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CHAPTER 2

Frameworks for Economic Evaluation

Policy decisions, such as those involved in EBM can have a wide range of economic outcomes, including changes in observable market activities, as well as in economic costs and benefits. To evaluate different types of economic policy outcomes, economists have developed various frameworks that measure and interpret well-defined economic benefits and costs, while others characterize indicators of economic activity. In some cases, however, methods purported to quantify "economic" outcomes have little or no relationship to economics at all! These include evaluation methods grounded in thermodynamic principles or energy transfers that have no quantifiable relationship to human values, preferences, or welfare.[1] Given the myriad potential uses and misuses of economic information, policymakers are sometimes confused as to the meaning and correct application of economic approaches for policy guidance—or, here, EBM policy.

Consider the example of a coastal wind farm, such as the Cape Wind project proposed (and progressing through federal permitting) for the Horseshoe Shoals area near Nantucket, Massachusetts, in 2009. Such projects can have many different effects, including benefits and costs realized by different groups. These include potential benefits related to renewable energy provision and a reduction in pollution associated with alternative energy sources. Such projects, however, may also cause marine habitat loss due to construction and maintenance activities, as well as damage to birds from turbine rotors. People who prefer an unrestricted view of the ocean may be negatively affected by impacts to the seascape, and there may be potential impacts on fisheries and boating. Economics provides a set of consistent and standardized frameworks through which such divergent effects on different population groups, may be balanced and compared. In contrast, sole reliance on commonly reported economic indicators, such as employment and income, as a means to evaluate projects will provide at best incomplete—and often grossly misleading—perspectives on economic benefits and costs.

This chapter reviews principal economic frameworks that provide information on economic outcomes of marine resource management and uses of marine resources, with an emphasis on an integrated management

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perspective, or EBM. Perhaps the most common framework for providing economic insight, *cost-benefit analysis* (CBA) entails either comprehensive or partial assessments of long-term economic costs and benefits of specific projects, policies, or management approaches. CBA is often used to compare the net economic benefits of different policy options that lead to different outcomes. Another of these frameworks, *cost-effectiveness analysis* (CEA), clarifies the tradeoffs made in cases where desired outcomes have already been determined. It helps identify the most efficient means of achieving a specified management goal when a goal has been predetermined by legislation, prior consensus, or other means. Still another economic framework sometimes used is regional economic modeling, or *economic impact analysis* (EIA). Unlike CBA or CEA, EIA measures changes in economic activity or its indicators (e.g., regional income, gross market revenues or expenditures, workers employed, etc.) as determined by monetary flows between economic sectors. These measures are only weakly related to net economic benefits, but they can hold interest for policymakers who are concerned with economic development or regional employment.

Among available evaluation frameworks, CBA is the only approach designed to estimate the full range of economic costs and benefits associated with management (or policy) actions. As such, it receives greater emphasis in this chapter. However, this chapter also presents alternative approaches, with an emphasis on cost-effectiveness analysis and economic impact analysis, that offer other relevant economic information to the policy process. Finally, the chapter highlights distinctions between economic analyses and analyses that are not based on economic theory and/or do not measure value or net benefits, as defined by economists. These include approaches that calculate values based on embodied energy, thermodynamics (the energy involved in the production of a product or service), or replacement costs, and other approaches that estimate values of local resources and scale them up to assess total values for entire ecosystems.[2] There is also a brief discussion of multi-attribute utility theory (MAUT), a cousin of CBA, that weights policy attributes using expert opinions or preferences rather than economic value. Different evaluation methods that answer different economic questions regarding ocean and coastal management and choosing the right economic tools to help ensure that policy evaluations provide the most useful and relevant information are among the central themes of this chapter.

Why Measure Economic Outcomes?

More and more, policymakers are asked to provide information on the economic implications of environmental policies, such as those that affect human uses of aquatic ecosystems. Behind the growing demand for economic

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information is recognition of the value of *ecosystem services*, defined as the outputs of natural systems that influence human well-being. Benefits of ecosystem services may be realized in or out of organized markets. In many, or perhaps even in most cases, analysis of market data alone will not provide complete measures of ecosystem service values. Moreover, policies that encourage greater market activity or economic growth at the expense of reducing ecosystem services or depleting natural resources may not necessarily enhance long-term public benefit. Public welfare encompasses an often complex interplay between natural and human systems. Economics, when appropriately applied and interpreted, offers a number of consistent and reliable analytical frameworks that can help policymakers understand how such interactions influence economic outcomes, both in and out of markets, and how these economic outcomes relate to human well-being.

Economic tools can predict the effects of policy options on individuals, groups, or society as a whole. They are particularly well suited to quantifying tradeoffs, for example, balancing the gains and losses experienced by different groups. Predictions of different economic outcomes using these tools can be particularly useful to policymakers when benefits (or costs) are not obvious or are realized outside of organized markets. Benefits conveyed by goods and services not exchanged in markets are called nonmarket benefits. An example would be the benefit received by an individual, or the increase in that individual's well-being, that might result from visiting a public beach or viewing a scenic coastal vista. Although the individual might be *willing* to pay for such sources of enjoyment, the fact that they are available outside of markets means that no payments are typically observed. As a result, alternative economic methods are required to measure these nonmarket benefits. Chapter 4 provides more details.

Like any tool, economic tools can be used incorrectly. Many economists—the authors included—have noted a disturbing trend toward incorrect or oversimplified uses of economics to support often predetermined policy goals. These faulty uses of economics can lead to inaccurate understandings of how natural and human systems interact and may promote actions that are not in the best interest of the public (actions that reduce long-term social welfare). Poorly applied economics can also lead to public outcry if policy outcomes adversely affect either public welfare or natural resources—or both. Hence, when considering various economic frameworks for policy evaluation, it is important to understand the type of information required by each framework and how each framework can guide policy.

Defining and Measuring Economic Values

Methods used to quantify relevant economic outcomes can sometimes be surprising to non-economists. For example, policymakers and the media often

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consider increases in employment (more jobs) to be an economic benefit. If modeled within an economic framework, however, employment increases are rarely considered an *economic* benefit of a project or policy. The reason is that if one consistently tracks both the benefits and costs associated with additional employment—and if the value of goods or services produced by newly employed individuals is measured appropriately elsewhere—then the benefits and costs of new employment wash out, leaving no additional net benefit of the created jobs. As a simple illustration, consider that the wages received by an employee (a benefit to the employee) are exactly offset by the wages paid by the employer (a cost to the employer). Although in reality the situation is somewhat more complex than this simple illustration, the common misperception that jobs are benefits illustrates that appropriate economic modeling does not always comport with common public understanding of what comprises an "economic" benefit or cost.[3]

Similarly, policymakers will often request information—for example, the "total" value of a very large ecosystem, such as the Chesapeake Bay—that is effectively meaningless from an economic perspective. Continuing the Chesapeake example, the nonsensical nature of "total" benefit measures relates to the lack of a consistent and meaningful baseline from which benefits or costs could be compared. Without a clear and detailed description of what it would mean to be "without" the bay in its entirety—something impossible to envision or characterize with any validity—measures of total value remain devoid of meaning. This lack of meaning has not prevented the publication of myriad reports that attempt to quantify exactly these types of values. The guidelines that determine the appropriate quantification of economic outcomes—be they economic impacts, benefits, costs, or other measures—are designed to promote consistent, comparable, and meaningful measures across policies and projects.

To illustrate the different ways that economists measure the effects of policy on public well-being, consider the relationship between economic values, economic impacts, and policy, as described by Bockstael et al. (2000):

> In economics, valuation concepts relate to human welfare. So, the *economic* value of an ecosystem function or service relates only to the contribution it makes to human welfare, where human welfare is measured in terms of each individual's own assessment of his or her well-being. Of course, this is not the only possible concept of value, nor is it always the most relevant. But for purposes of benefit-cost analysis in assessing policy options and for purposes of determining liability when natural resources have been harmed, this concept has considerable precedence as well as legal standing.[4]

Economic values or benefits are assessed only in comparative terms, relative to a well-defined baseline. They reflect the well-being of one or more individuals, such that "economic value of a policy change is defined by the amount

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(either positive or negative) of compensation that individuals would need in order to be as well off (by their own reckoning of well-being) as they would have been without the policy-induced change."[5]

Individuals or firms can realize economic benefits and costs. For individuals, benefits are generally measured as the maximum amount of other goods or services that the individual is willing to forgo in order to obtain the outcomes resulting from the policy in question. This reflects the individual's *willingness to pay* (WTP) for the policy change. Although WTP is often denominated in money units, it can be expressed in any unit of exchange. (For example, in some nations, cattle historically represent a common unit of exchange, and WTP could be denominated accordingly.) An individual's economic costs reflect the value of goods or services forgone as a result of the policy-induced change.

For producers or firms (e.g., shipping companies, commercial fishing vessels), the net benefits realized from production activity reflect the difference between earned revenues and production costs, over all units of a produced good or service. Revenues can be measured as a product of price and quantity sold. Production costs are often measured as the money spent to obtain production inputs, although more complex quantification methods can be required in a variety of circumstances, such as when inputs are unpriced (e.g., the labor of a company owner or the use of natural capital, such as timber, that is already owned by the firm). These and similar measures are well defined by economic theory and provide a systematic means of measuring the benefits and costs that come from a given policy.

Any activity (policy, recreation, manufacturing, etc.) that influences the quality or quantity of coastal or marine ecosystem services will likely generate benefits or costs to various groups. Hence, even the absence of EBM results in real and ongoing benefits and costs. Conversely, any set of guidelines, regulations, or incentive structures aimed at mitigating ecosystem impacts or restoring ecosystems will imply its own set of economic benefits and costs. Appropriate analysis of economic benefits and costs compares net social benefits in the *absence* of a specified policy to net social benefits in the *presence* of that policy. The difference represents the net social benefits (or costs) of the policy, as measured by CBA. When calculating this difference, it is also critical to isolate the changes in benefits or costs that are due only to the project in question, in addition to any changes that might occur in the absence of the policy. In contrast, CEA focuses on the cost side of the equation only, quantifying appropriately measured economic costs (or value given up) associated with various approaches to predetermined management goals.

When conducting or interpreting economic analysis, it is important to recognize the distinction between efficiency and equity (or benefit distribution). Efficiency relates to total or aggregated net benefits (benefits minus costs) realized by all affected groups. More efficient policies generate greater total benefits for all affected parties combined, compared to all available alternatives.

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Efficiency does not imply that all groups are better off, only that the combined benefits over all groups outweigh the combined costs. As typically implemented, CBA measures aggregate net benefits with the goal of promoting efficient policy, or policy that maximizes total net benefits aggregated over all groups. Policymakers may also consider impacts on equity, or the distribution of net benefits across different user groups. Although this is not a usual focus of CBA, the framework and methods can be easily adapted to answer questions related to the distribution of benefits and costs across different affected groups. Recognizing that different stakeholder groups are likely to derive different types of benefits, for example, CBA can be used to quantify tradeoffs among the net economic benefits received by different groups. This aspect can be particularly relevant when assessing EBM policies because these policies typically affect many different groups.

It is also important to recognize that economic benefits and costs are not necessarily related to compensation in dollars or other money flows. Increases in economic activity or payments do not always lead to economic benefits and may create hidden economic costs. Conversely, individuals can experience a change in real economic benefits or costs without any change in market-based economic activity or money payments. For example, the opportunity to view marine mammals such as whales can provide significant benefit to individuals, even if no money changes hands (e.g., if whales are viewed from shore or private boats). Recreational fishing or trips to the beach can provide similar nonmarket benefits. In these and many other instances, proper assessments of economic benefits and costs do not rely solely on measurements of pecuniary flows or market activities.

As an example of how measuring market activity alone can generate misleading inferences, consider a situation where a reduction in nutrients improves the water quality at recreational beaches and shellfish beds. These improvements might lead to negligible changes in market activities or money flows, but nonetheless could bring substantial benefits to local beach users. Conversely, disasters such as Hurricane Katrina (which caused extensive damage to the southern coast of the United States in 2005) can generate substantial economic activity (e.g., rebuilding damaged buildings and infrastructure), yet leave society much worse off.[6] Common economic measures of regional income, employment, and production—while seemingly simple to understand—cannot by themselves identify public policies that are in the long-term best interests of society.

In contrast, comprehensive assessments of the net benefits from EBM are generally complex and multidisciplinary, combining ecological and other natural science models with models of human behavior and welfare. The net benefits from any given policy depend not only on ecological and other parameters characterizing responses of natural systems (i.e., how the natural world responds to human activities) but also on the short- and long-term behaviors of various user groups. Complicating the analysis is the fact that EBM policies

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often have different effects on different groups—while many groups will gain from EBM policies, some may lose. An appropriate economic analysis recognizes these divergent effects.

EBM rarely incorporates all-or-nothing policies. (See chapters 6 and 7 for discussions of policy mechanisms.) Instead, it often involves relatively small changes in the activities or incentives facing various user groups. Economists refer to small changes as "marginal" changes; for example, the marginal benefit of catching a fish reflects the benefit of catching one additional fish on top of those already caught. Decisionmakers must consider whether a marginal policy change, such as closing an extra fishing area or constructing one more offshore wind turbine, will increase or decrease total net benefits to all groups combined. Because the marginal value of each additional EBM activity will differ, depending on management measures that are already in place, regulators must consider the net economic effects of successive small policy changes. Managers must balance, at the margin, the losses by sectors (or groups or individuals) whose activities are restricted (or whose resources are degraded) with the net benefits gained by all the others. As one moves farther from the margin, the accuracy of economic forecasts often declines (as do those of virtually any natural or social science model).

It is also important to understand the distinction between indicators of market or nonmarket activity and well-defined measures of benefit or cost. While economic values are often related to human activities, simple indicators viewed in isolation (e.g., number of beach visits) can sometimes provide misleading perspectives. For example, simple activity indicators ignore values realized by nonusers or benefits related to unmeasured activities (i.e., activities not captured by the indicator in question). Because of these and other limitations, indicators of economic activity sometimes increase due to negative changes in the environment. Suppose that closing local beach A due to pollution causes more people to visit neighboring unpolluted beach B. An analyst looking solely at visitor numbers for beach B might incorrectly conclude that this represents a positive change at beach B, when in fact more visitors to beach B simply reflects the closure of beach A (a substitute beach). Using the appropriate economic frameworks for analysis can prevent such misleading conclusions. Simple behavioral (and other) indicators can sometimes provide a cost-effective means to help guide policy—but they can also contribute to incorrect conclusions if not paired with more comprehensive economic analysis.

Subsequent sections of this chapter summarize various economic evaluation frameworks—CBA, CEA, and EIA, plus alternative non-economic analyses, such as EMERGY and embodied energy analysis—that can be used to inform EBM. Because this chapter focuses on frameworks for economic policy evaluation, there is greater coverage of CBA and CEA, techniques that are grounded in economic theory and can be used to prioritize management options based on social welfare.

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Cost-Benefit Analysis

Cost-benefit analysis is a subdiscipline of economics that is devoted to measuring social well-being. It measures net economic benefits received or lost by society or by various groups; its primary practical purpose is to assist decision-making by providing information on the gain or loss of net economic benefits. As described by Lipton and Wellman (1995), CBA is "a methodology that compares the present value of all social benefits with the present value of opportunity costs" associated with specified activities, policies, or resource uses. Here, opportunity costs reflect the value of the highest valued alternative given up in order to follow any given course of action—it is what we give up in order to obtain something else. The U.S. Environmental Protection Agency (2000) provided a similar description of CBA: "benefit-cost analysis evaluates the favorable effects of policy actions and the associated opportunity costs of those actions. The favorable effects are defined as benefits and the opportunities forgone define economic costs." In simple terms, CBA is designed to help resource managers make decisions that increase the net social productivity or benefits of society's resources. Under the general umbrella of CBA is a set of methods that measure economic benefits in a variety of conditions and for a variety of groups. CBA is also characterized by rules and guidelines for using different measurement methods and aggregating results from various methodologies.[7]

Conducting CBA involves careful development and application of studies, using one or more market and nonmarket valuation methods. (See examples of valuation methods in chapter 4.) The specific method used to estimate economic benefits depends upon the resource, good, or service of interest. For example, estimation of net benefits associated with the commercial harvest of red snapper (or any other fish) requires methods that quantify net benefits realized by producers and consumers in organized markets (i.e., related to the production and consumption of fish that are bought and sold). In contrast, estimation of recreational values associated with the same species typically requires nonmarket valuation methods that use data on recreational behavior to estimate anglers' willingness to pay, along with market valuation methods to estimate net benefits realized by commercial purveyors of recreational charter services. (Chapters 3 and 4 discuss these methods.) Although CBA methods were historically market based, the increasing recognition of nonmarket benefits and their relevance for policy has led to a large body of research on nonmarket valuation methods. As noted in chapter 4, much of what people value in ocean and coastal systems—including open space, attractive views, good beaches, clean water, and recreational uses of aquatic wildlife (e.g., fish, shellfish, marine mammals)—is not bought and sold in markets. Market analysis does not capture the value of these goods and services. Nonmarket valuation methods can therefore be critical components of CBA in coastal and ocean policy contexts and frequently are the only economic means available to assess certain costs and benefits of management actions.

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A full-scale CBA is often costly and time-intensive. Where time or budget constraints prohibit full-scale analysis, significant insight can still be gained through select analysis of specific areas of benefits or costs that are likely to be substantial or particularly relevant to the policy issue at hand. Most CBAs conducted by government agencies follow such a strategy, quantifying only a portion of the many benefits and costs associated with a policy change. To prevent major omissions in such cases, one must make particular effort to identify and quantify the primary areas of benefit or cost, leaving the smaller or more trivial effects unquantified or given only verbal characterization. One may also use more costly (and usually accurate) primary studies to estimate areas of benefit or cost expected to be the largest, and use benefit transfer to estimate others. As discussed in chapter 4, benefit transfer is the use of prior research conducted elsewhere (the study site) to approximate benefits or costs for a site at which policies will be implemented (the policy site).

The net economic benefits realized by various groups will also depend on the future state of the world—information that may be unavailable at the current time. Accordingly, a CBA will often assess the roles of risk and uncertainty in determining the net economic benefits—either in the aggregate or as realized by specific groups. In many cases, uncertainties mean greater potential economic consequences (gains or losses) to some groups than to others. (See chapter 5 for more discussion of decisionmaking under uncertainty and more formal definitions of risk and uncertainty.)

Although details vary across policy contexts, most applications of CBA share a set of common attributes. These include a foundation in established economic theory, the use of accepted methods for quantification of benefits and costs, incorporation of uncertainty, and discounting of future impacts. (Discounting allows meaningful intertemporal comparisons of benefits and costs. See the subsection "Discounting and the Time Value of Money," below.) CBAs also follow similar steps, regardless of application. Table 2.1 summarizes the steps of a full-scale CBA as two recent works define it: they categorize CBA components differently but include the same activities.

Within the context of EBM, large-scale policy changes are likely to generate benefits and costs for a wide range of user (and nonuser) groups. Each affected group may realize various types of market and nonmarket benefits and costs that should be counted in CBA. It is important, however, to be aware of cases where apparent benefits or costs must be *omitted* to avoid double counting and other biases. (See the subsection "Secondary Effects in CBA.")

Methods for Market and Nonmarket Valuation

Total economic value is generally composed of a number of different types of market and nonmarket values, associated with different aspects of natural resource goods and services. As mentioned above, benefits and costs may be realized both through activity in organized markets (market benefits and costs) and through

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changes that do not occur in markets (nonmarket benefits and costs). The primary difference between market and nonmarket benefits (or costs) in CBA is the methods available to measure them. Methods that assess net economic benefits differ depending on the source of the net benefit and the group receiving the benefit. These include established methods based on analysis of consumer and producer behavior in markets (market valuation), and methods designed to estimate values that are not reflected in organized markets (nonmarket valuation).

To understand the difference between a market and nonmarket benefit in conceptual terms, ask whether the benefit—or the commodity (good or service)—that directly provides the human benefit can be purchased in an organized market. Fish for human consumption is a market good; one obtains benefits by purchasing this good directly in a market. The fish provides the benefit and is also the commodity, which is purchased. Water quality at a beach used for recreation, in contrast, provides nonmarket benefits; in this case, benefits from water quality are realized through the allocation of time and other resources to beach recreation. These benefits cannot be directly purchased in a market, and hence market prices and quantities alone cannot be used to estimate them.

Both market and nonmarket valuation techniques are based on an internally consistent model of human welfare that allows resulting benefit and cost measures to be aggregated and/or compared. The theoretical basis of this model allows one to link estimated monetary values (e.g., benefits, costs, and willingness to pay) with the well-being of individuals, households, or groups. The linkage implies a utilitarian perspective to human behavior that, after considering the pros and cons of all options, humans choose behaviors that are expected to provide them with the greatest long-term satisfaction or utility. The related theory of human value and behavior—called neoclassical welfare economics—distinguishes economic analyses and measurements of social value from those of all other social sciences. It has also led, at least indirectly, to the important role that economic assessments of benefits and costs play in government policy decisions; when estimated appropriately, economic benefits and costs can always be interpreted and compared using the same consistent framework. Whenever one measures economic benefits or costs, one is relying at least implicitly on the same underlying theoretical structure.

Chapter 4 discusses nonmarket valuation in more detail. These valuations employ carefully designed methods that measure values where markets do not provide the price, quantity, and other data necessary to measure values. Market valuation, in contrast, uses often simple supply and demand patterns—easily observed in markets—to estimate values derived by both consumers and producers of valued products. Because time or budget constraints sometimes permit only a few market or nonmarket valuations for any particular policy question, the choices among competing approaches can have critical implications for the benefits and costs that are estimated. As a result, policy analysts must have sufficient understanding of the economic methods that may be employed for coastal policy issues, as well as the implications for specific type of values that are measured.

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TABLE 2.1 STEPS IN A COST-BENEFIT ANALYSIS

CBA steps *(from Lipton and Wellman 1995)*	CBA steps *(from Boardman et al. 2001)*	Description
1. Specify the program.	1. Specify the set of alternative projects. 2. Decide whose benefits and costs count.	This component of CBA includes a characterization of the baseline or status quo conditions, as well as the various policy alternatives that are under consideration. This component also includes decisions regarding those groups that should have standing (or whose benefits should count) within the analysis. This component is often conducted with substantial input from policymakers and other non-economists.
2. Describe quantitatively the inputs and outputs of the program.	3. Catalog the impacts and select measurement indicators. 4. Predict impacts quantitatively over the life of the project.	This component of CBA includes describing and quantifying both the physical and behavioral impacts (inputs and outputs) of the various policy alternatives relative to the status quo (i.e., what would happen in the absence of policy). These may include both direct and indirect impacts, but only those that affect human well-being. This set of steps often requires substantial input from non-economists, including natural scientists, engineers, and others.
3. Estimate benefits and costs.	5. Monetize (attach dollar values to) all impacts. 6. Discount benefits and costs to obtain present values.	This component includes many of the primary economic elements of CBA, in which economic values are assigned to each quantified input and output identified in prior research steps. This may include various methods for market and nonmarket valuation, depending on the resources and uses affected. Monetized values are then discounted to account for the time value of impacts (or money).

Continued

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TABLE 2.1 STEPS IN A COST-BENEFIT ANALYSIS *(Cont.)*

CBA steps *(from Lipton et al. 1995)*	CBA steps *(from Boardman et al. 2001)*	Description
4. Compare benefits and costs.	7. Compute the net present value (NPV) of each alternative. 8. Perform a sensitivity analysis. 9. Make a policy recommendation based on NPV and sensitivity analysis.	The final steps in a CBA combine aggregated, discounted benefits and costs to generate a final present value or net benefit (positive or negative) of the various project or policy alternatives. From an economic efficiency standpoint, alternatives with greater net benefits are preferred. This last stage may also include analysis of distributional impacts, or benefits and costs to different affected groups. Sensitivity analysis may be conducted at this stage to account for areas in which risk exists, to show the potential effects of different future possibilities on CBA results. One may also calculate expected values or option prices, where possible and appropriate, to address risk.

Demand and supply curves, such as those in figure 2.1, can be estimated using statistical analysis of historical price and quantity patterns, combined with additional market data (e.g., the income and demographics of consumers). Although the example of the softshell clams in figure 2.1 is an uncomplicated hypothetical case, analysis of more complex instances often includes straightforward extensions of the simple model illustrated here.[8]

Secondary Effects in CBA

Occasionally EBM policies that affect one market (e.g., softshell clams) may affect prices of other goods or species (such as scallops), solely due to market forces. For example, if clams become more scarce (and, hence, more expensive) due to a change in EBM policy, consumers may instead purchase different shellfish, such as scallops or oysters. This places upward pressure on the prices of these substitute products—in other words, it affects their prices and causes the prices to rise. In general, apparent benefits or costs related to these secondary price or quantity changes should *not* be counted in CBA. The rationale lies in the concept of double counting. *If one appropriately measures net benefits in primary markets, these measurements have already captured effects in secondary markets.*[10] Measuring effects in secondary markets most often double counts the same benefits or costs, which will bias the measure of benefits and can potentially misinform policy decisions. Although secondary effects may be important from an equity

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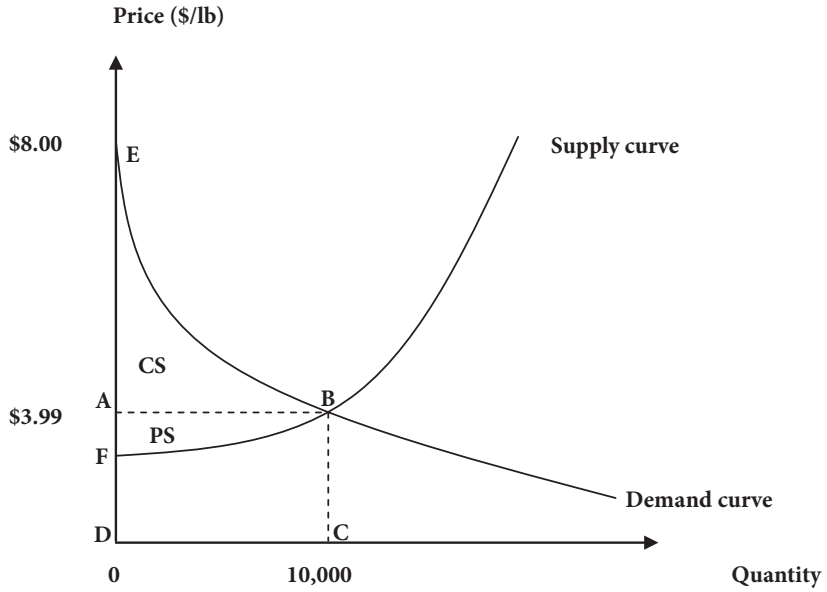
FIGURE 2.1 MEASURING BENEFITS TO CONSUMERS AND PRODUCERS USING A MARKET MODEL: A HYPOTHETICAL EXAMPLE OF SOFTSHELL CLAMS (STEAMERS)



As a straightforward example of empirical techniques for measuring *market values*, figure 2.1 shows a simple market supply-and-demand model of a stylized market for softshell clams, or steamers. The *demand curve* shows the number of pounds of steamers that the hypothetical consumers will purchase, based on the current market price (in dollars per pound). The demand curve also shows the amount that consumers are *willing to pay* for each additional pound of steamers, based on the total quantity purchased. The area underneath the demand curve represents the total willingness to pay for all pounds consumed. The *supply curve* shows the quantity of steamers that the producers will provide, which is also determined by the current market price. The intersection of the supply and demand curves shows the market-clearing or *equilibrium price*, which is the price expected to occur in free markets.

The difference between the amount that a person or group is willing to pay to obtain a particular product and the amount that is actually paid is defined as *consumer surplus* (*CS*), and represents the net economic benefit obtained by the individual or group. Given the market price of $3.99 per pound in figure 2.1, consumers will purchase 10,000 pounds of steamers and will pay the same amount ($3.99) for each pound purchased. The total amount that consumers will spend is $3.99 × 10,000 pounds = $39,900. The rectangle *ABCD* shows this expenditure. However, the total amount that consumers would have been willing to pay for these clams is given by the entire area underneath the demand curve, between 0 and 10,000 pounds on the graph, in the roughly triangular area *EDCB*. Subtracting what the consumers actually pay (*ABCD*) from what they would be willing to pay (*EDCB*) for 10,000 steamers gives an estimate of the benefits gained by consumers. This area, *EBA*, is the consumer surplus. Think of it as a measure of "unpaid-for benefits," or the difference between costs and benefits for consumers.

Benefits to producers (here, the suppliers of softshell clams) are calculated as the *difference between total revenues and production costs*. In this simple case, the producers' revenues are the same as consumer expenditures—area *ABCD* ($3.99 × 10,000 pounds = $39,900). Economic theory states that the area underneath the supply curve also indicates the total (variable) cost of producing steamers. This total cost is equal to area *FBCD*. Hence, the difference between revenues and costs is equal to area *ABF*, which is the *producer surplus (PS)*. This is the economic measure of benefits received by producers and is conceptually similar to profits.[9]

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perspective, they should—in general—not be counted in aggregate net social benefits. This is a very common mistake made by inappropriate economic analyses—they seek to count both primary and secondary effects, and consequently double count the same benefits (or costs).[11]

Likewise, secondary support industries may also see changes in economic activity due to price or quantity changes in the primary market. For example, in the market for softshell clams, there may be secondary effects on the firms that supply fuel, process the catch, repair boats, and offer other needed services to fishing vessels. When a beach is nourished,[12] there may be secondary effects on local restaurants and hotels as the number of beach visitors increases. Again, these secondary effects should generally not be counted in cost-benefit analysis. Similarly, changes in the revenues of fish markets or other firms in the supply chain are generally secondary effects; instances when such effects should be counted are rare. This assumes, of course, that all primary effects have been properly measured.

As discussed by Boardman et al. (2001), the theory explaining why secondary effects should not be included in CBA can sometimes be complex. However, the basic intuition is often quite simple. To help clarify this point, Johnston and Sutinen (1999) used an example of recreational fishing to explain why CBA should *not* include secondary effects on hotels, restaurants, and other businesses. Individuals often change from one form of recreation to another (substitution). For example, if they do not go charter fishing (say, for sea bass), they may spend their time hunting, camping, or hiking. Accordingly, if recreational sea bass fishing increases in one community, then anglers spend more money in that community's hotels, restaurants, and other establishments. Such an increase will almost always be offset by revenue losses (of hotels, restaurants, and establishments) in another community with different recreation opportunities. This is because the individual has substituted time spent in the recreational fishing community for time that would otherwise be spent in a community with hunting or trout fishing (different species), for example. The financial gain by one area's secondary businesses is generally offset by financial losses elsewhere. When one properly accounts for all secondary effects in both communities, the net economic benefit of this shift is, most times, very close to zero.[13] Given such patterns, which are ubiquitous throughout the economy, appropriately conducted CBA does not consider secondary effects. Indeed, if secondary effects were included, the result would be an upward bias, or overestimation, of changes in net economic benefits.

Although it is appropriate in economic terms to ignore secondary effects in CBA, regional policymakers often have a political economy motivation to assess these effects, especially if they affect aggregate *economic activity* in their jurisdiction. EIA can aid such analysis and may be an important consideration when policymakers value regional economic growth or activity. However, it is important to note that such measurements of secondary impact should not be interpreted as indicators of net economic benefit; rather, they are measures of

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aggregate economic activity. (These and other details of EIA are discussed later in this chapter.)

Benefits and Costs to Different User Groups: An Example from Essential Fish Habitat Regulation

This section and the following subsections highlight examples of the type of benefits and costs that should be measured by an appropriate CBA, as well as those that should be omitted. The issues are framed in a policy scenario influenced by EBM—the case of essential fish habitat (EFH) regulations in fisheries.

The examples come from Johnston et al. (2003) and illustrate the appropriate application of CBA to designate and minimize adverse effects on EFH under the 1996 Sustainable Fisheries Act (Public Law 104-297). Although policies designed to protect EFH represent only one component of EBM, they may nonetheless lead to nontrivial benefits and costs to a variety of groups. Related policies may also have impacts that, while commonly associated with economic benefits or costs, should not be incorporated within an appropriate CBA. Although these examples deal with EFH regulations, similar rules and patterns also apply to a wide range of potential policies falling under the general umbrella of EBM.

For simplicity, these examples present a static perspective on benefits and costs during a single time period. Clearly, appropriate renewable resource policy addresses dynamic aspects of resource use and renewal over time. A full-scale assessment of fisheries policy, for example, would combine the measurement of net benefits (outlined below) with suitable economic-ecological models. These models quantify the linkages between economic behavior and ecological systems, together with implications of these linkages for dynamic changes in economic net benefits over time. (See chapters 3 and 4 for discussions of economic-ecological models.)

Table 2.2 summarizes the calculation of net economic benefits realized by different groups in a hypothetical EFH policy scenario. The subsections below discuss ways in which each of these groups can be affected and how one measures associated benefits. Note that secondary effects on commercial fishermen, vessel owners, and fishery support industries are not included, and that certain indicators, such as the number of fishermen employed, are also missing. While the creation of jobs may be desirable from a variety of perspectives—and may represent an informative *economic indicator*—it does not usually represent an economic benefit that is counted in CBA. As a general rule, changes in employment alone are not—and do not result in—economic costs or benefits.[14]

Net Benefits to Commercial Fishermen

Long-term net economic benefits in the commercial fishery are measured as a change in fishing profits, which are equal to total ex-vessel revenues[15] (from

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TABLE 2.2 GROUPS REALIZING NET ECONOMIC BENEFITS IN A HYPOTHETICAL EFH POLICY SCENARIO

Group affected by EFH policy	Measurement of net benefits
Commercial fishing vessels	Change in *economic profits* = change in *total revenues* minus *total costs*. Alternatively, the change in producer surplus = change in *total revenues* minus *total variable costs*.
Recreational (e.g., charter) vessels	Change in *economic profits* = change in *total revenues* minus *total costs*. Alternatively, the change in *producer surplus* = change in *total revenues* minus *total variable costs*.
Recreational anglers	Change in consumer surplus = change in *willingness to pay* minus *actual expenditures* for fishing.
Seafood consumers	Change in *consumer surplus* = change in *willingness to pay* minus *actual expenditures* for seafood products.
Land-based businesses	Change in *economic profits* = change in *total revenues* minus *total costs*. Alternatively, the change in *producer surplus* = change in *total revenues* minus *total variable costs*.
Other consumer and producer groups (e.g., divers, other marine/coastal users, and residents, etc.)	Benefits and costs may include changes in consumer surplus and/or nonuse values, where significant. Businesses that also *directly* benefit from improved habitat (e.g., dive operators) may realize additional producer surplus. Other businesses whose activities are constrained directly may lose producer surplus.

the sale of fish products) minus the total costs related to fishing activities. This measure of *net economic benefit reflects the difference between economic costs and economic benefits*. In general, it is *not* equivalent to other single economic indicators, such as vessel expenditures, fish landings, ex-vessel revenues, etc. In the case of EFH, there are generally two groups of commercial fishermen (they may overlap) impacted by policy changes: 1) fishermen who benefit from a fishing activity that inflicts damage on the EFH and 2) fishermen who harvest species that rely on the habitat protected by EFH policy.

Fishermen Who Benefit from Activities That Damage EFH: Certain fishermen benefit from behavior (e.g., using mobile fishing gear, such as dredges or bottom trawl nets, in vulnerable habitat) that damages fish habitat—usually in terms of higher profits or *producer surplus.* For these groups, EFH restrictions

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in most cases 1) reduce their harvest and resulting ex-vessel revenues, 2) increase their resource costs associated with fishing, or 3) both. As a result, the net benefits received by this group of fishermen will likely decline when the EFH designation is imposed. The actual change in net benefits depends on a variety of factors, including but not limited to the particular EFH restrictions imposed; the availability of alternative fishing methods, areas, or species; entry and exit in the fishery; reactions of the biomass to reduced fishing pressure; and changes in market prices related to reduced supply.[16]

Fishermen Who Harvest Species That Rely on Protected EFH: Some fishermen's livelihoods are harmed when fishing or nonfishing activities damage EFH upon which their target species depend. EFH policies are designed to reduce habitat damage and consequently improve the growth, recruitment (reproduction and maturation), or sustainable stock size of particular species. Hence, for this group of fishermen, EFH restrictions are designed to 1) increase potential harvest and resulting ex-vessel revenues, 2) decrease costs associated with fishing, or 3) both. As a result, with EFH restrictions, the net benefits received by this group increase, ex-vessel revenues will generally increase, and fishing costs will often decline. The ultimate change in net benefits depends on a variety of factors, including but not limited to the effectiveness of the EFH restrictions in improving habitat, entry and exit in the fishery, fishery management mechanisms in place, reactions of the biomass to improved habitat, and changes in market prices related to increased supply. However, if the habitat recovers slowly, there might be a significant delay before these fishermen realize benefits.

Net Benefits to Fish Consumers

Consumers of seafood products benefit when prices decline, when product quality improves, or when availability (supply) improves. Typically, because price, quality, and availability are related (changes in product quality or availability are expected to influence price, for example), any changes will occur simultaneously and will manifest as shifts in either or both the market supply or demand curve. Appropriate CBA will measure net benefits to the final consumers of fish (for whom price, availability, or quality are affected by EFH regulations)—as long as these changes represent a *primary effect* of the new EFH policy. Primary effects are related to direct changes in the cost or efficacy of fish harvesting, either positive or negative, and these effects carry through to the consumer market in terms of price changes. The resulting net benefits to seafood consumers are typically measured as changes in *consumer surplus*, or the difference between what consumers are willing to pay to obtain seafood products and what they actually pay in the market. (Note that net benefits to consumers are not equal to their total expenditure on seafood products.) EFH gear or area restrictions often increase the cost of harvesting or reduce harvest efficiency of the fishing activity that otherwise would damage habitat; this is a primary effect. Net benefits or costs (i.e., changes in consumer surplus) caused

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by resulting price changes in consumer markets should be counted in CBA. Presumably, the EFH regulations will benefit other species, resulting in decreased harvest cost or increased efficiency for other fisheries. This, again, is a primary effect, and resulting price changes at the consumer level will result in net benefits that should be measured using standard market analyses (i.e., of demand and consumer surplus).

Net Benefits to Recreational Vessel Operators (Charters or Party Boats)

Although recreational charter vessel operators and commercial fishermen work in different sectors and provide different products, their net economic benefits are measured the same way. Net economic benefits to charter vessels are equal to total revenues associated with providing recreational fishing opportunities (i.e., revenues received from anglers) minus the total resource costs of providing these fishing activities (e.g., fuel, labor, docking, and other costs). Just as with commercial fishermen, some recreational vessels may lose net benefits because of EFH restrictions, while others may gain. Given that EFH restrictions are typically placed on commercial activities that damage habitat, such as dredging and otter trawling, one might expect to see net economic gains in the recreational fishery.[17] Beneficiaries of such policies include vessels that directly harvest species that rely on EFH, including recreational vessels. However, note that recreational charter vessels only realize net economic benefits if the EFH protections result in either increased revenues or decreased costs. Changes in harvest rates alone are not sufficient to alter net benefits to charter vessels because charter vessels' profits are not directly related to harvest but rather to the number of anglers served. Also, note that changes in economic benefits in the charter sector are not equal to changes in revenues alone.

Net Benefits to Recreational Private-Boat Anglers

Economic value received by recreational anglers is subjective; it is equal to the amount that an individual would be *willing to pay* to obtain a recreational fishing experience minus what the angler *actually pays*. This difference represents the net benefit that the recreational angler realizes. For example, if an angler is willing to pay $500 for a fishing trip and the actual cost of the fishing trip is $200, then the angler realizes a net economic gain of $300.

Why is total expenditure not equal to economic value? In the same way that the price of a good does not represent consumer surplus, the actual expense of a fishing trip (price of the trip) does not represent the net benefits of the trip. If EFH policy changes either the amount that an angler is willing to pay for a fishing trip or the amount that the angler actually pays, then the net benefits received by anglers will change. This change in net economic benefits should be counted in an appropriate CBA.

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Net Benefits to Land-Based Firms

When land-based firms are restricted by EFH policy, the change in economic benefits to these firms should be incorporated in an appropriate CBA. For example, if a power plant has to restrict the intake or outflow of water it uses for cooling to protect fish habitat, then it is appropriate to measure and count the net costs that are imposed on both the power plant owner and its customers. As above, the net benefits to land-based firms are equal to total revenues minus total costs. Changes in net benefits to consumers are measured as changes in consumer surplus, as above. It is important to note that only *primary or direct effects* on land-based firms should be addressed, such as when EFH or other habitat regulations directly affect the activities of a firm. Secondary effects, like those for the commercial fishermen, should not be included in an appropriate CBA.

Other Benefits and Costs from EFH Policies

EFH policies may have direct economic effects on those not involved in fishing. Because appropriate economic analysis accounts for all social benefits and costs within the predefined region of interest, these nonfishery net benefits should, at least in theory, be measured. Whether they are measured in practice often depends on their size relative to net benefits (positive or negative) realized in the fishery and data availability.

For example, actions to preserve EFH may increase the food supply for local birds (i.e., juvenile fish) that are in turn valued for hunting or viewing. Similarly, EFH policies that prevent trawling or dredging on the seafloor may—in limited cases—benefit certain user groups, such as recreational divers. In such cases, economic benefits may be realized by hunters, bird-watchers, or divers in the form of increased consumer surplus, and measured as the difference between what these groups are willing to pay to hunt, bird-watch, or dive minus what they actually pay. Other individuals may also realize *nonuse* or *passive-use benefits*, defined as a change in well-being that is unrelated to any active use of a resource or observable behavior.[18] For example, some individuals may benefit from simply knowing that healthy fish stocks are being passed on to future generations, aside from any actual or planned use of these resources. Depending on the policy context, nonuse values may be either smaller or larger than other types of economic value, and are no less legitimate from an economic perspective.

Similarly, policies that establish marine protected areas for the purpose of habitat protection may have wide-ranging impacts on a variety of user and nonuser groups, including recreational divers, boaters, etc. While these groups may not participate in local fisheries, changes in their net economic benefits—where significant—should be addressed by appropriate economic analysis.

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Discounting and the Time Value of Money

In most cases, the benefits and costs of projects occur over many years. To account for the time value of money in aggregating multiyear benefits and costs, CBA applies an approach known as *discounting*.[19] This is similar to methods used to assess the market value of a business that provides a flow of revenues every year. Just as a bank recognizes the time value of money by charging borrowers interest, a CBA must recognize the time value of benefits or costs by discounting those received in the future. For example, the (present) value of a business is the sum of all the expected cash flows generated by that business—in essence, someone who purchases the business is paying now for the opportunity to make income in the future. However, people usually will not pay a whole dollar today for the opportunity to obtain a dollar in the future. Future cash flows, then, are worth less than present cash flows, which reflects the time value of money. As a result, future cash flows (or benefits and costs) must be *discounted* in order to make them comparable to cash flows today.

Assuming that time is counted in discrete units and discounting is calculated accordingly, a simple formula for the present value (PV) of a future payment of $\$X$—what that future payment is worth today—is given by

$$\text{PV} = \frac{\$X}{(1+r)^t},$$

where r is the discount rate per time period in decimal notation (i.e., 6% = 0.06) and t is the number of periods into the future when the payment will be received. Using this formula, a discount rate of 6% means that a dollar to be received next year is worth 94.3 cents today, a dollar to be received two years from now is worth 88.9 cents, and a dollar to be received 20 years in the future is worth only 31.2 cents today. Adding up all the (discounted) future benefits and costs associated with a project, over all time periods, results in the *net present value* (NPV) of the project. An NPV greater than zero implies that the discounted benefits exceed the costs (a good investment), and an NPV less than zero implies that the discounted costs exceed the benefits (a bad investment).

Although discounting is the most appropriate means of aggregating benefits and costs over time, it can lead to unintended consequences when assessing projects with very long time horizons. For example, if one uses common discount rates between 4% and 10%, then benefits or costs in the distant future (e.g., 50 to 100+ years) often have little impact on NPV. At a discount rate of 6%, a 1-dollar benefit to be received in 100 years is worth less than 1 cent. For this reason, researchers have proposed a number of alternative discounting approaches for project with long-duration effects. One approach is *sensitivity analysis*, where one assesses the NPV of a project under a variety of different discount rates to evaluate the impact of different discount rates on CBA results. Other options may include a time-declining rate of discount, which

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might begin at a standard 4%–10% value and then decline slowly over time. For most projects, however, standard discounting procedures will generate the most accurate reflections of true economic benefits and costs.

Limitations of CBA

As discussed above, CBA is the appropriate means to assess net economic benefits from EBM policies. However, actual quantification of these net economic benefits may sometimes pose empirical (and some conceptual) challenges. As with all forms of empirical research, the quality of the results depends on the quality of the data and analysis methods. CBA is also reductionist, in that it collapses often complex and multidimensional policy changes into a small set of (often monetized) results. Moreover, the use of CBA implies a set of testable and untestable assumptions—many are associated with utilitarian theories of value and an ability to link willingness to pay to social welfare—that may not apply in all circumstances. For example, CBA presumes that individuals engage in well-informed behaviors that maximize their well-being, so that observations of behavior (e.g., alternatives that are chosen or not chosen) provide insight into human value and welfare.

The following sections discuss other important characteristics and limitations of CBA and identify attributes that may be used to identify unreliable or invalid analysis. This section is not meant to provide a comprehensive list of all potential limitations of CBA in all circumstances, but rather to highlight some of the primary limitations of which those using CBA methods should be aware.

Distribution and Equity Implications of CBA

CBA analysis can assess net benefits and costs for different groups affected by policy decisions, as well as the distribution of benefits and costs within an affected group. However, in practice, CBAs typically report the average benefit received by a representative group member, even if the representative member is part of a heterogeneous population. For example, a typical CBA might report the gain in average producer surplus or loss of an average commercial fisherman, without considering the differences in impact between a fisherman from a small rural community and one operating out of an urban center. However, given the uneven distribution of policy benefits among fisheries and fishermen, such aggregate net benefit measures might provide an inadequate representation of policy effects. Alternatively, a CBA might estimate the average impact of an offshore wind energy facility on the well-being of coastal property owners, without explicitly recognizing that its impacts will differ across individual owners. Policymakers often wish to consider both the total benefits of a policy and the distribution of benefits across regions and population groups. This requires information concerning who receives the benefits from a particular policy and where those individuals are located.

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Often because of data limitations or concerns that equity issues are outside the scope of the analysis, some CBAs obscure ways in which benefits of natural resource policies are distributed. Despite this tendency, available CBA tools do allow economists to assess the distribution of benefits across relevant population groups and subgroups—given such information, resource managers may consider these distinct sets of net benefits when making policy choices. The advantage of such an approach to CBA is that it can show how benefits are explicitly distributed among affected groups. Such approaches, however, often add to the complexity and cost of the analysis and may require data that are not readily available.

Another potential complication associated with the use of CBA to address benefit distribution is that it raises often difficult questions that resource managers must address. For example, policymakers must decide whether benefits to different groups will be given equal distributional weight in the analysis. For example, some policymakers might argue that greater weight should be given to the net benefits received by commercial fishermen (whose livelihoods depend on fishing), compared to recreational anglers (whose benefits are related to recreational activities). Economists generally resist such arguments, and give equal weight to net benefits received by all concerned groups. Policymakers, however, may wish to emphasize benefits received by specific groups (e.g., those with less income); such choices will affect the outcome of a CBA.

Measurement Issues in CBA

Like measurements in any empirical science, economic measurements may be subject to inconsistencies or errors. Simple errors in CBA arise for many reasons. One common source of error is inaccurate data, such as errors in the observation, recording, or interpretation of events. Clearly, any such measurement errors will carry over into CBA results, leading to potential bias. Another set of potential errors may occur in forecasting future events or trends. For example, assessments of producer and consumer surplus for various products depend on an accurate estimate of prices as they will exist at the time of the policy change. Accordingly, if future prices shift unexpectedly, earlier surplus estimates will not produce accurate estimates of net economic benefits. Not surprisingly, economists cannot predict the future conditions with certainty, and ex ante CBA results are generally conditional on at least some assumptions made about the future. Inappropriate behavioral or model assumptions by researchers can also generate potential errors.

Additional potential measurement errors can come from specific market and nonmarket valuation methods, including a variety of revealed and stated preference methods, discussed in chapter 4. Each valuation method has a large and growing literature supporting it. Although discussion of the potential errors associated with each of the existing methodologies is beyond the scope of this chapter, resource managers must be aware that improperly conducted market

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or nonmarket valuation assessments can result in biased benefit estimates. Accordingly, valuation research must be conducted according to stringent quality standards and guidelines. (Chapter 4 provides additional information.)

In summary, CBA is capable of generating valid, accurate, and reliable benefit estimates and/or approximations, but it is also subject to possible measurement errors and other biases. The validity and accuracy of CBA results depend on the quality of the underlying analyses and the data used by those analyses.

Intrinsic and Other "Non-economic" Values

Assessment of net economic benefits provides an anthropocentric, or human-based, view of value. When valuation estimates the monetary value of natural resource damages, for example, one assumes that the resources only have value insofar as they provide services that people directly (or indirectly) value. Some individuals may find such assessments incomplete or misleading because they fail to consider "intrinsic" values, or values apart from those held by people. For example, some ecologists argue that nature has a "value" unto itself—apart from any human perception or sense of its worth. The potential legitimacy of such arguments aside, CBA only measures anthropocentric benefits or costs—those realized by humans. Anyone seeking to incorporate "intrinsic" or other concepts of value into policy deliberations must look to other, non-economic frameworks for guidance.

CBA tools are also poorly equipped to deal with moral, religious, and cultural issues. For example, it may be empirically difficult (although perhaps not theoretically impossible) to measure the net economic benefit associated with the culture of a fishing community or the religious, sacred, or cultural value that some cultures place on natural resources (e.g., the value that some native American tribes place on salmon runs in the western United States). In addition, legitimate economic effects may cause social impacts that are difficult to assess using CBA. For example, the collapse of a commercial fishery in a rural village and the accompanying large-scale unemployment might lead to increased local rates of alcoholism or other social problems. Where such concerns arise, CBA may provide an incomplete assessment of all factors relevant to management, but remains the tool of choice for measuring net economic benefits. In such cases, however, policymakers might also wish to consider the large variety of non-economic tools that can be applied to such issues.[20]

Cost-Effectiveness Analysis

Sometimes it may be unnecessary or impractical to estimate benefits associated with EBM alternatives. At times, for example, policymakers may conclude that the need to establish an ecologically safe minimum standard trumps the need to optimize net social benefits—particularly where long-term human

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effects on ecological systems are uncertain.[21] In these and other cases, CEA may be more appropriate, useful, and practical than CBA. Moreover, many of the most difficult challenges in CBA concern the measurement of benefits associated with difficult-to-observe or quantify changes in nonmarket goods, services, or resources. The use of CEA eliminates the need to measure these benefits.

CEA estimates the costs associated with various options for achieving stated and given goals, and identifies those that are most cost-effective (that cost the least to implement). CEA "compares (mutually exclusive) alternatives on the basis of the ratio of their costs and a single quantified but not monetized effectiveness measure."[22] This is an important distinction from CBA, which compares benefits and costs as a means of determining which goals are most socially beneficial. With CEA, the goals have already been identified—and the sole purpose is to find the most cost-effective means of realizing those goals. For example, one might estimate the least-cost means of ensuring the future survival of the North Atlantic right whale with a certain ecological degree of certainty, or the least-cost means of maintaining a certain area of beach for recreational use.

CEA is frequently applied in cases where policy goals are not based on economic grounds. For example, in evaluations of competing pharmaceutical products, a primary consideration is often cost per life saved—the goal of saving lives is a given. Similarly, in cases where irreversible ecological consequences are possible (such as extinction of a species), policymakers may desire information on the least-cost means of achieving a given preservation goal (preventing extinction). Still other examples involve specific objectives established by statute.

Aside from these primary distinctions, CEA shares many of the same methods as CBA. Both CBA and CEA are based on neoclassical welfare economics to validate methods and estimates; both assess impacts on humans, and the same guidelines for appropriate cost estimation apply to both. Although CEA is often more straightforward than CBA (because benefits need not be monetized), there are different types of CEA and associated choices that confront analysts. One of the primary choices involves whether the CEA will be sensitive to scale. This, in turn, relates to the definition of the established policy goal(s). In some instances, policy goals are highly specific; this includes specificity with regard to scale. For example, the policy goal may be to restore 50 acres of beach for recreation on a given site. Here, the scale is specified (50 acres of beach), and the sole question is which management approach will meet this goal with the least cost. This is the simplest form of CEA.

However, the policy might also stipulate goals without precise details as to scale. What if the goal is to restore a beach or wetland and does not specify the number of acres? In such cases, CEA might calculate the average cost per unit of effectiveness, or the average cost per acre of beach maintained. Projects can then be judged according to their cost-effectiveness per acre of beach restoration, on average. (This approach, however, faces difficulties when projects

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have different scales.) Consider the three mutually exclusive options for beach restoration illustrated in table 2.3.

The simple example in table 2.3 shows how issues of project scale can be critical to proper interpretation and use of CEA results. Analysts who use such methods must decide whether they want the most cost-effective approach, regardless of policy scale (e.g., cost per acre), whether they wish to set a minimum possible scale for the project (cost for a project of at least 50 acres), or whether they want to set a limit on the project budget (the most cost-effective project that costs less than $250,000).

The steps of a CEA are relatively similar to those of a CBA, but notice that table 2.4 omits information regarding policy benefits. This is because CEA takes the policy goal as given. However, it is important to note that, in some cases, the *costs* assessed within a CEA may be *benefits lost* by a user group because of a policy change. These are opportunity costs. When nonbudgetary or nonfinancial opportunity costs (costs that do not affect the money cost of a project) are significant, CEA does not eliminate all difficulties associated with these hard-to-measure benefits or costs. A common and potentially misleading solution with many CEAs is to ignore nonbudgetary costs. When nonbudgetary costs are small, ignoring them may still provide an acceptable approximation of true project cost-effectiveness, but it can result in substantial biases if these costs are large.

Note, too, that CEA in many cases incorporates similar mechanisms as CBA to address issues, such as the time value of costs and uncertainty in final project outcomes. For example, CEA discounts future costs, just as CBA discounts future costs and benefits. Similarly, CBA and CEA can apply identical methods to account for risky or uncertain project outcomes, particularly

TABLE 2.3 COST-EFFECTIVENESS OF HYPOTHETICAL BEACH RESTORATION OPTIONS

	Beach restoration *Option 1*	Beach restoration *Option 2*	Beach restoration *Option 3*
Acres restored	50	50	20
Total cost ($)	$500,000	$600,000	$100,000
Cost per acre (cost-effectiveness)	$10,000	$12,000	$5,000
Cost per 50 acres	$500,000	$600,000	N/A*

* Assumes that projects may not be duplicated; hence option 3 can restore a maximum of 20 acres.

As shown by the table, the most cost-effective policy depends on what scale one uses to measure cost-effectiveness. On a cost-per-acre basis (cost-effectiveness), option 3 is preferred, with a cost per acre of $5,000. If the policy goal is to restore beach acres using the most cost-effective means, choose this option. However, if the goal is 50 acres of restoration, the most cost-effective approach becomes option 1. Option 1 is not the most cost-effective per acre, but it is the most cost-effective way to restore 50 acres. This is because option 3 can only be implemented once and therefore can restore a maximum of only 20 acres.

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TABLE 2.4 STEPS IN A COST-EFFECTIVENESS ANALYSIS

CEA steps	Description
1. Specify the set of policy goals and alternative projects.	Identify established policy goals and the alternative policy options under consideration.
2. Decide whether nonbudgetary costs should be assessed, and whose costs should count.	Determine those groups that should have standing (or whose costs should count) within the analysis, and whether the analysis should include non-budgetary costs.
3. Quantify the impact of each policy option on the policy outcome of interest.	Where scale is relevant, quantify the scale of impact resulting from each policy option (e.g., how many lives saved, how many acres restored?).
4. Monetize costs for each policy option.	Quantify all significant budgetary and (where appropriate) nonbudgetary costs associated with each identified policy option.
5. Discount costs to obtain present values.	Where costs are incurred over different time periods, use discounting to account for the time value of money.
6. Compute the cost-effectiveness of each alternative.	Combine aggregated, discounted costs and divide by a measure of project outcomes to generate a final cost-effectiveness ratio for the various project or policy alternatives. This last stage may also include analysis of distributional impacts, or costs to different affected groups.
7. Perform a sensitivity analysis.	Sensitivity analysis may be conducted at this stage to account for areas in which risk exists, to show the potential effects of different future possibilities on results. One may also calculate expected values or use other mechanisms (e.g., option prices) to account for risk.
8. Make a policy recommendation based on CEA results and sensitivity analysis.	Recommend the option with the greatest cost-effectiveness for the predetermined policy outcome.

where a variety of contingencies are possible (see discussion in chapter 5). CEA and CBA are also subject to many of the same caveats and guidelines for possible measurement errors, omission of secondary effects, and the treatment of cost distributions over heterogeneous populations.

Considering the issues just noted, CEA is most often useful in cases where 1) policy goals have already been established, 2) benefits are difficult to measure, and 3) nonbudgetary costs either are easily measurable or are trivial. Where these conditions apply, an appropriately conducted CEA can provide significant insight into the optimal means of achieving stated goals. Moreover, this insight is often less expensive than a full-scale CBA.

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Economic Impact Analysis

When many people think of economic analysis, they envision forecasts of outcomes, such as regional employment and income. These forecasts, which come from *economic impact analysis*, or EIA, are commonly reported by the media and often used to justify public projects. EIA provides a snapshot of the financial linkages among sectors in a regional economy. In simple terms, it tracks monetary payments as they move through a regional economy—measuring the transfer of money from one sector to another. It estimates changes in gross output, income, and/or employment that result from exogenous policy changes.[23]

EIA provides familiar measures of economic impacts resulting from environmental policy, including those influencing coastal and marine resources. EIA is an appropriate tool for regional planning and regional industries and governments often use it to assess the impact of policy changes or development proposals on the distribution of income and employment. However, despite its common use in assessing aggregate *economic impacts* of policy decisions, *EIA is not a substitute for either CBA or CEA*, and does not provide an estimate of the net economic benefits of policy changes.[24] EIA can be used in conjunction with a properly performed CBA to provide additional information about income distribution among industry sectors. However, it cannot be used alone to determine the most socially beneficial (or productive) use of any coastal resource or policy decision within an EBM framework. Moreover, the distribution of income among industry sectors (as forecast by EIA) does not have any systematic relationship to the distribution of net economic benefits or costs; there is no relationship (even in direction) between changes in net economic benefits and changes in economic impacts such as regional income or employment. A project that generates larger economic impacts will *not* necessarily generate larger net social benefits.

These distinctions can be a source of confusion to non-economists. EIA is not designed to identify those policies or situations that generate the greatest possible social benefits—rather, it identifies only those options that may increase observable economic (market) activity. Nonetheless, it is used frequently to inform policy and can be influential in policy debates. Put simply, EIA is not designed to find optimal solutions.[25] EIA cannot determine which of a set of EBM policies is best for society—only which policy will generate the greatest gross economic activity. Despite these limitations, if the level of market activity in a region is a primary concern of policymakers, EIA can be a useful tool for policy analysis.

Use, Elements, and Assumptions of EIA Models

Although the models required for many types of impact analysis can be mathematically complex, software packages (such as IMPLAN or REMI) that allow

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non-experts to estimate such models are increasingly available. The resulting explosion of EIA has provided sought-after information to policymakers, but has also caused many to question the validity of its many applications and to point out the many critical issues upon which appropriate EIA depends. EIA can be an important element in the policymaker's toolbox, but it is subject to considerable risk of misuse and misinterpretation. For example, small (often unnoticed) changes in model assumptions can lead to large changes in estimated economic impacts.[26] Moreover, many of the outputs of EIA have no relationship to net policy benefits realized by the public or by any stakeholder group.

EIA is based on a "parsimonious accounting of financial links among industries, households, export markets, and, often, the public sector."[27] Primary financial links between sectors are defined as input links (which capture payments for resources or inputs that are part of the production of a final good or service purchased by consumers) or output links (which represent financial payments for final products, generally from consumers to industries). Other types of linkages capture taxes and other transfers (e.g., transfers of funds between government agencies, government subsidy payments, etc.) involving the public sector. Industries within a given region are divided into relatively homogeneous sectors, where each sector has similar inputs and outputs. Based on surveys or other data, links can be specified among industry sectors and among consumers and industries. EIA draws distinctions between households in a given region and those outside the region, between payments for imported inputs and outputs, and between payments to inputs and outputs produced within the region.[28]

Results of EIA are based on the patterns of predicted monetary payments as they move through a regional economy. They are based on a snapshot of past monetary flows between identical sectors during prior time periods and on the assumption that future flows will match past patterns.[29] For example, production of a good or service by an industry sector (e.g., "production" of recreational fishing trips by charter boat operators) requires monetary payments to other (secondary) sectors to purchase inputs (such as bait, tackle, boat fuel). These secondary sectors then use these funds to hire labor, pay the owners of productive assets, purchase inputs from still other industries, etc. In this way, money is "recycled," producing income for various sectors as it travels through the economy. A *transactions flow table* records these linkages and tracks financial transfers. This table, along with associated multipliers, may be used to forecast the income changes for any industrial sector that will be generated by policy-induced changes to any other sector. (A multiplier is calculated within the EIA model and indicates the projected effect of a change in one industry sector on broader measures of economic activity, such as regional income.) Note, however, that EIA results are determined solely by the flow of money. If an economic change does not result in money changing hands, it is not reflected in an EIA.

Leakage from the regional economy occurs when money is spent on imports (or paid to a sector that removes it from the local economy) or is saved

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by households. All else being equal, the more times that a dollar earned by an industry sector is "recycled" before "leaking" from the regional economy, the greater is the income generation attributed to that dollar. Accordingly, EIA may also be interpreted as a measure of the self-sufficiency of a regional economy. In a highly self-sufficient economy (such as one with few imports), every additional dollar earned by an industry sector will likely have a relatively large impact on regional income because the dollar will change hands many times within the economy before being spent on imports and leaving the economy. Estimated economic impact also depends on the definition of the region. If the local economy is defined on a small scale (say, a rural community), then the estimated economic impact of any policy change will likely be small because nearly all industrial and consumption inputs are imported from outside the local economy. However, if the defined local economy is a state (a larger scale), for example, then the estimated economic impacts of the same policy change will be much larger because more industrial and consumption inputs will be purchased from local sources.

Within an EIA, the effects of an exogenous EBM policy change on income and production are typically described in terms of three levels of effect: 1) direct effects, 2) indirect effects, and 3) induced effects. The direct effects of an increase in production of one sector (i.e., as might result from a policy change) reflect the direct purchase of inputs from other industry sectors within the economy. This initial increase in demand generates indirect effects as these secondary industries re-spend the resulting dollars for inputs into their production processes over several rounds of economic activity, effectively recycling the same dollars. Induced effects capture the secondary labor-consumption effects as new income earned by labor and as payments to the owners of capital and natural resources are spent on new products—again creating a feedback loop through which money is recycled within the economy. Table 2.5 illustrates the type of economic impact estimates generated by an EIA.

Once the spending and re-spending of dollars, resulting from a policy change, is complete, the total income from all rounds of spending may be expressed by different types of output or income multipliers. Various types of multipliers exist with different interpretations. For example, some multipliers are expressed in terms of regional incomes, while others are expressed in terms of regional employment. However, each is based on the fundamental idea of the "recycling" of dollars within a regional economy plus a financial accounting of the resulting transfers. The standard output multiplier reflects the "overall, or total effect of a change in final expenditures on regional production, divided by the initial, direct effect" on a single industrial sector.[30]

Contrasting EIA and CBA for Policy Guidance

The principal reason that EIA is not an appropriate normative tool for policy decisions (i.e., a tool that indicates what policies ought to be pursued, based

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TABLE 2.5 SUMMARY OF TOTAL ECONOMIC IMPACTS FROM PARTY AND CHARTER FISHING IN MAINE

Category	Total angler expenditures	Direct impact	Indirect impact	Induced impact	Total impact
			Sales		
Nonresident	$1,117,336	$646,318	$227,280	$163,891	$1,037,489
Resident	$275,750	$143,860	$50,880	$29,819	$224,559
Total	$1,393,086	$790,178	$278,160	$193,710	$1,262,048
			Income		
Nonresident	$1,117,336	$194,516	$105,912	$92,713	$393,141
Resident	$275,750	$41,106	$22,948	$17,451	$81,505
Total	$1,393,086	$235,622	$128,860	$110,164	$474,646
			Jobs		
Nonresident	$1,117,336	31.1	3.8	3.7	38.6
Resident	$275,750	8.3	0.8	0.8	9.9
Total	$1,393,086	39.4	4.6	4.5	48.5

Sources: Steinback (1999) and Johnston and Sutinen (1999).

Interpreting the results in table 2.5, a total of $1.39 million in total expenditures for party and residential fishing in Maine generated total regional sales of $1.26 million, total regional income of $474,646, and 48.5 "new" jobs. These results are also broken down into the impacts of expenditures by residents and nonresidents, and into direct, indirect, and induced effects. If one accepts the assumptions of the underlying EIA (created in IMPLAN), these estimates indicate the aggregate economic activity that is generated by party and charter fishing in Maine (Steinback 1999), after all the spending and re-spending of money by various sectors is complete.

on social welfare) is that it does not measure economic benefits. Although this limitation is well known by EIA practitioners, it is sometimes ignored by interested parties who may wish to use associated results to argue for specific policy alternatives. It bears repeating that economic benefits are comprised of benefits to consumers (consumer surplus) and benefits to producers (producer surplus). Total economic performance increases when the sum of surpluses increases. EIA models do not measure benefits to consumers at all and do not accurately measure benefits to producers. EIA analysis simply measures economic transfers—the shift of money from one group to another. CBA estimates the economic net benefits to society of a policy or activity. This determines whether resources are being best used; activities or policies with higher net benefits have a greater net positive effect on aggregate or average social well-being. In contrast, EIA measures changes in economic activity and associated financial gains and losses within various sectors of the economy. These financial gains and losses are not measures of net benefit, do not provide insight into social well-being, and cannot be used to determine which policies are in the best economic interests of society.

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TABLE 2.6 COMPARISON OF EIA AND CBA

	EIA	CBA
What it measures?	Includes indicators of regional economic activity, such as changes in total income, jobs, and expenditures.	Includes changes in net economic value (benefits minus costs), such as value to producers and consumers of both market and nonmarket goods and services.
Scope of analysis?	Can be conducted for specific regions or nationwide.	Often measures net social benefits on a national scale, but can be implemented at any desired scale.
Accounts for the value of alternative uses of resources?	No. Opportunity costs are ignored.	Yes. Opportunity costs are incorporated.
Measures net economic benefits to consumers?	No. Benefits to consumers are not considered. Consumers enter analysis only as a source of expenditures.	Yes. Estimates consumer surplus.
Measures net economic benefits to producers?	Not directly, but results may be used to provide an approximation of profits or producer surplus.	Yes. Estimates producer surplus.
Assesses changes in social well-being resulting from EBM policies?	No	Yes
Accounts for changes in labor and input use patterns?	No. Is based on a static snapshot of labor and input-use patterns.	Yes. Can account for predicted changes in labor and input uses.
Accounts for indirect and induced effects?	Yes. These effects are critical to EIA, even though they may be offset by counter-effects in other regions.	No. These effects are assumed to be negligible, given likely offsetting effects.
Accounts for offsetting impacts?	No	Yes
Assesses the net economic return generated through ecological services?	No	Yes
Considers distribution of revenues and expenditures?	Yes. Considers distribution of impacts on income and employment.	Often no, but can be used to assess benefits and costs to different groups.

Continued

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TABLE 2.6 COMPARISON OF EIA AND CBA *(Cont.)*

Useful for estimating effects on regional economic development and employment?	Yes. This is one of the primary purposes of EIA.	Partially. CBA incorporates forecasts of producer and consumer activities within a regional economy, but is not explicitly designed to forecast regional economic development or employment.
Can be used to identify policy options which are best for society from an economic perspective?	No	Yes

Accordingly, the limitations mentioned here apply to all EIA, even those conducted with the most stringent quality standards. However, additional problems will occur if EIA is not performed properly, if the data are poor quality, or if the results are misinterpreted. (These same caveats apply to all economic frameworks.) This does not suggest that EIA does not have legitimate uses. For example, if the stated goal of a policy change is to increase regional employment (regardless of whether this will provide economic benefits), then an EIA can help identify policies that will most effectively promote this goal. The same applies to regional income. However, the measurement of economic benefits, efficiency, or social well-being is not one of the legitimate uses of an EIA.

Put another way, EBM policies that generate the greatest income, revenue, or employment are *not necessarily* preferred from an economic standpoint. The common myth that income, revenues, or jobs are equivalent to economic benefits is propagated by general confusion over what constitutes economic value. The economic value of revenue, income, or new jobs cannot be ascertained without information about the opportunity costs, or alternative uses, of productive assets. Recall that revenue to one group is simply an expense to another group—the simple transfer of money does not create economic value. The 1989 Exxon Valdez oil spill illustrates the difficulty with this argument. This disaster brought hundreds of millions of dollars of revenue to those involved in cleaning up the oil, as well as additional revenue to area hotels, restaurants, etc., but it did not create economic value and left the local community (and society) much worse off. Similarly, sole reliance on EIA to guide EBM policies can also reduce the long-term well-being of society, if it is not placed within an appropriate context.

Hence, while EIA results may be attractive to policymakers whose primary interest is maximizing economic development or economic activity, they cannot substitute for or even reasonably approximate the results of CBA or

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CEA. Measures of net economic benefits and measures of economic activity are not necessarily correlated, even in terms of algebraic sign (positive or negative). Economic activity does not approximate economic benefit, although it may provide relevant information in its own right.

Alternatives to Economic Analysis

As noted above, economic analysis—whether CBA or CEA—is based on neoclassical economic theory, which assesses value based on the well-being of humans. Economic value is subjective and is based on people's individual needs and wants. It is also subject to the current state of information: as the amount of available information about different goods and services changes, so may individuals' willingness to pay. For example, new information about mercury contamination of certain fish products may change individuals' demand for similar or substituted products and, hence, affect or change the measurable market value. It is also important to note that the use of CBA to guide policy does not guarantee that any specific ecological resource or service will be sustained. Appropriate use of CBA can help ensure that policies will encourage maximum sustainable benefits to society, but this may involve improvements in some ecological resources or systems and declines in others. In addition, appropriate economic analysis can be costly, intricate, and data-intensive. It is also "rare in the [CBA] literature [to find] examples of wide-scale changes, very small changes, or the consequences of long-term ecological and economic change."[31]

For these and other reasons, some non-economists have expressed dissatisfaction with economic approaches to inform policy. For example, some ecologists, voicing concerns about value systems based on subjective human values, have proposed alternatives based entirely on the functioning of natural systems. These non-economic approaches are often founded on thermodynamic principles and include embodied energy valuation and EMERGY.[32] These and similar non-economic valuation methodologies quantify values based on the energy required or the "work" previously done to make a product or service. According to energy theories of value, people's values and preferences play no significant role in assessing the benefits, costs, or values of resource policies.

Energy-based theories of value are internally consistent and provide results that policymakers might wish to consider when weighing alternative policy options, *but they bear no relationship to economics or social welfare*, nor do public values and well-being play any role in the calculation of values within these theories. As a result, energy-based theories of value have been widely criticized by economists.[33] Much as EIA tracks the flow of money through economic systems, embodied energy models track the flow of energy through ecological systems, based on average patterns observed in model systems. Neither approach, however, shows the impact of these flows on human welfare.

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Moreover, while proponents of thermodynamic approaches often criticize the assumptions implicit in CBA, these approaches require their own set of sometimes questionable assumptions. For example, EMERGY relies on the fundamental assumption the value of a resource or commodity is determined by the solar energy directly and indirectly required to produce that resource or commodity through ecological systems, regardless of effects on people.[34]

When contrasting energy-based theories of value with economic approaches, three differences are paramount. First, as noted above, policies guided solely by EMERGY or other thermodynamic value models will *not* necessarily improve the well-being of society, either in the short or long term. Thermodynamic models of value have no formal relationship to human values or well-being. For this reason, they are often referred to as *ecocentric* theories of value by practitioners.[35] An EBM policy that maximizes EMERGY or embodied energy will not necessarily maximize human welfare and may indeed diminish it.

Second, because these approaches sever the relationship between human welfare and assessed values (they are based solely on thermodynamic and ecological relationships), they avoid the perceived subjectivity of human values and sensitivity of these values to information. This property also allows EMERGY values to be calculated for resources even if the total contribution of those resources to human welfare is unknown. This independence from human subjectivity, knowledge, and information is one of the primary reasons that some ecologists and other natural scientists champion such methods.

Third, thermodynamic models of value are entirely "donor based." That is, they quantify values based on the ecological cost of producing goods or services (what is required to make them), rather than the benefit that is derived from these services. From an economics perspective, this confuses the concepts of benefits and costs, and can lead to counterintuitive results. For example, according to EMERGY and other such methods, the "value" of a gallon of whale oil is constant, even though the human or economic value of whale oil has changed dramatically over the past 200 years. Similarly, "two paintings with similar EMERGIES can have drastically different [human] values, especially if one of them is by a renowned painter."[36] The inability of EMERGY to account for such patterns can lead to difficulties when resulting values are applied to policy development. For example, EMERGY results can favor policies that appear to make humans unambiguously worse off.

Yet another set of approaches that is sometimes proposed for the valuation of ecological systems is based on the concepts of *replacement costs* and *defensive costs.* Replacement costs quantify the value of an ecological good or service based on the cost of either replacing that good or service using technological or other means. Defensive costs are costs incurred to offset the negative impacts caused by the loss of a good or service. For example, a replacement-cost approach might value the water filtering services of a wetland based on the cost of replacing those services with technology, such as a water treatment

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plant. Defensive cost methods, in contrast, might attempt to estimate or bound the value of drinking water quality using the costs that households are willing to incur to protect themselves when water quality declines, such as purchasing bottled water.

Like the thermodynamic approaches summarized above, valuations based on replacement costs do not generally provide appropriate measures of economic value or benefit to human welfare. This is because, again like thermodynamic theories of value, replacement-cost approaches do not distinguish between benefits and costs. The failure of replacement-cost approaches to provide well-defined measures of social benefits is well known. Per the U.S. Environmental Protection Agency, "alternative approaches that estimate the total value of ecosystems based on the replacement cost of the entire ecosystem or its embodied energy (e.g., Costanza et al. 1997; Ehrlich and Ehrlich 1997; Pearce 1998; Pimentel et al. 1997) have received considerable attention as of late. However, *the results of these studies should not be incorporated into benefit assessments*. The methods adopted in these studies are not well grounded in economic theory nor are they typically applicable to policy analysis."[37]

Under narrow circumstances, some types of replacement costs (mainly incurred defensive costs) may be used to estimate appropriate measures of economic benefit or cost.[38] The conditions under which this applies are restrictive and do not apply to most cases where replacement cost measures of value have been proposed: 1) the expenditures on defensive or replacement behavior must be *voluntary*, 2) the costs must *actually be paid* by the affected individual or group, and 3) there must be *no joint production*[39] or additional utility or disutility (i.e., benefit or harm) associated with the defensive or replacement behavior. The third condition implies that the replacement is an exact match—in terms of services provided and related benefits—to the original natural resource in question. Unfortunately, these conditions, and particularly the third, rarely hold. Hence, as a generalization, one should treat replacement or defensive cost measures of value with skepticism—at least if measuring social value is the aim.

For these and other reasons, most economists are highly critical of thermodynamic and replacement-cost theories of value largely because such theories cannot be relied upon to promote policies that are in the best short- or long-term interests of society (i.e., that encourage maximum sustainable human welfare). Defensive-cost methods have a somewhat greater role, particularly in some areas of economic analysis. The primary area in which these approaches have been applied appropriately is to estimate the value of environmental damage that causes direct human health effects; there have been fewer appropriate applications to coastal and ocean policy. Nonetheless, these methods offer a competing perspective to other economic approaches in the EBM policymaker's toolbox.

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Multi-attribute Utility Theory

A final framework, discussed here briefly, is multi-attribute utility theory. MAUT is a cousin of CBA in that it allows assessment of policies, such as EBM, where multiple attributes (i.e., policy characteristics or outcomes) are affected. Like CBA, MAUT provides a method whereby one can evaluate alternative policies and attempt to choose the one that is, at least, arguably "best" for society. However, the ways in which MAUT evaluates policy are distinct from those of CBA, relying generally on the opinions of experts rather than on estimated values of affected individuals to evaluate policies.

Steps in a MAUT analysis vary, but generally include seven steps:[40]

Step 1 **Identify objectives and attributes**—Identify relevant policy attributes through literature reviews, background research, or expert interviews.

Step 2 **Quantify attributes**—Measure or estimate the magnitude of physical impacts on the attributes identified in step 1.

Step 3 **Verify the relevance of assumptions**—Explore various functional forms for the overall utility (or benefit) function and assess implications for behavioral expectations.

Step 4 **Examine the single attribute utility function**—Estimate functional forms that identify the "utility" or relative weight given to each single attribute in the overall utility function.

Step 5 **Determine the importance of attributes**—Ranking (or choice tasks) by experts are used to determine weights given to each attribute.

Step 6 **Construct the multi-attribute utility function**—Combine information from steps 1–5 to construct the final utility function used to rank policies.

Step 7 **Assess tradeoffs**—Use the final utility function to rank policies and assess policy tradeoffs.

Like CBA, MAUT attempts to estimate a single cardinal value that policymakers can use to prioritize policy options or choose the preferred policy from a set of alternatives. (One of the policy alternatives is often the status quo, or no policy change at all.) However, unlike CBA, the weights or relative importance given to each policy attribute are not determined by economic value or the willingness to pay of affected households or individuals. Indeed, one of the primary motivations for using MAUT is the discomfort that some analysts feel with the concept of monetization. Instead, within a MAUT analysis, generally decisionmakers, well-informed stakeholders, policy experts, or analysts define the weights. These weights may be directly assigned or estimated based on the results of ranking tasks designed to reveal the implicit weights given by experts to each policy attribute.[41]

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For example, assume that policymakers have requested an evaluation of alternative beach nourishment programs. The relevant characteristics (attributes) of each program include the amount of sand required, the resulting width of the beach, the location from which the sand would be obtained, the frequency with which the sand would have to be replaced, the cost of the program, etc. A MAUT might ask experts to rank a large number of possible beach nourishment options from most to least preferred, where each option would be characterized by different levels for each of the attributes listed above. By analyzing experts' rankings using statistical procedures, one could then estimate the weights (or relative importance) that the average expert gave to each attribute, when deciding which options were preferred. These weights could then be used to calculate a utility score for any possible beach nourishment program, whereby that program could be compared to alternatives.

The distinction between ranking policies based on aggregate net benefits (as measured by aggregate willingness to pay) versus weighting and assessment of policy attributes using expert-determined attribute weights is one of the primary differences between MAUT and CBA. Although MAUT approaches have been applied to a number of policy decisions,[42] they neither measure nor attempt to measure economic value. Rather, they seek expert values, opinions, and preferences to determine the weights of the attributes that represent policy benefits. Put another way, CBA evaluates policy at least in part based on the subjective preferences and values of individuals and households; these preferences and values are a fundamental factor determining economic values and benefits. In contrast, MAUT is grounded in a belief that experts and well-informed stakeholders are best suited to identify the policy choices that are in the best interests of the public. Hence, using either MAUT or CBA is often decided by philosophical beliefs about whether individuals can identify choices and behaviors that are in their own best interest, and have sufficient information to do so.

A similar analytical tool—multigoal analysis—does not seek to reduce various impacts to a single score, but rather only quantifies impacts on different valued attributes. The ability of MAUT-influenced policy decisions to improve social well-being depends on the relationship between the values and the perceptions of the experts or stakeholders (who determine the weights of MAUT attributes) and the values of the public at large. MAUT also requires that one accept a variety of testable and nontestable assumptions in order to derive final policy rankings, and some of these do not correspond to common neoclassical economic perspectives. As a result, economists are often skeptical of MAUT results used in isolation to rank policies. However, as a complement to CBA or other economic approaches to policy evaluation, MAUT approaches can provide an alternative perspective that policymakers may wish to consider when choosing among EBM policies.

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Conclusion

Policy analysis often involves numerous forms of natural and social science assessments. Quantification of the economic outcomes associated with EBM alternatives can provide important information regarding the effects of these policies on social welfare. Different approaches to evaluating outcomes—both economic and non-economic—exist. There are also various ways that one can integrate economic information into the policy process, each with unique interpretations and appropriate uses. While each of these methodologies can represent an important addition to the policymaker's toolbox, it is incumbent upon those using such tools to be aware of their appropriate uses, interpretations, and limitations.

EBM by its very nature addresses simultaneous impacts on multiple ecological resources and user groups. As a result, economic analysis that includes all affected resources and groups may be impractical. In such cases, policymakers must balance the need for information from economic analyses against the cost of the analyses, in addition to deciding which resources require detailed assessments. Where data are available at reasonable cost, appropriate CBA—either full or select components—will generally provide the most appropriate economic guidance for EBM policy decisions. (Few would argue, however, that CBA should be the *only* consideration informing policy.) CEA can provide similar information on costs when policy goals have been predetermined. EIA, in contrast, quantifies economic activity and money flows that are often interesting to those promoting regional economic development or employment. Any economic analysis should, of course, be conducted according to professional standards by experts familiar with the methods in question. Any presentation of results should make clear the limitations and assumptions associated with the data or analysis used, and sensitivity analysis is often necessary to illustrate the impact of uncertain parameters on key results.

In summary, policymakers must be aware that different analytical methods provide different, and often incomparable, results. Appropriate use and interpretation of the empirical results of economic analysis can help make certain that EBM encourages the most socially beneficial long-term use and preservation of coastal and marine resources.

Endnotes

1. See, for example, Odum (1988).
2. See, for example, Costanza et al. (1997).
3. For example, some net benefits can be generated if a project hires previously unemployed workers or causes a broader wage increase. See Boardman et al. (2001) for discussion of these and related issues.
4. Bockstael et al. (2000, *1386*).

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5. Ibid.
6. See Lipton and Wellman (1995, *24–25*) for additional examples and straightforward discussion of such issues.
7. Quotes are from Lipton and Wellman (1995, *27*) and U.S. EPA (2000, *20*), respectively. Various sources provide discussions of CBA at different levels of technical difficulty. For example, see Lipton and Wellman (1995) for a discussion aimed at policy audiences, Boardman et al. (2001, 2006) for an intermediate-level text that presumes some familiarity with economics, and Just et al. (2004) for a technically more rigorous presentation suited to those with extensive economics background. Other works that highlight particular aspects of CBA, such as nonmarket valuation, are Freeman (2003), Champ et al. (2003), Kopp and Smith (1993), Sassone and Schaffer (1978), and Garrod and Willis (1999), for example. Government agencies also provide guidelines for the use of associated methods (e.g., U.S. EPA 2000, 2002a).
8. For additional discussion regarding the underlying theory at varying levels of technical rigor, see Boardman et al. (2001, 2006) or Just et al. (2004), for example.
9. The difference between profits and producer surplus lies in the treatment of fixed costs, or costs that do not vary with the quantity of production in the short run. For example, a mortgage payment for a factory or fishing vessel is a fixed cost because it must be paid regardless of the quantity produced in the short run. Such fixed costs are considered when calculating profits; they are not considered when calculating producer surplus.
10. See Boardman et al. (2001, 2006) and Just et al. (2004) for additional development of these issues.
11. Secondary *nonmarket* benefits or costs should often be counted, however. This is because these benefits and costs, unlike secondary *market* benefits and costs, are not generally captured elsewhere in the analysis. Continuing the softshell clam example from above, if the increased secondary effect on scallop consumption leads to increased ecological damage to the ocean floor from scallop dredges, and if this damage causes a loss of nonmarket benefits to recreational divers or anglers who use the same areas, then these nonmarket losses should be included in a comprehensive CBA. See Boardman et al. (2001, 2006) for additional discussion.
12. As beaches undergo erosion, beach nourishment is the process of replenishing the sand and spreading it across the beach to restore it to initial conditions.
13. Occasionally, proponents of certain policies will argue that secondary effects *should* be counted if one is *only* interested in benefits and costs realized in a specific region. For example, one might argue that residents of Alaska do not care if secondary benefits to local hotels and restaurants in Alaska are offset by secondary losses elsewhere. However, even in this case, it is generally inappropriate to count secondary effects—at least at their full value. The reason is that if one is truly interested only in regional benefits and costs, then one must subtract all nonregional effects. This includes all benefits realized by visitors, nonresident business owners, and consumers who live outside the region, for example. Considering these and other factors, a regional perspective rarely provides a legitimate argument for counting secondary effects that should otherwise be ignored (Boardman et al. 2001, 2006). At the very least, policy analysts should be consistent when add-

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ing and subtracting benefits realized in different areas, so that double counting does not occur.

14. Economic impact analysis often presents estimates of the number of jobs that will be lost or gained in different industry sectors as a result of policy changes. A common assumption is that these employment changes represent an economic cost or benefit. In cases where 1) current residents (who are otherwise unemployed or underemployed) gain new jobs or 2) new jobs result in a sectorwide wage increase, a relatively small portion of new job income may be considered an economic benefit. The converse applies if jobs are lost. This implies that the creation of jobs may generate real economic benefits in communities where jobs are scarce (i.e., workers would otherwise be unemployed). In communities where jobs are plentiful, however, new jobs are typically taken by new workers, immigrants, or workers who are already employed in the region (i.e., those leaving one job to take another), resulting in negligible net benefits to the region.
15. In the short term, the benefits are defined by producer surplus, which differs from economic profits in that it does not consider fixed costs. In the long term, the concepts are identical because long-term fixed costs are always zero (i.e., all costs are variable in the long run). See additional comments in footnote 9 above.

    Ex-vessel revenue may be defined as the quantity of fish landed by commercial fishermen multiplied by the price they receive per unit of quantity.
16. "Entry" is when a new fishing vessel begins to operate in a fishery in which it had not operated previously. "Exit" is when a fishing vessel ceases fishing in a particular fishery. Fish biomass refers to the total mass of living fish matter within a given ecosystem, sometimes disaggregated by species or species group.
17. For measuring net economic benefits in different fisheries sectors, see Sutinen and Johnston (2001). For EFH restrictions on commercial activities and related economic effects, see Hicks et al. (2001, 2004). In dredging, the boat drags a steel box along a shallow sea bottom. At the same time, the boat pumps seawater through a large hose, forcing water into the sand, "temporarily fluidizing it," which permits the dredge to pass through the sand. Bars on the bottom of the dredge are specifically spaced to allow smaller clams and other species to fall through and hold in larger clams (or other sought-after species). In otter trawling, boats drag a large net along the sea bottom (or just above the bottom) to catch fish or shellfish. See www.fishingnj.org/techhd.htm.
18. Freeman (2003).
19. See Boardman et al. (2001, 2006) or Goulder and Stavins (2002) for a general nontechnical discussion of discounting.
20. Turner (1999b) provides a good discussion of issues related to economic and noneconomic perspectives on value.
21. Swallow (1996).
22. Boardman et al. (2001, *437*).
23. The commercial software package IMPLAN, for example, can analyze changes in a broad range of sectors in regions across the United States.
24. See Edwards (1990) and Lipton and Welman (1995) for further discussion.
25. For more on EIA and policy dos and don'ts, see Crompton (1995), Tyrrell and Johnston (2006), Hushak (1987), and Edwards (1990, 1991).

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26. Crompton (1995) provides good examples of this in his discussion of the use of EIA to assess sports facilities and events.
27. Edwards (1990, *10*).
28. This section draws from prior work of Johnston and Sutinen (1999), as well as from Edwards (1990).
29. As with any approach that tries to predict future scenarios, if future money-flow patterns do not match past patterns, bias will be introduced into the analysis.
30. Edwards (1990, *12*).
31. U.S. EPA (2000, *98*).
32. "EMERGY analysis . . . is a technique of quantitative analysis which determines the values of nonmonied and monied resources, services, and commodities in common units of the solar energy it took to make them." Embodied energy analysis, similarly, is "the process of determining the energy required directly and indirectly to allow a system (usually an economic system) to produce a specified good or service" (Brown and Herendeen 1996, *220*, both quotations). Odum (1988) pioneered this concept.
33. See discussion by Hau and Bakshi (2004). To illustrate the basis for these criticisms, consider the basic process of EMERGY valuation. "The EMERGY of renewable energies, nonrenewable resources, goods, services, and even information are determined by the energy required to make them. When values are expressed in these terms, we call the new measure EMERGY and define it as the amount of one type of energy that it takes to make another . . . To derive solar EMERGY of a resource or commodity, it is necessary to trace back through all the resources and energy that are used to produce it and express them in the amount of solar energy that went into their production. This has been done for a wide variety of resources and commodities and the renewable energies driving the biogeochemical process of the earth. When expressed as a ratio of the total EMERGY used to the energy produced, a transformity results . . . As its name implies, the transformity can be used to 'transform' a given energy into EMERGY, by multiplying the energy by the transformity. For convenience, in order not to have to calculate the EMERGY in resources and commodities every time a process is evaluated, we use transformities that have been previously calculated" (Brown and Herendeen 1996, *221*). Notice that this process has no basis in human preferences, welfare, or behavior.
34. Hau and Bakshi (2004) and Brown and Herendeen (1996) discuss many of the assumptions implicit in EMERGY analysis.
35. Hau and Bakshi (2004).
36. Ibid., *219*.
37. U.S. EPA (2000, *98,* emphasis added).
38. See detailed discussions in Freeman (2003) and Champ et al. (2003), for example.
39. Joint production refers to a case in which the same process produces multiple valued outcomes. An example would be when a defensive behavior in question (e.g., purchasing bottled water to avoid waterborne illness) provides other benefits as well (e.g., bottled water tastes better than tap water).
40. Kim et al. (1998).
41. See Gregory et al. (1993) and Kim et al. (1998) for more detail.
42. Some argue strongly for their use over CBA, such as Gregory et al. (1993).

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