondary research method applied when data and other constraints limit the feasibility of doing site-specific primary research. Although primary research methods are generally considered to be superior to benefit transfer methods, benefit transfer is often a second-best (or only) alternative to original studies. Chapter H4 provides greater detail on specific values used in the benefits transfer approach.

[5] Walsh et al. (1990) review 20 years of research and derive an average value of over $30 per day for warm water angling, and higher values for cold water and salt water angling

[6] Some researchers have argued that revealed preference methods (such as the travel cost method) suffer fundamental flaws which render them no more reliable than stated preference methods (Randall, 1994).

❖ ***Avoiding double-counting of direct use benefits***

Many of the I&E-impacted fish species at CWIS sites are harvested both recreationally and commercially. To avoid double-counting the economic impacts of I&E of these species, the Agency determined the proportion of total species landings attributable to recreational and commercial fishing, and applied this proportion to the number of affected fishery catch.

❖ ***Subsistence anglers***

Subsistence use of fishery resources can be an important issue in areas where socioeconomic conditions (e.g., the number of low income households) or the mix of ethnic backgrounds make such angling economically or culturally important to a component of the community. In cases of Native American use of affected fisheries, the value of an improvement can sometimes be inferred from settlements in legal cases (e.g., compensation agreements between impacted Tribes and various government or other institutions in cases of resource acquisitions or resource use restrictions). For more general populations, the value of improved subsistence fisheries may be estimated from the costs saved in acquiring alternative food sources (assuming the meals are replaced rather than foregone). This method may underestimate the value of a subsistence-fishery meal to the extent that the store-bought foods may be less preferred by some individuals than consuming a fresh-caught fish. Subsistence fishery benefits are not included in EPA's regional analyses, although impacts on subsistence anglers may constitute an important environmental justice consideration, leading to an underestimation of the total benefits of the regulation.

A9-3 Indirect Use Benefits

Indirect use benefits refer to welfare improvements that arise for those individuals whose activities are enhanced as an indirect consequence of fishery or habitat improvements generated by the final section 316(b) rule. For example, the rule's positive impacts on local fisheries may generate an improvement in the population levels and/or diversity of fish-eating bird species. In turn, avid bird watchers might obtain greater enjoyment from their outings, as they are more likely to see a wider mix or greater numbers of birds. The increased welfare of the bird watchers is thus a legitimate but indirect consequence of the proposed rule's initial impact on fish. Impacts on other species such as birds have not been estimated for the Phase II regulation, but Chapter A4 of this document presents a qualitative discussion of the potential indirect effects of the rule on birds.

Another example of potential indirect benefits concerns forage species. A rule-induced improvement in the population of a forage fish species may not be of any direct consequence to recreational or commercial anglers. However, the increased presence of forage fish will have an indirect affect on commercial and recreational fishing values if it increases food supplies for commercial and recreational predatory species. Thus, direct improvements in forage species populations can result in a greater number (and/or greater individual size) of those fish that are targeted by recreational or commercial anglers. In such an instance, the incremental increase in recreational and commercial fishery benefits would be an indirect consequence of the proposed rule's effect on forage fish populations.

The regional case studies use two distinct estimates of trophic transfer efficiency to relate foregone forage production to foregone fisheries yield that would result from two kinds of food web pathways. The two estimates, referred to as secondary and tertiary forgone yield in this document, reflect the following:

- that portion of total forage production that has a high trophic transfer efficiency because it is directly consumed by harvested species; and
- the remaining portion of total forage production that has a low trophic transfer efficiency because it is not consumed directly by harvested species, but instead reaches harvested species indirectly after passage through other parts of the food web.

The dollar value of foregone commercial and recreational production was estimated using the same monetary values as for the direct use benefits estimates.[7] The indirectly consumed production enhancement from forage species that is not embodied in the landed recreational and commercial fish was examined in a similar manner, but values were adjusted downwards to reflect a much lower trophic efficiency transfer rate. This approach is described in greater detail in Chapter A5. A serious limitation with this approach is that I&E data collected for CWIS often overlook impacts on forage species (focusing instead on

[7] Note that in practice values contributed by forage fish have been included as part of the valuation of increased landings of commercial and recreational species.

recreational and commercial species). Therefore, the results developed using this approach generally reflect considerable underestimates of forage species values.

A9-4 NON-USE BENEFITS

In contrast to direct use values, non-use values are often considered more difficult to estimate. Stated preference methods, or benefit transfer based on stated preference studies, are the generally accepted techniques for estimating these values. Stated preference methods rely on carefully designed surveys, which either (1) ask people to state their WTP for particular ecological improvements, such as increased protection of aquatic species or habitats with particular attributes, or (2) ask people to choose between competing hypothetical "packages" of ecological improvements and household cost. In either case, analysis of survey responses allows estimation of values.

Non-use values may be more difficult to assess than use values for several reasons. First, non-use values are not associated with easily observable behavioral trails. Second, non-use values may be held by both users and non-users of a resource, and non-users may be less familiar with particular services provided by water resources. Third, the development of a defensible stated preference survey that meets the NOAA blue ribbon panel requirements is often a time and resource intensive process. Fourth, even carefully designed surveys may be subject to certain biases associated with the hypothetical nature of survey responses (Mitchell and Carson, 1989).

EPA routinely estimates changes in use values of the affected resources as part of regulatory development. However, given EPA's regulatory schedule, developing and implementing stated preference surveys to elicit total value (i.e., non-use and use) of environmental quality changes resulting from environmental regulations is often not feasible. An extensive body of environmental economics literature demonstrates the importance of valuing all service losses, rather than just readily measured direct use losses. These studies typically reveal that the public holds significant value for service flows from natural resources well beyond those associated with direct uses (Fisher and Raucher, 1984; Brown, 1993; Boyd et al., 2001; Fischman, 2001; Heal et al., 2001; Herman et al., 2001; Ruhl and Gregg, 2001; Salzman et al., 2001; Wainger et al., 2001). Studies have documented public values for the non-use services provided by a variety of natural resources potentially affected by environmental impacts, including fish and wildlife (Stevens et al., 1991; Loomis et al., 2000); wetlands (Woodward and Wui, 2001); wilderness (Walsh et al., 1984); critical habitat for threatened and endangered species (Whitehead and Blomquist, 1991a; Hagen et al., 1992; Loomis and Ekstrand, 1997); overuse of groundwater (Feinerman and Knapp, 1983); hurricane impacts on wetlands (Farber, 1987); global climate change on forests (Layton and Brown, 1998); bacterial impacts on coastal ponds (Kaoru, 1993); oil impacts on surface water (Cohen, 1986); and toxic substance impacts on wetlands (Hanemann et al., 1991), shoreline quality (Grigalunas et al., 1988), and beaches, shorebirds, and marine mammals (Rowe et al., 1992). Brown (1993) reports that in many studies, total values exceed direct use values by greater than a factor of two.

In the case of the final section 316(b) existing facilities rule, no primary research was feasible within the budgeting, scheduling, and other constraints faced by the Agency. The Agency explored various alternatives to quantifying and monetizing non-use benefits based on secondary research. However, given the uncertainties in estimating non-use benefits with secondary estimation techniques at the national level, the Agency presented only a qualitative assessment of the non-use benefits of the environmental protections at issue in the final section 316(b) benefit cost analysis. Chapter A12 details the meta-analysis approach considered for estimating non-use benefits of the final section 316(b) regulation. Approaches to valuing I&E impacts on special status species are examined in Chapter A13. Chapter A15 discusses another way to put I&E losses into perspective: the value of habitats required to replace organisms lost to I&E.

A9-4.1 Role of Non-Use Benefits in the Final Section 316(b) Rule Benefits Analysis

Accounting for non-use values in the final section 316(b) rule benefits analysis is especially important because the portion of I&E losses consisting of organisms that have a direct human use value (i.e., those that contribute to forgone harvest) represents only a very small percentage of the organisms impinged and entrained by cooling water intake structures (CWIS). The remaining I&E losses include unharvested recreational and commercial fish and forage fish. Approximately 99.0 percent of all final section 316(b) rule Phase II estimated I&E organism losses and 98.6 percent of age-one adult equivalent losses are either forage species or the unlanded portion of recreational and commercial species. Neither forage species nor the unlanded portion of recreational and commercial species have direct uses; therefore, they do not have direct use values. Their value to the public has two sources: (1) their indirect use as both food and breeding population for fish that are harvested; and, (2) their non-use value, stemming from a sense of altruism, stewardship, bequest, or vicarious consumption, as indicated by the willingness of individuals to pay for the protection or improvement in fish numbers. To rely only on estimated use values would substantially undervalue the benefits of the final section 316(b) rule.

Table A9-1 provides detailed information on the number and percentage of organisms and age-one adult equivalent losses valued by EPA in the use commercial and recreational fishing analyses.

Table A9-1: Annual Number and Percentage of Losses Valued

Region[a]	Age-One Adult Equivalents (millions)				Forgone Harvest as % of Age 1 Eq. Lost
	Total Losses All Species[b]	Forage Losses[c]	Com./Rec. Species Losses[d]	Forgone Harvest	
California	312.9	170.6	142.3	14.9	4.8%
North Atlantic	65.7	49.7	16.0	0.7	1.0%
Mid-Atlantic	1,733.1	1,115.6	617.6	28.4	1.6%
South Atlantic	342.5	208.1	134.5	6.5	1.9%
Gulf of Mexico	191.2	53.5	137.8	8.1	4.2%
Great Lakes	319.1	300.8	18.3	0.5	0.2%
Inland	369.0	284.8	84.2	0.2	0.1%
Total	3,449.4	2,255.8	1,193.6	62.1	1.8%

[a] Regional numbers are unweighted. National totals are sample-weighted and include Hawaii.
[b] Total organisms lost to I&E expressed as age 1 equivalent fish. See Chapter A5 for details on the calculation of age 1 equivalents.
[c] Total I&E losses of fish species that are forage for species that are caught by recreational or commercial anglers.
[d] Total I&E losses of fish species that are caught by recreational or commercial anglers.

Source: U.S. EPA analysis for this report.

The organisms that remain unvalued in the analysis provide many important ecological services that do not translate into direct human use. While some ecological services of aquatic species have been studied, other ecosystems services, relationships, and interrelationships are unknown or poorly understood. To the extent that the latter are not captured in the benefits analyses, total benefits are underestimated.

Although individuals do not directly use most of the of the organisms lost by cooling water intake structures, individuals may nonetheless value these organisms. All individuals, including both commercial and recreational fishermen as well as those who do not use the resource, may have non-use values for unlanded and forage fish. Non-use values may be substantial, and may in some cases exceed use values in the aggregate.

For resource non-users, non-use values (if >0) must by definition exceed use values, which are zero if resource use is zero. Economic literature suggests that the non-use values for users of aquatic resources are significantly higher than the non-use values for non-users. This may result from additional information about water resources associated with past or expected future use, which is likely to enhance non-use value (Whitehead and Blomquist, 1991a). Other studies (e.g., Silberman et al., 1992), however, suggest that users may include their personal use values in non-use values, which could potentially result in double counting of use values. To avoid this problem, EPA used values from non-users (who have zero use values) to estimate non-use values for users *and* non-users.

A9-4.2 Overview of Explored Methods for Estimating Non-Use Benefits in the Final Section 316(b) Rule Benefits Analysis

EPA notes that results of the analyses discussed below were not used as a part of the national benefits analysis due to the unavoidable uncertainties in estimating non-use benefits at the national level.

❖ *Benefit transfer*

EPA considered the use of meta regression analysis to estimate passive or non-use benefits in the final section 316(b) rule benefits analysis These meta regressions are designed to statistically summarize the relationship between the computed benefit measures and a set of characteristics compiled from original primary study sources. The mathematical estimation of this functional relationship at study sites allows the researcher to better forecast estimates of WTP for the policy specific scenario and sites versus other types of benefit transfer. Additional advantages of the methodology employed by EPA include:

- Meta analysis utilizes varied source studies which provide increased information on the underlying components of reported benefits measures;
- Methodological differences that contribute to differences in estimated benefits across source studies can be determined and controlled with meta analysis;
- In developing benefits estimates for the policy site and scenario, the independent variable coefficients of the meta function can be adjusted to account for differences between the forecasted application and the values derived within the original studies; and
- Meta regression analysis can provide forecasted values of benefits outside the specific geographical region, site and policy specific characteristics, and scope constraints of the source study data.[8]

Much of the primary research into non-use values that is applicable to estimating benefits produced by the final section 316(b) rule implementation deals with eliciting an individual's WTP for improvements in site water quality. EPA used meta analysis of information from a number of these studies to determine the relationship between generally reported WTP values for improved water quality and those produced in studies where people were asked to value improvements in water quality that specifically affect only fish populations. This information can be used to estimate an individual's non-use WTP for an improvement in water quality that produces an increase in fish populations, a measure that the Agency believes is closely correlated with a pure WTP for increases in fish.

The meta analysis, described in Chapter A12 of this document, the meta-analysis results can used to estimate an annual willingness-to-pay estimate per non-user household (e.g., Mitchell and Carson, 1986; Carson and Mitchell, 1993). Applying this non-use value to all the households with non-use motives for the impacted waterbody (including both user and non-user households) would yield an estimate of the total non-use value.[9] EPA notes that this method for estimating non-use values may underestimate non-use values for users of aquatic resources (Whitehead and Blomquist, 1991a).

❖ *Societal revealed preference approach*

Other approaches can also provide important information to decision makers. For some specific affected fish species, non-use (or total) valuation may be deduced using restoration-based costs as a proxy for the value of the change in stocks. For example, for T&E species, the costs of restoration programs and various resource use restrictions indicate the revealed preference value of preserving the species. Where a measure of the approximate cost per preserved or restored individual fish can be deduced, and the number of individuals spared via best technology available (BTA) can be estimated, this is a viable approach. This approach is examined in the final section 316(b) rule case study of the San Francisco Bay/Delta Estuary (Chapter B.6 of this document). Improvements have been made to fish habitats by increasing stream flows, installing screening devices and fish passages, removing dams, and controlling temperatures. These changes in operations and

[8] These meta regression forecasted values, like any other forecast, decrease in confidence or probability of correctness when used further from the range of the source data.

[9] Note that Mitchell and Carson estimate "total value," including use and non-use components. However, EPA notes that total value estimates for non-users can be interpreted as their non-use value (i.e., there is no difference between their total and non-use value). Since non-users of a resource generally have lower non-use values than users, assuming that all members of the relevant population (users and non-users) have non-use values equal to the total values of non-users is a conservative assumption.

technologies all entail significant costs, which society has shown to be willing to pay for the protection and restoration of healthy fish populations, particularly the T&E species of the Sacramento and San Joaquin Rivers. These investments provide a means to evaluate the loss imposed on society when a portion of these same fisheries are adversely impacted by I&E. Because the species involved in this restoration costing approach have no use value (due to their status as threatened or endangered), the approach yields an estimate of non-use values.

❖ ***Habitat-based approach***

Another way to put I&E losses into perspective is to consider the value of the habitat required to replace organisms lost to I&E. In the absence of primary stated preference survey information, EPA believes that a restoration-based analysis can serve as a useful supplement or alternative to other benefits assessments, particularly in the context of the Clean Water Act. Restoration of aquatic species in I&E-impacted waters clearly constitutes a significant public natural resource benefit and is an important public goal, as evidenced by the Clean Water Act goals of restoring the "biological integrity" of the Nation's waters and achieving water quality for the protection and propagation of fish [33 U.S.C. § 1251(a)(2)]. It is also consistent with the wetlands protection program under Section 404 of the Clean Water Act where it is accepted that ecosystem losses that cannot be avoided are to be offset with wetlands restoration or creation to replace the functions and services (values) of the lost wetlands.

EPA recognizes the important distinction between the costs of supplying a resource or service, and the values that are derived from the active and passive uses of those resources and related services. Benefits are based on values that underlie the demand for these services, and the cost of providing such services may in some instances exceed these values, and in other instances may be less than these values. Nonetheless, available information suggests that individuals are both aware of the ecological importance of habitat restoration and value such programs.

Voluntary habitat restoration to improve the production of aquatic organisms is one indication that the public may consider habitat replacement to be worth its cost. A voluntary commitment of resources suggests economic efficiency and positive net benefits (as opposed to mandated actions that do not necessarily reveal values of those required to pay). In addition, long-standing legislation to preserve or restore aquatic habitats is a broad indication that habitat restoration is widely perceived as being worth its cost to society. Finally, a number of studies indicate a WTP for habitat restoration, and survey data could be developed to test the value of habitat restoration in the final section 316(b) rule context.

EPA believes that valuation of the amount of restoration required to offset I&E can provided important information for the final section 316(b) rule benefit-cost discussion because valuation of only direct use benefits (recreational and commercial fisheries) leaves a significant portion of I&E losses either unvalued or undervalued. Moreover, economic research indicates that many of the I&E-related benefits that are inadequately addressed through traditional benefits valuation approaches may be of considerable value. A description of how this approach can be used in the final section 316(b) rule context is presented in Chapters A15, C6, D6, and G6 of this report.

A9-5 SUMMARY OF BENEFITS CATEGORIES

Table A9-2 displays the types of benefits categories expected to be affected by the final section 316(b) rule. The table also reveals the various data needs, data sources, and estimation approaches associated with each category. Economic benefits can be broadly defined according to direct use and indirect use, and are further categorized according to whether or not they are traded in the market. As indicated in Table A9-2, "direct use" and "indirect use" benefits include both "marketed" and "nonmarketed" goods, whereas "non-use" benefits include only "nonmarketed" goods.

Table A9-2: Summary of Benefit Categories
Data Needs, Potential Data Sources, Approaches, and Analyses Completed

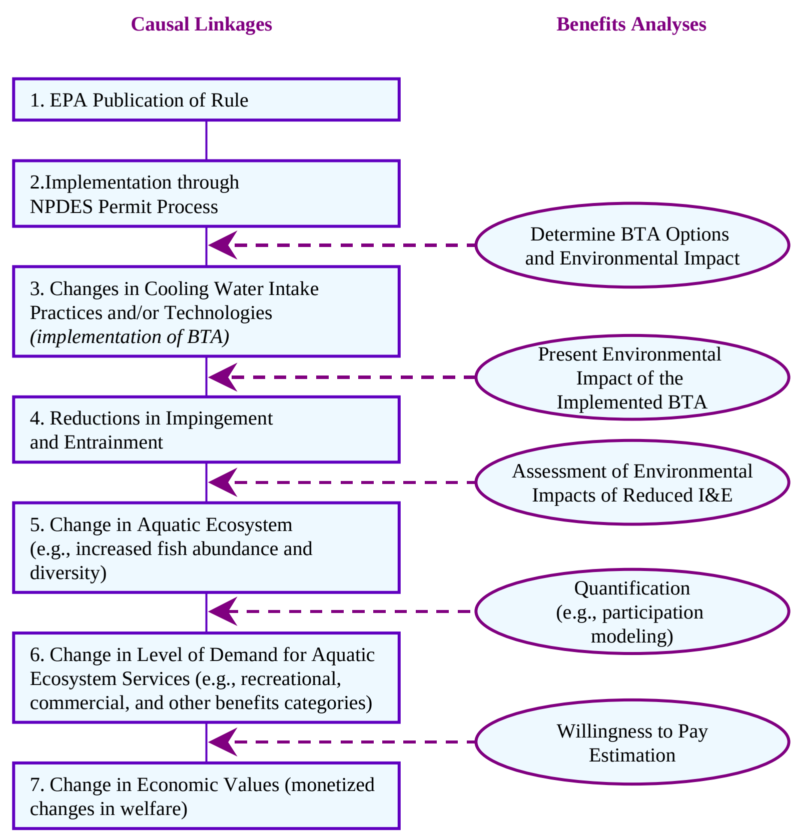
Benefits Category	Basic Data Needs	Potential Data Sources/Approaches/ Analyses Completed
Direct Use, Marketed Goods		
Increased commercial landings Fishing tournaments with entry fees and prizes	▸ Estimated change in landings of specific species ▸ Estimated change in total economic impact	▸ Market-based approach using data on landings and the value of landings data from the National Marine Fisheries Service (NMFS) ▸ Based on facility specific I&E data and ecological modeling ▸ Based on available literature
Indirect Use, Market Goods		
Increase in market values: ▸ equipment sales, rental, and repair ▸ bait and tackle sales ▸ increased consumer market choices ▸ increased choices in restaurant meals ▸ increased property values near water ▸ ecotourism (charter trips, festivals, other organized activities with fees such as riverwalks)	▸ Estimated change in landings of specific species ▸ Relationship between increased fish/shellfish landings and secondary markets ▸ Local activities and participation fees ▸ Estimated numbers of participating individuals	Not estimated for the final section 316(b) rule analysis due to data constraints
Direct Use, Nonmarket Goods		
Improved value of a recreational fishing trip: ▸ increased catch of targeted/preferred species ▸ increased incidental catch	▸ Estimated number of affected anglers ▸ Value of an improvement in catch rate	▸ Regional RUM analysis ▸ Benefit transfer (Inland region)
Increase in recreational fishing participation	▸ Estimated number of affected anglers or estimate of potential anglers ▸ Value of an angling day	Regional RUM analysis (not estimated for the California and Inland regions)
Indirect Use, Nonmarketed		
Increase in value of boating, scuba-diving, and near-water recreational experience: ▸ enjoying observing fish while boating, scuba-diving, hiking, or picnicking ▸ watching aquatic birds fish or catch aquatic invertebrates	▸ Estimated number of affected near-water recreationists, divers, and boaters ▸ Value of boating, scuba-diving, and near-water recreation experience	Not estimated for the final section 316(b) rule analysis due to data constraints
Increase in boating and near-water recreational participation	▸ Estimated number of affected boating and near-water recreationists ▸ Value of a near-water recreation experience	Not estimated for the final section 316(b) rule analysis due to data constraints
Increase in non-use values: ▸ existence (stewardship), ▸ altruism (interpersonal concerns), ▸ bequest (interpersonal and intergenerational equity) motives ▸ appreciation of the importance of ecological services apart from human uses or motives (e.g., eco-services interrelationships, reproductive success, diversity, and improved conditions for recovery).	▸ I&E loss estimates ▸ Primary research using stated preference approach (not feasible within EPA constraints) ▸ Applicable studies upon which to conduct benefit transfer	▸ Site-specific studies or national stated preference surveys ▸ Benefits transfer, including meta-analysis of applicable studies ▸ Restoration-based values of common and/or endangered species

A9-6 CAUSALITY: LINKING THE FINAL SECTION 316(B) RULE TO BENEFICIAL OUTCOMES

Understanding the anticipated economic benefits arising from changes in I&E requires understanding a series of physical and socio-economic relationships linking the installation of Best Technology Available (BTA) to changes in human behavior and values. As shown in Figure A9-2, these relationships span a broad spectrum, including institutional relationships to define BTA (from policy making to field implementation), the technical performance of BTA, the population dynamics of the aquatic ecosystems affected, and the human responses and values associated with these changes.

The first two steps in Figure A9-2 reflect the institutional aspects of implementing the final section 316(b) rule. In step 3, the anticipated applications of BTA (or a range of BTA options) must be determined for the regulated entities. This technology forms the basis for estimating the cost of compliance, and provides the basis for the initial physical impact of the rule (step 4). Hence, the analysis must predict how implementation of BTAs (as predicted in step 3) translates into changes in I&E at the regulated CWIS (step 4). These changes in I&E then serve as input for the ecosystem modeling (step 5).

Figure A9-2: Causal Linkages in the Benefits Analysis



In moving from step 4 to step 5, the selected ecosystem model (or models) are used to assess the change in the aquatic ecosystem from the pre-regulatory baseline (e.g., losses of aquatic organisms before BTA) to the post-regulatory conditions (e.g., losses after BTA implementation). The potential output from these steps includes estimates of reductions in I&E rates, and changes in the abundance and diversity of aquatic organisms of commercial, recreational, ecological, or cultural value, including T&E species.

In step 6, the analysis involves estimating how the changes in the aquatic ecosystem (estimated in step 5) translate into changes in the level of demand for goods and services. For example, the analysis needs to establish links between improved fishery abundance, potential increases in catch rates, and enhanced participation. Then, in step 7, as an example, the value of the increased enjoyment realized by recreational anglers is estimated. These last two steps are the focal points of the economic benefits portion of the analysis.

A9-7 CONCLUSIONS

The general methods described here are applied to the regional studies which are provided in Parts B through H of this document. Variations may occur to these general methodologies within distinct regional analyses to better reflect site-specific circumstances or data availability.