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**NOAA COASTAL OCEAN PROGRAM**  
Decision Analysis Series No. 5



# **ECONOMIC VALUATION OF NATURAL RESOURCES**

**A Handbook for  
Coastal Resource Policymakers**



**U.S. DEPARTMENT OF COMMERCE**  
**National Oceanic and Atmospheric Administration**  
Coastal Ocean Office

The Decision Analysis Series has been established by NOAA's Coastal Ocean Program (COP) to present documents for coastal resource decision makers which contain analytical treatments of major issues or topics. The issues, topics, and principal investigators have been selected through an extensive peer review process. To learn more about the COP or the Decision Analysis Series, please write:

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# ECONOMIC VALUATION OF NATURAL RESOURCES

## A Handbook for Coastal Resource Policymakers

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# Note to Readers

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*Economic Valuation of Natural Resources: A Handbook for Coastal Resource Policymakers* is the outcome of COP-sponsored environmental valuation workshops. As the text to support the teaching in these workshops developed and as the need to transfer this information to a wider audience of coastal managers than workshop attendees became apparent, it was decided to present the Handbook as a stand-alone document. The Handbook is a unique blend of writing by highly regarded experts in the field specifically tailored for the management community and input by managers who have attended the COP workshops. Each workshop participant is asked to provide comments on the curriculum, teaching effectiveness, and materials. Over the past three years, these comments have helped us to improve all aspects of the training.

The NOAA Coastal Ocean Program (COP) provides a focal point through which the agency, together with other organizations with responsibilities for the coastal environment and its resources, can make significant strides toward finding solutions to critical problems. By working together toward these solutions, we can ensure the sustainability of these coastal resources and allow for compatible economic development that will enhance the well-being of the Nation now and in future generations. The goals of the program parallel those of the NOAA Strategic Plan.

A specific objective of COP is to provide the highest quality scientific information to coastal managers in time for critical decision making and in a format useful for these decisions. To help achieve this, COP inaugurated a program of developing documents that would synthesize information on issues that were of high priority to coastal managers. A three-step process was used to develop such documents: 1) to compile a list of critical topics in the coastal ocean through a survey of coastal resource managers and to prioritize and select those suitable for the document series through the use of a panel of multidisciplinary technical experts; 2) to solicit proposals to do research on these topics and select principal investigators through a rigorous peer-review process; and 3) to develop peer-reviewed documents based on the winning proposals. Seven topics were selected in the initial round, but the series is expanding because of the suitability of findings from other COP-funded research to appear in this synthesis format. The documents already published are listed on the inside back cover.

As with all of its products, COP is very interested in ascertaining the utility of the Decision Analysis Series particularly in regard to its application to the management decision process. Therefore, we encourage you to write, fax, call, or E-mail us with your comments. Please be assured that we will appreciate these comments, either positive or negative, and that they will help us direct our future efforts. Our address and telephone and fax numbers are on the inside front cover. My Internet address is [DSCAVIA@HQ.NOAA.GOV](mailto:DSCAVIA@HQ.NOAA.GOV).



Donald Scavia  
Director  
NOAA Coastal Ocean Program

## ACKNOWLEDGMENTS

This handbook has grown out of a series of workshops sponsored by the NOAA Coastal Ocean Program (COP). The workshops were developed to meet an expressed priority need on the part of coastal resource managers for more information in the area of environmental valuation. The workshop concept was developed by Rodney Weiher and Katherine Wellman, both at the time in the Economics Group in the NOAA Office of the Chief Scientist, who were asked by COP to formulate a program to meet managerial needs. Nancy Bockstael and Douglas Lipton of the University of Maryland's Department of Agricultural and Resource Economics were brought into the team. Together this team, with coordination from Isobel Sheifer of COP, helped to lay the foundation and framework of the workshops and the handbook that grew out of them.

The handbook contains the written substance of the material being taught at the workshops. The first part of each workshop is devoted to the teaching of a core curriculum by Wellman and Lipton, who have been participating in these workshops beginning with a pilot in Durham, New Hampshire, in summer 1992. The second part of the workshop involves the innovative use of case studies through which workshop attendees get an opportunity to try out these newly studied techniques in actual case situations under the tutelage of a case leader. In addition to individuals already mentioned, case studies have been facilitated by Lewis Queirolo of the NOAA National Marine Fisheries Service, Rebecca Baldwin of the U.S. Forest Service, and Elliot Rosenberg of the Environmental Protection Agency.

Among those making the greatest contribution to the development of this handbook have been the participants in the workshops. By filling out evaluation forms at the end of each session and by their private conversations with teachers and other workshop personnel, participants have helped us improve what we teach, how we teach it, and the sequence of teaching exercises. Participation levels in case study sessions and the kind of discussions that take place have indicated to us which cases were the best tools to promote the learning experience we hoped to achieve.

As the handbook has developed and become refined, we feel it is important to transfer this kind of information to the widest possible audience of coastal managers, regardless of their workshop attendance. To that end, we have undertaken a revision of materials to make the document a stand-alone learning tool and have included cases from many regions of the country to make the scope of this part of the learning truly national. However, it should be noted that a case study for one region can be used by managers anywhere as a guide to understanding environmental valuation. The problems recounted in these cases have general applicability.

Merrill Leffler and Sandy Harpe have been responsible for editing and design of the text.

*Economic Valuation of Natural Resources* is not a textbook but a guide for policy makers and managers regarding how to assess and understand the economic value of the coastal resources for which they are stewards. We hope it will receive wide distribution and use.

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# PREFACE

Professionals who are responsible for coastal environmental and natural resource planning and management have a need to become conversant with new concepts designed to provide quantitative measures of the environmental benefits of natural resources. These amenities range from beaches to wetlands to clean water and other assets that normally are not bought and sold in everyday markets.

At all levels of government — from federal agencies to townships and counties — decision-makers are being asked to account for the costs and benefits of proposed actions. To non-specialists, the tools of professional economists are often poorly understood and sometimes inappropriate for the problem at hand. This handbook is intended to bridge this gap.

The most widely used organizing tool for dealing with natural and environmental resource choices is benefit-cost analysis — it offers a convenient way to carefully identify and array, quantitatively if possible, the major costs, benefits, and consequences of a proposed policy or regulation. The major strength of benefit-cost analysis is not necessarily the predicted outcome, which depends upon assumptions and techniques, but the process itself, which forces an approach to decision-making that is based largely on rigorous and quantitative reasoning.

However, a major shortfall of benefit-cost analysis has been the difficulty of quantifying both benefits and costs of actions that impact environmental assets not normally, nor even regularly, bought and sold in markets. Failure to account for these assets, to omit them from the benefit-cost equation, could seriously bias decisionmaking, often to the detriment of the environment. Economists and other social scientists have put a great deal of effort into addressing this shortcoming by developing techniques to quantify these non-market benefits.

The major focus of this handbook is on introducing and illustrating concepts of environmental valuation, among them Travel Cost models and Contingent Valuation. These concepts, combined with advances in natural sciences that allow us to better understand how changes in the natural environment influence human behavior, aim to address some of the more serious shortcomings in the application of economic analysis to natural resource and environmental management and policy analysis.

Because the handbook is intended for non-economists, it addresses basic concepts of economic value such as willingness-to-pay and other tools often used in decision making such as cost-effectiveness analysis, economic impact analysis, and sustainable development. A number of regionally oriented case studies are included to illustrate the practical application of these concepts and techniques.



The National Oceanographic and Atmospheric Administration's Coastal Ocean Program and its Economics Group participated in the development of this handbook and a series of regional workshops for state and local coastal planners and managers in an effort to apply advances in physical sciences to modern environmental economic, management, and policy problems.

# 1

## HISTORY AND LEGISLATIVE MANDATES FOR ENVIRONMENTAL VALUATION

In the earliest versions of benefit-cost analysis of federal projects, there was no provision for accounting for economic gains or losses due to environmental benefit or harm. Even when aware of the physical harm a project or policy would have on the environment, decisionmakers were unable to quantify these using the available economic tools of the time. Economic theory has progressed to address the problems of environmental valuation, as have federal environmental laws and regulations.

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# HISTORY

Environmental valuation has its origin in the **River and Harbor Act of 1902**. This Act required a board of engineers to report on the desirability of the Army Corps of Engineers' river and harbor projects by accounting for both the costs and benefits to commerce.

In the 1930s, the idea of broader social justification for projects emerged as a theme. For example, the **Flood Control Act of 1936** authorized federal participation in flood-control schemes if the benefits of such actions exceeded the estimated costs. The practice of such analyses then spread to other agencies concerned with water development projects. The purpose was both to justify public works projects and to help decide who should pay for these projects.

By the end of World War II, federal agencies had broadened their approach to account for secondary, or indirect, benefits and costs as well as **intangibles**. Intangibles reflected what are now considered environmental assets. This was really the beginning of benefit-cost analysis (as will be discussed in greater detail in Chapter 3). In the 1950s, a federal interagency committee produced the **Green**

## Environmental Valuation Legislative History

- ▶ River and Harbor Act of 1902
- ▶ Flood Control Act of 1936
- ▶ Broadened approach to include *intangibles*
- ▶ *Green Book* published in 1950
- ▶ Environmental movement of the late 1960s
- ▶ National Environmental Policy Act of 1969
- ▶ Clean Air Act of 1970
- ▶ Clean Water Act of 1972
- ▶ Comprehensive Environmental Response, Compensation and Liability Act of 1980 and natural resource damage assessment
- ▶ Executive Order 12291 (Regulatory Impact Analysis) issued in 1981

**Book**, an attempt to codify and agree on general principles of project justification. This document was notable for bringing in the language of welfare economics.<sup>1</sup>

In the late 1960s, the environmental movement began. Pollution control was of particular concern and the economics community was ready and willing to play a role. Unfortunately, the economic view had little impact on the initial surge of legislation for pollution control. Two of the cornerstones of federal environmental policy on pollution control — the **Clean Air Act of 1970** and the **Clean Water Act of 1972** — explicitly prohibited weighing benefits and costs in the setting of environmental standards. Instead, standards were based solely on public health criteria.

While the **National Environmental Policy Act of 1969** (as amended through 1982) required the use of benefit-cost analysis in environmental impact statements, environmental valuation did not really come into its own until the 1980s, when **Executive Order 12291** (the Regulatory Impact Analysis requirement) was issued.<sup>2</sup> Additional environmental legislation, particularly the **Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA)**, gave natural resource trustees the right to claim damages for injuries to natural resources that result from the release of oil and other hazardous materials into publicly owned rivers, lakes, estuaries, oceans, or other aquatic or terrestrial habitats. The natural resource damage assessment process explicitly calls for the estimate of interim lost values of injured natural resources and resource services.

During the 1980s, interest in environmental valuation continued to expand, and this attention has continued into the 1990s. This increased attention stems from the implementation of the **Oil Pollution Act of 1990** and its subsequent natural resource damage assessment regulations. The Act put pressure both inside and outside of government to improve the decision-making criteria affecting public funds and resources. In addition, relatively recent legislative mandates, through amendments to existing legislation, have strengthened the requirement of net economic benefit analysis as part of management and regulatory programs.

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<sup>1</sup> Interagency River Basin Committee, Proposed Practices for Economic Analysis of River Basin Projects.

<sup>2</sup> Early in the Reagan Administration the President issued Executive Order 12291. This Order requires cabinet-level departments to prepare benefits-cost analyses justifying major rules. These analyses are scrutinized by the Office of Information and Regulatory Affairs within the Office of Management and Budget. Executive Order 12291 has subsequently been superseded by Executive Order 12866.

## LEGISLATIVE MANDATES

The following section provides a summary of legislation which indicates the extent of the applications of environmental valuation in the coastal and marine resource management and policy arena.

► **WETLANDS PERMITTING.** Among the many pieces of legislation related to wetlands, the most important is probably Section 404 of the Clean Water Act which is a component of the permit process necessary for wetlands conversion for development. When making a permitting decision, the Army Corps of Engineers is expected to balance the public and private benefits of the project against the costs, and to take into account environmental values. No guidelines are provided on how the Army Corp of Engineers should measure costs and benefits. Nor is there any requirement that an actual study be conducted. However, agencies making recommendations to the Corps can (and occasionally do) make their arguments in terms of costs and benefits.

► **NONPOINT SOURCE POLLUTION CONTROL.** Section 319 of the Clean Water Act establishes a national program to control nonpoint sources of water pollution. In addition, Section 6217b of Coastal Zone Act Reauthorization Amendments of 1990 requires that all states with coastal management programs must develop and submit to EPA and NOAA for approval a Coastal Nonpoint Pollution Control Program. Under Section 6217g, EPA is required to publish guidance for specifying economically feasible management measures. All management measures in *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters* are to be economically achievable and cost-effective. This language does little to aid the coastal manager or planner in actually evaluating which management measures create the greatest welfare to society. In order to determine the depth and breadth of nonpoint source pollution control, the value of the resources (water quality, shellfish beds, recreation) must be determined. Once the value of the resources is established, the costs of such regulations can be weighed against the benefits (i.e., enhanced resource and resource service quality).

► **ENVIRONMENTAL REGULATION.** The National Environmental Policy Act (NEPA) requires federal government agencies to conduct an assessment of environmental impacts of proposed legislation and “other major federal actions significantly affecting

the quality of the human environment.” Over the years this authority has been extended to include any actions funded in part or regulated by the federal government, even though they are carried out by private parties. The result of the assessment is an Environmental Impact Statement (EIS). Under NEPA, benefit-cost analysis is discussed but not required. When a benefit-cost analysis is prepared, a discussion of the relationship between the analysis and any analyses of unquantifiable environmental impacts, values and amenities must be included.

► **FISHERIES MANAGEMENT.** The **Magnuson Fishery Conservation and Management Act of 1976** and its amendments require the preparation of fishery management plans under federal jurisdiction by the Fisheries Management Councils for review by the Secretary of Commerce/National Oceanic and Atmospheric Administration (NOAA). Benefit-cost analysis is required under the regulatory impact review component of the plan. Typical analyses might include determining the value of a recreational fishing day or the value of a sector of the commercial fishing industry to society. The National Marine Fisheries Service (for Commerce and NOAA) has issued guidance from time to time on economic analysis, but the adequacy of these analyses has yet to be challenged in court.

► **LITIGATION OF OIL AND HAZARDOUS WASTE SPILLS.** The **Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA)** mandates the preparation of regulations by which natural resource damages from spills of oil or hazardous substances should be assessed to compensate society for losses before the resources are fully restored. The **Oil Pollution Act of 1990 (OPA)** also mandates the preparation of regulations by which natural resource damages, specifically from oil spills, will be calculated. Under CERCLA and OPA, in the event of a spill of oil or other hazardous substances, the public must be compensated for natural resource injuries in order to make them as well off as they would have been without the spill. In developing a damage claim, the resource trustees must determine the value of lost resources and service flows pending restoration. In this case, values may include the value of injured marine mammals or seabirds or the value society attaches to just knowing that a natural wilderness area exists. CERCLA and OPA natural resource damage assessment has attempted to incorporate state-of-the-art environmental valuation techniques. Methods for measuring damages are discussed by name in the regulations, in-

## A Sampling of Legislative Mandates

- ▶ Wetlands Permitting: Section 404 of Clean Water Act
- ▶ Litigation of Oil and Hazardous Waste Spills: The Comprehensive Environment Response, Compensation and Liability Act of 1980
- ▶ Oil Pollution Act of 1990
- ▶ Coastal Resource Management: Coastal Zone Management Act of 1972 (as amended)
- ▶ Marine Sanctuary Designation: Marine Protection, Research and Sanctuaries Act of 1972 (as amended)

cluding travel costs, hedonic valuation, and contingent valuation. Also discussed is the range of types of values, including market-related, nonmarket use values, and nonuse values.

▶ **OTHERS.** The Coastal Zone Management Act of 1972 (as amended) identifies coastal resource uses subject to management that may require benefit-cost analysis including the siting of major facilities related to energy; fisheries developments, recreation, ports and transportation; and the location of new commercial and industrial developments. In addition, the Act encourages the preparation of Special Area Management Plans (SAMP) for reasonable coastal-dependent economic growth. Net economic benefit analysis, in this case, is prepared by state Coastal Zone Management (CZM) programs and submitted to NOAA, which issues SAMP funds.

The **Marine Protection, Research and Sanctuaries Act of 1972** (as amended) requires that public and socio-economic benefits derived from sanctuary designation be assessed as part of the approval process for a proposed site. In addition, an environmental impact statement, fisheries management guidance, and ocean pollution regulations are required.

The **National Estuary Program (NEP)** was established under **Sections 317 and 320 of the Water Quality Act of 1987** (amendments to the Clean Water Act). Under the NEP, the Administrator of EPA is authorized to convene management conferences that represent a partnership across federal, state, and local levels, designed to reach consensus on priority problems of the estuary, the causes of those problems, and the actions that must be taken to correct those problems. The management conference also provides a mechanism for obtaining commitments to take action. These commitments, reflected in the **Comprehensive Conservation and Management Plan (CCMP)**, are the result of the NEP process. Development of the CCMP is critically dependent on the determination of values of estuarine functions and services. Environmental valuation could be an integral part of the scientific characterization process, linking science with policy-relevant issues. Such values could play a major role in the socio-political acceptability of action plan alternatives laid out as a part of the CCMP development and implementation process. Recent guidelines on the role of environmental valuation in NEP planning have been issued by the EPA Ocean Coastal Protection Division.

# 2

## CONCEPTS IN ENVIRONMENTAL VALUATION

The term *value* in economics has a precise definition — it is the price individuals are willing to pay in order to obtain a good or service. The basic economic concepts of supply and demand are employed to estimate willingness-to-pay (called producer surplus and consumer surplus, respectively). This idea of value and its measure remain consistent whether a market good or a state of the environment is at stake.

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The term *value*, in the context of coastal issues, can have different meanings to those with different interests. To an ecologist, the value of a salt marsh might mean the significance or importance of the marsh to the reproductive capacity of certain species of fish. To a coastal engineer, the value of a salt marsh may be associated with its contribution to shoreline stabilization. In general, these values are mathematical and functional: mathematical, meaning magnitude, and functional, meaning the physical or biological relationships of one entity to another. These values exist whether or not humans prefer them or are even aware of them.

## ECONOMIC VALUE

A fundamental distinction between the way economics and other disciplines such as ecology use the term value is the economic emphasis on human preferences. Thus, the functionality of economic value is between one entity and a set of human preferences. If a coastal area is degraded so it supports a lower abundance of organisms, an ecologist would characterize this degraded area as less valuable for those organisms than a non-degraded area. In economic terms, however, a polluted area only has less value than an otherwise equivalent non-polluted area if some individual members of society prefer non-polluted to polluted areas. If no one cares that there are fewer organisms in the polluted area, then there is no difference in economic value. Typically, some members of society will display a preference for an environment that is less degraded.

Economic value is a measure of what the maximum amount an individual is willing to forego in other goods and services in order to obtain some good, service, or state of the world. This measure of welfare is formally expressed in a concept called *willingness-to-pay* (WTP). Thus, the lost value from the degraded environment is the maximum amount individuals are willing to pay to have a state where that same area is free of pollution.

A common difficulty in understanding economic valuation is distinguishing between what something is valued at by individuals and what its economic value really is. Thus, one can find commercial fish landings in the United States in 1993 *valued* at \$3.5 billion and assume that is the value of our commercial fishery. But what is the willingness-to-pay of commercial fishers to be able to land this catch? If all the fisheries were closed tomorrow, would we have to pay \$3.5 billion a year in compensation to leave them as well off as if the fishery were open? The answer would be yes only if fishing was a com-

pletely costless activity, which we know it isn't. The harvesters have to pay for fuel, gear, and, of course, their time which would have been available for alternative income earning endeavors. The fishery, therefore, is worth somewhat less to the harvesters. Figuring how much it is worth is the subject of Chapter 5, Measuring the Value of Non-Market Goods and Services.

In assessing the value of some policy or management plan, the economist is interested in estimating how much an individual's (or society's) well-being would change: how much it will decrease if a natural resource were lost or increase if a natural resource or resource service were better managed or its quality improved. In other words, when economists try to estimate the economic value of a coastal resource or resource service, they attempt to answer one of two questions:

- How much are people willing to trade (give up) of other goods and services to have some natural resource or resource service?
- How much better off would people be if a policy or management plan action were implemented and the amount or quality of a resource or resource service were improved?

## SCARCE RESOURCES, LARGE DEMANDS

The economic definition of value is rooted in a simple idea: all resources are scarce, but the demands for those resources are large relative to their availability. There is never enough labor or land or water to do all the things that all individuals might wish. Because resources are scarce, it is necessary to make choices about how society will use what is available. We make choices about the amount of money to devote to schools, roads, libraries, and natural resource protection programs individually and collectively. These choices are often based on complex tradeoffs; thus, value is revealed in decisions about how individuals and society collectively choose to allocate these resources. People may recoil at the notion of placing a value on the natural environment, but there are other uses or alterations of that environment that might be proposed. Society always has to compromise, giving up something to get something else.

The most direct and visible monetary symbol for a good is its

### Characteristics of Economic Value

- ▶ Products or services have value only if human beings value them, directly or indirectly.
- ▶ Value is measured in terms of trade-offs, and is therefore relative.
- ▶ Typically, money is used as a unit of account.
- ▶ To determine values for society as a whole, values are aggregated from individual values.

market price. The relationship between a good's market price and its value in terms of willingness-to-pay (WTP) can be confusing. We might think, for example, that because an individual buys a certain good at a market price of \$8, then \$8 is what the individual is willing to pay for this good, and thus \$8 is the value to the individual. Such reasoning, however, is not necessarily true. If an individual spends \$8 to obtain a good, we know only that the good is worth at least this much to the individual; he or she may also have been willing to spend more, for instance a maximum of \$10, to obtain the good. In this case, the \$8 market price is only a lower bound estimate of the total value of the good to the individual, that is, the individual's total WTP for the good.

You might conclude from this example that total market expenditures for a good (i.e., price times quantity sold) would constitute a lower bound estimate of its consumer value. The problem with this conclusion is that the appropriate economic measure of welfare or value is *net benefit*, not total value. The net benefits society derives from a good is represented by net WTP, or the amount society would be willing to pay to produce and/or use a good *beyond that which it actually does pay*.

The same principle of economic value holds for *non-market goods*, goods that do not have observable market prices. For example, consider the case of a recreational fisher who would be willing to spend up to \$30 a day to use a particular fishing site, but only has to spend \$20 a day in travel and associated costs. The net benefit or economic value to the fisher of a fishing day at the site is not the \$20 expenditure, but the \$10 difference between what that fisher would be willing to spend and what he or she actually has to spend. If a development project eliminated all fishing opportunity at the site, the fisher would lose the satisfaction of fishing there, as represented by \$10 a day in net benefits. The \$20 a day he or she would have spent to visit the site would not be lost but would be available to spend elsewhere.

Because market expenditures are not measures of net benefits, we cannot use expenditures on the purchase of related goods as a direct measure of the *social value* of the good. Several steps must be taken to provide the information on social value.

Because a market provides a forum for society to express relative preferences in monetary terms, market transactions can be used to infer preferences, and thus economic values. Also, non-market goods can sometimes be valued based on information on preferences provided by market transactions for related products. For example, we

## Economic Value Based on Net Willingness to Pay (WTP)

Consider the case in which only one unit of a certain market good, oysters, is produced at a cost of \$1 per dozen and sold at a price of \$8. If the purchaser had been willing to pay \$10, the net benefit of a dozen oysters to this consumer would be \$2 (\$10 less \$8) — this amount is called consumer surplus. At \$8 a dozen, the producer earns \$7 from the sale (the selling price minus the production price), so the net benefit of the good to the producer is \$7 (called producer surplus). The total economic value of a dozen oysters is thus \$9 (\$2 net benefit to the consumer plus \$7 net benefit to the producer). If for some reason the producer was denied the opportunity to produce and sell oysters (say because of a moratorium on fishing) — and the consumer was denied the opportunity to buy and consume oysters — the total loss to these individuals would be \$9.

can estimate the value of a recreational site by travel expenditures (i.e., gas, lodging, meals).

## CONSUMER AND PRODUCER SURPLUS

In measuring the general satisfaction that society as a whole derives from a good or service, economists often use the concepts of *consumer surplus* and *producer surplus* to approximate the net willingness-to-pay (WTP). When a good is exchanged in a perfectly competitive market, its market price measures the consumer demand (marginal WTP) for the last unit of the good purchased. Market price is determined by the equilibrium of demand and supply, i.e., the price and quantity that correspond to the level at which the consumer's WTP for the next unit produced is equal to the cost of producing it. For all other units of the good purchased, however, the consumer marginal WTP for each unit exceeds market price.

Before discussing consumer and producer surplus, it will be useful to first review supply and demand curves. Supply curves describe the relationship between the quantities of a producer's good or service and the price the producer receives. This relationship is shown

in Figure 2.1. The price for fish and shellfish or whale watching trips, for example, might be represented by the ex-vessel price or fee, respectively. The greater the quantity of whale watching trips or fish produced, the higher the incremental costs (e.g., fuel, ice and crew wages). The producer will produce a higher quantity only for a higher price. Thus, supply curves are upward sloping. Industry supply curves are the aggregation of the quantities of individual firm supply curves.

Demand curves describe the price-quantity relationship for a particular good or service for a consumer (Figure 2.2). They describe what a consumer is willing to pay for various quantities of the good or service, such as whale watching trips or fresh fish. As the number of whale watching trips or fish offered to a consumer increases, satiation sets in and the consumer's WTP for the marginal unit is less. Thus, the demand curve slopes downward to the right. Consumer demand curves are summations of the quantities of individual demand curves.

The excess of what consumers are willing to pay over what they actually do pay for the total quantity of a good purchased is called *consumer surplus* (Figure 2.3); it represents the good's value to consumers in terms of net WTP, and is represented by the area under the good's demand curve, bounded by price (Figure 2.2). Moreover, a good's market-clearing price — the price that satisfies supply and demand simultaneously, represented by the intersection of the supply and demand curves — also corresponds to the marginal cost of producing the last unit of output. For all other units of the good produced, however, the producer marginal production cost for each unit is less than market price.

The excess of what producers earn over their production costs for the total quantity of a good sold is called *producer surplus* or economic rent. This value represents the production value or net benefit of the good to producers, and it is represented by the area over the good's supply curve, bounded by price (Figure 2.3). While not an exact measure of social welfare, the sum of consumer surplus and producer surplus provides a useful approximation of the net benefit of a good or service.

The concept and measurement of economic value, generally upheld in courts of law, has been evolving. There are clearly issues that have not yet been resolved in this conceptual framework. For example, there is controversy about whether it is appropriate to use a minimal amount one is willing to accept when estimating welfare losses due to environmental damage. Yet, these concepts are useful. They bring us closer than we have ever been before to incorporating some

Figure 2.1. Supply Curve

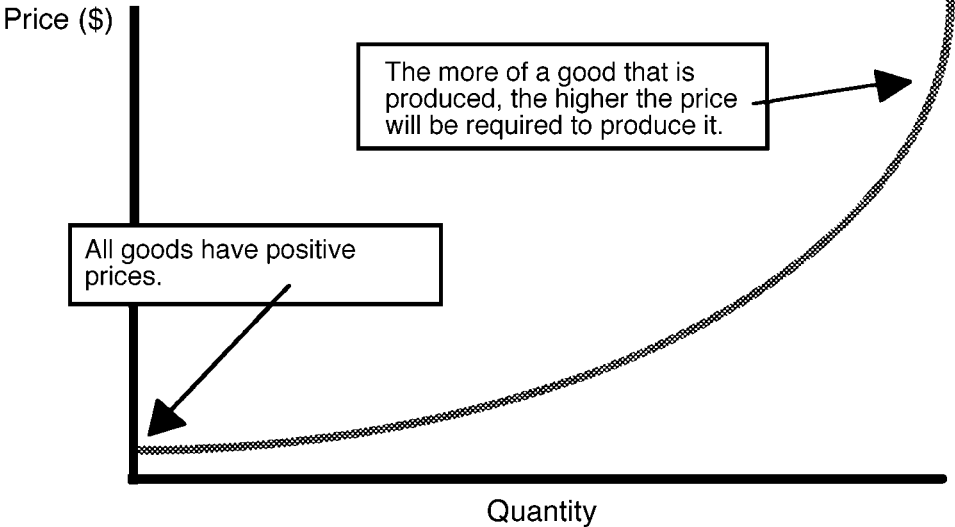


Figure 2.2. Demand Curve

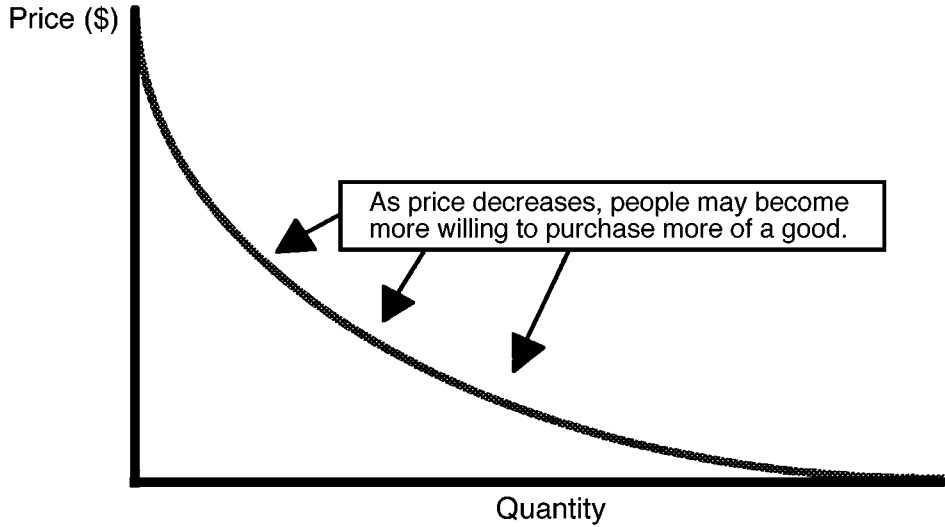
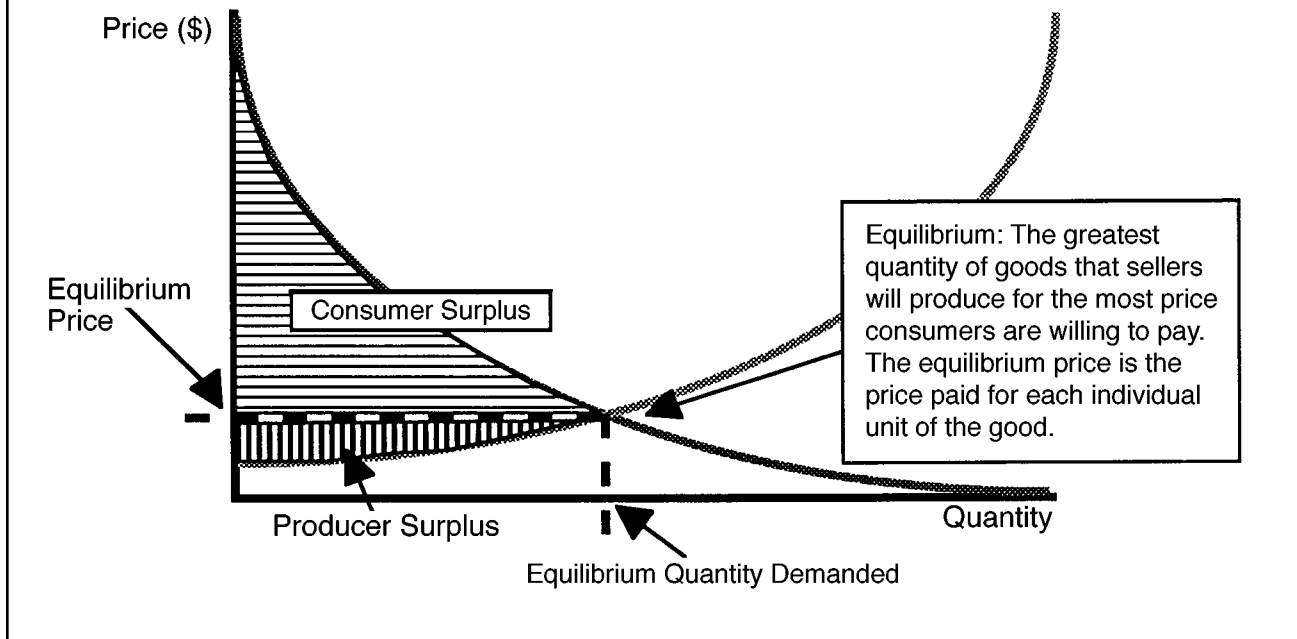


Figure 2.3. Consumer and Producer Surplus



of the natural resource values that we all know exist into the trade-off decisions that are made by government agencies and by courts.

## ENVIRONMENTAL VALUATION

*Environmental valuation* is a series of techniques that economists use to assess the economic value of market and non-market goods, namely natural resources and resource services. It applies the *welfare economics* concepts of producer and consumer surplus to issues involving natural resources and the state of the environment. Welfare economics tries to answer the question “Is society better off?” Environmental valuation is the application of welfare economics when the differences in circumstances relate to the uses or states of natural resources or the quality of the environment.

When economists refer to evaluating societal benefits, it is necessary to recognize two “states of the world”: *with* and *without*. *Without* is the base state if an activity, circumstance and policy does not change. *With* is the state when the change occurs. A distinction is made between *with* and *without* and *before* and *after*. *Before* and *after* does not control for changes in the state of the world that do not result from the action or policy in question. Economists try, for exam-

ple, to weigh social benefits associated with a commercial development project against environmental benefits that would be lost should the project be implemented. Such a *social accounting* analysis tallies all real costs associated with an activity, including the cost of lost or damaged environmental assets and quality of life. Desirable characteristics of this social accounting scheme are these: it is internally consistent (i.e., the underlying theory does not change with circumstance), usually intuitively appealing, and acceptable in major courts of law.

The measurement of gains or losses is a *net value* (i.e., the value of a site's services over and above the next best alternative). As we will see, the estimates of benefits are not restricted to losses in commercial enterprises, such as losses to commercial fisheries. Benefit measures attempt to account for the subjective preferences of society regarding the use and existence of coastal or marine resources. For example, in siting a proposed development project, the location should be where the net benefits (commercial gains from the development) minus the costs of production and environmental damages it causes, are maximized. If benefits are negative, then the development would represent an inefficient use of society's resources. For example, a shopping mall built on wetlands provides less net benefits than the same project, just as convenient to shoppers, built on common uplands.

As a general rule, the fewer substitutes available for a good or service, the greater the loss. Thus, a site that provides excellent recreational experiences might be adjacent to another site that provides equally good recreational experiences. The loss to the recreationist from losing one site would be smaller than if there were no close substitute. However, if elimination of one site causes congestion at another site and lowers the quality of the recreational experience for everyone, then those losses must also be taken into account.

Gains from development will be higher where substitutes are fewer and more costly. Take again the simple case of a shopping mall: gains from a new shopping mall would be the extra profits the retail stores could make plus the gains to consumers from having shorter distances to travel to shop. However, if another mall exists nearby, consumers will gain little from the additional mall and the retail stores in the first mall may lose almost as much in profit as those made by stores in the new mall. The net value to shoppers, real estate, and stores owners is the figure that should be compared to the losses from building the mall.



# THE SOCIAL ACCOUNTING SCHEME: A CASE STUDY

*Orian Corporation v. State of Washington Department of Ecology* illustrates how environmental economists employ social accounting techniques as a first step in doing an economic valuation. The case provides an example of the role environmental valuation could play in decisions related to development of environmentally sensitive areas and, potentially, to the determination of compensation in the event of a regulatory taking.

In the 1960s, the Orian Corporation proposed to dredge and fill lands that they owned in the Padilla Bay tidelands of Skagit County in northwestern Washington State to create a Venetian-style community. According to Charles Lean, former Assistant Attorney General and counsel for the State of Washington in *Orian*, the planned community would have been the most populous town in Skagit County.

Padilla Bay is home to the largest contiguous expanse of eelgrass in the state, serves as a salmon and dungeness crab nursery, and is critical habitat to thousands of ducks and geese, as well as endangered bald eagles and peregrine falcons. Recognizing the importance of these natural resources, Skagit County's 1976 Shoreline Master Program (administered by the Washington State Department of Ecology), required by the State's Shoreline Management Act, designated Padilla Bay tidelands "aquatic," which prohibited all uses except nonintensive recreation and aquaculture. The use restrictions in Skagit County's Shoreline Master Program essentially barred Orian's plans to dredge and fill the bay for an overwater housing development.

Orian Corporation argued the shoreline regulations constituted a "regulatory taking" and sued for the right to develop the property. The courts had to determine whether state interference with Orian's use of the property was sufficiently restrictive to deny Orian any reasonable use of the land without offering fair market value. The Washington Supreme Court held that the shoreline regulations did not cause an unconstitutional taking on two grounds.

First, the court held that "the public trust doctrine would have prohibited the intended development anyway, despite the Shoreline Management Act. Therefore, since there was no right to place fills or

## Desirable Properties of a Social Accounting Scheme

- ▶ Accounts for all real costs or benefits from an activity
- ▶ Internally consistent
- ▶ Intuitive
- ▶ Accepted in courts

build houses in the first place, there was no taking. The state does not have to pay for taking a property right which never existed.” Second, the Supreme Court declared that the shoreline regulations did not violate the Constitution because “whenever the state imposes land use restrictions in order to safeguard the public interest in health, the environment, and the fiscal integrity of the area,” it is a legitimate use of police power and is “insulated” from takings claims.

The court, however, also recognized that regulations intended to protect the Padilla Bay National Estuarine Research Reserve may have prevented reasonably profitable use of Orian’s tidelands. Because the regulations were not intended to protect public health and safety but instead served to enhance the value of the publicly owned Reserve, they could have caused a temporary taking. The Court sent the case back to a lower court to resolve factual issues, where a jury held that the Padilla Bay Reserve caused a temporary taking and Orian was due compensation.

The final settlement included the cost of the acreage plus interest accrued since the creation of the Padilla Reserve in 1980, in addition to attorney fees. In exchange for \$3.6 million, Orian released all claims against the Department of Ecology and transferred all rights in Padilla Bay tideflats to the state. Thus in June 1993, the Padilla Bay National Estuarine Research Reserve in Skagit County quadrupled in size with the acquisition of 8,004 acres from the Orian Corporation and its Padilla Bay associates.

Now, suppose Washington wished to assess the potential benefits and costs of allowing the Orian Corporation to proceed with this

## Stakeholders in Padilla Bay Development

### LOSERS

- ▶ Commercial Fishers
- ▶ Recreational Fishers
- ▶ Fish Consumers
- ▶ Wildlife Viewers
- ▶ Nonusers

### GAINERS

- ▶ Orian Corporation
- ▶ Wildlife Viewers
- ▶ Consumers of Housing

development project rather than incur legal costs and takings compensations. If this situation were analyzed from the environmental economist's perspective, the first step would be to ask: "Who are the players that would be affected by the decision?" That is, "Who are the gainers and losers of limiting Orian's ability to use the tidelands as they wished?" Here is a summary of how some of the stakeholders could be affected. First, the losers.

► **COMMERCIAL FISHERS.** Development activities on or near the shoreline could destroy salmon and dungeness crab habitat, ultimately resulting in reductions in the stocks of these species and subsequent loss of profit to local harvesters. In this market case, it is the lost profits (lost revenues minus costs) that matter — what harvesters would be willing to pay to avoid the development.

If development occurs unchecked, harvesters may move to other grounds (necessarily less desirable, or they would have already been fishing there) and so they may continue to make some profits (but probably less than they would have made). The appropriate loss to measure takes this move into account. It is a measure of how much worse off fishermen are after they make all the adjustments they can. Additionally, if their adjustments affect others (e.g., deplete other's fishing grounds), then those losses must be counted.

Economics has empirical methods for approximating all of these losses. Commercial harvesters may also have other non-commercial values associated with this environment. Harvesters may value the aesthetic setting, the wildlife they see while fishing, etc. These values are typically measured along with other people's values of this sort.

► **RECREATIONAL FISHERS.** The same ecological disruptions that harm the commercial fishers may also harm the recreational salmon and crab fishers. As a result of development by the Orian Corporation, the recreational fishers may have fewer grounds to fish and their catch rates may decline.

Substitution is again an issue. Recreational fishermen will have other alternative fishing sites and target species, possibly less desirable. We must measure the net effect of the development on these alternatives as well. Note that if the result makes remaining grounds more congested, this loss must be taken into account.

Unfortunately, there is no market that captures how much worse off recreational fishermen are as a result of the development. The measure we seek is the maximum amount of money recreational fishers would be willing to pay to avoid these damages. How we get

this measure will be discussed in Chapter 5, Measuring the Value of Non-Market Goods and Services.

► **FISH CONSUMERS.** If Orian's development were to affect the fishery for salmon and crab so that significantly fewer salmon and crab were available in the market, fish prices would rise and the consumers of fish would be negatively impacted.

Here, substitution possibilities are very important. The crab and salmon consumers will substitute other products but will, by definition, be worse off (or they would have made these choices to begin with). In addition, if their substitution causes prices of other species of fish to rise, this rise should also be taken into account.

► **WILDLIFE VIEWERS.** If the Orian overwater housing development on Padilla Bay were to destroy the critical habitat of migrating shorebirds, bald eagles or peregrine falcons, the available area to view these birds may be reduced, as may the number of birds themselves, thus creating an overall reduction in birdviewing opportunities. There is no market to capture these losses directly and we will need to resort to non-market techniques.

► **NONUSERS: NATURALISTS AND OTHERS WHO CARE ABOUT THE ENVIRONMENT BUT DON'T USE THE TIDEFLATS OF PADILLA BAY.** Padilla tideflats are a relatively rare ecosystem and provide critical habitat to endangered bald eagles and peregrine falcons. There may be individuals who do not visit this area but to whom the existence of these important natural resources is valuable. These people may be willing to pay some dollar amount to prevent the destruction of this habitat. Thus, in the event that the Orian development was allowed to occur and the unique resources of Padilla Bay were impacted or injured, these individuals would experience a loss of value.

If development did occur, the following stakeholders might be gainers:

► **ORIAN CORPORATION.** Orian Corporation would probably be able to increase its profits from the development over and above what they would have made in the next best alternative (i.e. developing housing somewhere else). Most, if not all, of the gains from development will be measurable in markets.

► **WILDLIFE VIEWERS.** The Orian development could enhance access to the tidelands and thus improve bird-viewing opportunities. If these prospects were to occur, the benefits to wildlife viewer might increase. Again there is no market to capture these losses directly and we will need to resort to non-market techniques to measure them.

► **CONSUMERS OF HOUSING.** If the Orian development was to have sufficient impact on the Skagit County housing market, the price of housing might drop with the increased availability of housing provided by Orian. Thus, the consumer would gain by the amount of the reduction in housing prices. Again, these gains could be measured using market prices.

# 3

## ECONOMIC TOOLS FOR USE IN COASTAL MANAGEMENT DECISIONMAKING

Several types of economic information are useful for coastal decisionmaking. Environmental value is important in some of these: benefit-cost analysis, natural resource damage assessments and sustainable development assessment. Other kinds of information such as economic impact analysis are often confused with value measures, but provide different information to the decision process.

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## Economic Tool Kit

- ▶ Economic Impact Analysis
- ▶ Cost-Effectiveness Analysis
- ▶ Benefit-Cost Analysis
- ▶ Natural Resource Damage Assessment
- ▶ Sustainable Development

Coastal management and policy decision making requires information that ranges widely from land-use impacts on natural resources to economic implications of changes to terrestrial and aquatic ecosystems. While the availability of accurate information does not mean that such decision making will necessarily be good, it is clear that the lack of accurate information will almost always contribute to uninformed decisions.

While the focus of this handbook is on environmental valuation, namely, determining the dollar value of natural and environmental resources and resource services, it is important for coastal managers and planners to recognize a variety of alternative economic approaches to generating and presenting economic information. Each approach calls for different skills and research procedures, and each is intended to answer a different question.

Which of these economic approaches planners choose depends on what they want to know. This chapter provides a brief review of the most important economic approaches that can be applied to coastal zone planning and management.

## ECONOMIC IMPACT ANALYSIS

Economic impact analysis is a methodology for determining how some change in regulation, policy, or new technological breakthrough, or other action affects regional income and other economic activities including revenues, expenditures, and employment. Economic impact analyses can be focused at any level, for example:

- Local environmental groups may want to assess the impact of a wetlands law on the rate of population growth and tax base in their community
- Regional groups might need to understand the impacts of a national regulation on their particular economic circumstances
- International agencies might be interested in how efforts to control CO<sub>2</sub> emissions might impact the relative growth rates of rich and poor countries

To begin with, we must first distinguish economic activity from economic value. Companies supporting the worth of a proposed development plan, for example, will often cite figures on sales volume or increases in jobs. They may claim that the new development will boost sales of other companies. These numbers are measures of eco-

conomic activity; they are not measures of social value, or what things are worth to people (see Chapter 2, Concepts in Environmental Valuation). Techniques for measuring the economic or market activity that such development generates is sometimes called economic impact analysis.

If a new establishment moves into a region, economic impact analysis would measure the impact or effects of this new establishment on other businesses. Assume the establishment hires local workers, buys products from local suppliers, and purchases transportation facilities or other services. The individuals and firms that the new establishment buys from may then increase their purchases from other suppliers. Economic activity, then, measures the additional income that is generated by the new spending.

Economic impact analysis does not account for social benefit or value. It does not account for what is being given up, nor what alternatives are foregone (i.e., opportunity costs). For example, an impact analysis of recreational fishing does not contain an analysis of what people would do with their time and money if, as the result of a fishery closure or moratorium, they couldn't go fishing. Would they go bowling instead of fishing? If so, would they generate more or less economic activity in the alternative activity? In addition, impact analysis does not take into account anything that is not traded on the market.

## Economic Impact Vs. Social Value

Natural disasters offer examples of why economic activity is not a measure of social value. Most people would have considered society better off had Alaska's Exxon Valdez oil spill not occurred. Likewise, society would have been better off had Hurricane Andrew not hit south Florida. However, each of these disasters generated increased amounts of economic activity. A good deal of money changed hands in the form of increased demand for services, oil spill cleanup employment, construction, sales of plate glass and household supplies. While no one would claim that society benefited as a whole (clearly some individuals and businesses did), the economic impact of these events was positive.

While these expenditures represent revenue to a local community, they also represent costs to the recreationists. Furthermore, expenditures do not measure the loss of value to the angler that would result should fishing no longer be available in an area, or the gain in value to the angler that results from establishing a new fishing opportunity. From a broader perspective, increased fishing activity in one area may generate more expenditures within that area but may also mean an offset of activity and, therefore, expenditures in another area. As a result, the net gain in economic activity between areas may be zero, or even negative.



## COST-EFFECTIVENESS ANALYSIS

Cost-effectiveness analysis is a methodology that can be applied whenever it is unnecessary or impractical to consider the dollar value of the benefits provided by alternatives under consideration (e.g., each alternative has the same benefits expressed in monetary terms or each alternative has the same effects but dollar values have not been assigned). A project is cost-effective if it is determined to have the lowest cost of competing alternatives in present value terms for a given amount of benefits.

Suppose a community determined that its current water supply was contaminated with some chemical, and that it had to switch to an alternative supply. Assume there are several possibilities: the community could drill new wells into an uncontaminated aquifer, it could build a connector to the water supply system of a neighboring town, or it could build its own surface reservoir. A cost-effectiveness analysis would estimate the costs of these different alternatives with the aim of showing how they compared in terms of, say, the costs per million gallons of delivered water into the town system.

A cost-effectiveness modeling approach avoids the issue of evaluating benefits by setting desired objectives beforehand and searching for the lowest-cost ways of achieving these. Such an approach can facilitate the comparison among alternative policy or management plans. Cost-effectiveness analysis can help you eliminate those actions that cost more than equally, or less, effective alternatives or those actions that cost the same as more effective options. Such an approach also allows decision makers to build a “frontier” of cost-effective actions that highlights the higher marginal costs associated with different alternatives.

It may make good sense to do a cost-effectiveness analysis even before there is a strong public commitment to the objective you are costing out. In many cases, it may not be obvious how much people value a given objective. Once a cost-effectiveness analysis is done, they may be able to tell, at least in relative terms, whether any of the different alternatives would be desirable. They may be able to say something like: “We don’t know exactly how much the benefits are in monetary terms, but we feel that they are more than the costs of several of the alternatives that have been costed out, so we will go ahead with at least one of them.”

## BENEFIT-COST ANALYSIS

Benefit-cost analysis is a methodology that compares the present value<sup>3</sup> of all social benefits with the present value of opportunity costs in using resources. It can give valuable insights into the economic efficiency of management and regulatory actions. If the net value (benefits minus costs) of a project or action is greater than zero, then the that project is considered to be economically efficient. The more the benefits exceed the costs, the better off society is in economic terms as a result of the activity.

It is important to note at the outset that the basic benefit-cost framework has limitations, among them, determining the discount rate of future costs and benefits, discounting and future generations, distributional issues, uncertainty and risk, and irreversibility; these factors will be discussed further in Chapter 7, Theory and Application: Reconciling Differences.

Despite these limitations, benefit-cost analysis is the major tool for conducting economic evaluation of public programs in natural resource management, such as flood control, irrigation, hydropower, harbor improvements, and alternative energy supply projects. It is a four-step process that includes the following elements.

► **SPECIFY THE PROGRAM.** Benefit-cost analysis is a tool of public analysis, though there are actually many publics. Thus, the first step is to decide on the perspective from which the study is to be done. If you are doing a benefit-cost study for a national agency, the “public” normally would be all the people living in the particular country. But if you are employed by a city or regional planning agency to do a benefit-cost analysis of a local environmental program, you would undoubtedly focus on benefits and costs accruing to people living in those areas. The first step also includes a complete specification of the main elements of the project or program: location, timing, groups involved, connections with other programs, etc.

► **DESCRIBE QUANTITATIVELY THE INPUTS AND OUTPUTS OF THE PROGRAM.** For some projects, determining the input and output flows is reasonably easy. In planning a wastewater treatment facility, the engineering staff will be able to provide a full physical specification of the plant, together with the inputs required to build it and keep it running. For other types of programs, such determinations can be much harder. A restriction on development in a particular region, for example, can be expected to deflect development

### Benefit-Cost Analysis is a Four-Step Process

- Specify the project or program and alternatives.
- Describe quantitatively the inputs and outputs of the program.
- Estimate the social costs and benefits of inputs and outputs.
- Compare benefits and costs.

<sup>3</sup> Field, B.C. 1994. Environmental Economics. McGraw-Hill, Inc., New York.

**Benefit-cost analysis involves measuring, adding up, and comparing all the benefits and all the costs of a particular public project or program.**

elsewhere into surrounding areas. In this step, we first have to recognize the great importance of the time it can take to complete large undertakings: environmentally related projects or programs may require years. Therefore, the job of specifying inputs and outputs involves predictions of future events, sometimes many years after a project begins. Consequently, having a good understanding of factors such as future growth patterns and future rates of technological change and possible changes in consumers' preferences is important.

► **ESTIMATE SOCIAL COSTS.** Assigning economic values to input and output flows is to measure costs and benefits. The methods for such measurements are the subject of Chapter 4, Measuring the Value of Goods and Services Traded in Markets and Chapter 5, Measuring the Value of Non-Market Goods and Services.

► **COMPARE BENEFITS AND COSTS.** In this final step, total estimated costs are compared with total estimated benefits. Table 3.1 illustrates the estimated benefits and costs associated with a regulatory program to control various airborne and waterborne pollutants coming from a group of marinas.

**Table 3.1. Results of a Benefit-Cost Analysis of a Proposed Emission Reduction Program for a Group of Marinas**

Totals over life of the program (\$ millions)	
<b>Costs</b>	
Private compliance	
Capital equipment	580
Operating	560
Public monitoring and enforcement	96
<b>Total</b>	<b>\$1,236</b>
<b>Benefits</b>	
Increased benefits to recreators from improved water quality	1,896
Increased property value from reduced air emissions	382
Nonuse value increase related to ecological integrity	749
<b>Total</b>	<b>\$3,027</b>
<b>Net benefits</b>	<b>\$1,791</b>

## Guidelines for Benefit-Cost Analysis that Incorporate Environmental Valuation

While legislation requires net economic benefit analysis, and there are clear applications for environmental valuation, the guidelines for actually doing such an analysis are limited. The two most widely referred to guidelines are the following:

► **WATER RESOURCES COUNCIL.** *The Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies, 1983*, is the latest in a series of guidelines published by the Water Resources Council under the Water Resource Planning Act. It provides the required guidelines to be used for estimating the benefits and costs of constructing a public works project. The early versions of these guidelines first codified the use of applied welfare economics in evaluating public projects. The guidelines establish the elements that need to be taken into account when assessing the benefits and costs of a project, and incorporate the concepts of consumer and producer surplus measures in markets, as well as their counterpart in non-market settings. Unfortunately, the methodological prescriptions are somewhat out of date.

► **ENVIRONMENTAL PROTECTION AGENCY.** The Environmental Protection Agency's *Guidelines for Performing Regulatory Impact Analysis, 1991*, provides the latest set of guidelines for performing benefit-cost analysis on proposed environmental regulations, as mandated by Executive Order 12291. These guidelines are, for the most part, quite good and are continually being revised to reflect methodological advances. The focus is on measuring and valuing both health and environmental effects. Techniques for valuing the benefits of environmental improvements include travel cost, hedonics, and contingent valuation. The guidelines show an awareness of distributional considerations, both across the current population and between generations.

These emissions reduce the water quality in the bay on which they are located and contribute to air pollution in the vicinity of the marinas. The dollar values are totals of various cost and benefit categories over the life of the regulatory program. Compliance costs in the industry consist of \$580 million of capital equipment costs and \$560 million of operating costs. Public-sector monitoring and enforcement required to achieve an acceptable level of compliance total \$96 million. There are three major benefit categories: recreationists (fishers and boaters) benefit from improved water quality at an estimated value of \$1,896 million; property values of local homeowners are expected to increase to \$382 million because of improved air quality and visibility resulting from reduced airborne emissions;

nonuse values associated with the general improvement in the ecological integrity of the bay are estimated at \$749 million.

We can compare total benefits and costs in several ways. One way is to subtract the total costs from total benefits to get “net benefits.” In Table 3.1, the net benefits are \$1,791 million (\$3,027 minus \$1,236). Another criterion is the benefit-cost ratio, found by taking the ratio of benefits and costs. This shows the benefits the project will produce for each dollar of costs; the benefit-cost ratio is 2.5 (\$3,027 divided by \$1,236)

## NATURAL RESOURCE DAMAGE ASSESSMENT

Natural resource damage assessment is a methodology for determining the liability for injury to natural assets that results from release of oil or hazardous substances. Three federal statutes — the Clean Water Act, CERCLA, and the Oil Pollution Act — all impose liability assessments for injury to natural assets that result from oil spills or hazardous wastes and other substances. Under these acts regulations for comprehensive natural resource damage assessments have been developed by the Department of the Interior and NOAA. The process includes three steps: (1) injury determination; (2) quantification of service effects; and (3) damage determination. Environmental valuation plays a role in the latter step. Natural resource damages are the sum of:

- Restoration costs
- Compensable value (diminution in value of foregone natural resource services prior to restoration)
- Damage assessment costs

► **RESTORATION COSTS** (which also include costs of rehabilitation, replacement, and/or acquisition of equivalent resources) include both direct and indirect costs. Direct costs are costs charged directly to the conduct of the selected alternative, such as staff time, materials, equipment, and the like. Indirect costs are costs of activities or items that support the selected alternative but cannot be directly accounted for, such as overhead.

► **COMPENSABLE VALUE** is the amount of money required to compensate the public for natural resource services losses between

the time of the release and the time when these services are fully restored to their baseline condition. Compensable value excludes any losses associated with secondary economic impacts resulting from the release, such as losses incurred by businesses patronized by users of the injured resources (e.g., bait and tackle shops).

► **DAMAGE ASSESSMENT COSTS** are the costs of performing the studies to determine the other costs mentioned above.

## SUSTAINABLE DEVELOPMENT ASSESSMENT

Sustainable development — development that meets the economic needs of the present without compromising the ability of future generations to meet their economic needs — links two basic ideas: ecological sustainability, which implies that biological elements (including humans) and processes that keep ecosystems productive and resilient, should be maintained; and economic development, which seeks to maintain economic growth or expansion, should be undertaken.

Ecological sustainability and economic development must be linked when implementing policies that would lead to sustainable development. The ability to implement such policies requires multidisciplinary approaches which blend the perspectives, the goals, and objectives of disciplines such as ecology, social science, and economics.

Determining the value of natural resources and environmental assets in the sustainable development framework is useful in a number of ways, including:

- National and regional income accounting
- Strategic benefit-cost analysis
- Project level benefit-cost analysis

► **NATIONAL AND REGIONAL INCOME ACCOUNTING.** Environmental values may be used to modify national income accounts so that they reflect improvements and declines in environmental resources. The objective is to obtain a better index of economic well-being and avoid net loss transfers of wealth between the market and non-market sectors. Standard gross domestic product (GDP) accounts reflect only a portion of a nation's economic productivity (the portion traded in ordinary markets). Using standard accounts, a

county or region could destroy its resource base but show an increase in wealth. For sustainable development to be operational in economic policy, environmental accounts and standard economic accounts must be integrated.

► **STRATEGIC BENEFIT-COST ANALYSIS.** The objective of strategic benefit-cost analysis is to set priorities and make trade-offs across a range of alternative policies. Such analysis is motivated by the economic consequences of environmental investments. For instance, strategic analysis may assess the benefits of investments in salmon habitat restoration relative to nonpoint source pollution controls. Alternatively, such an analysis may respond to questions such as, “How much should we clean up? What level of investment should we make in nonpoint source pollution control or salmon habitat restoration?” Beneficial policies are selected and put together to construct an overall policy package or agenda.

► **PROJECT-LEVEL BENEFIT-COST ANALYSIS.** Examines the benefits and costs of specific policy actions and controls and extends conventional benefit-cost procedures to the non-market sector. This extension is increasingly common in development decisions. For example, a study might estimate a household’s willingness to pay to hook up a centralized sewer system in order to reduce nonpoint source pollution. In controlling nonpoint source pollution, project-level analysis examines the benefits and costs of specific actions. It addresses the means and methods of control once the general direction of policy is set.

# 4

## MEASURING THE VALUE OF GOODS AND SERVICES TRADED IN MARKETS

If goods or services are traded in the market, there are well established and accepted empirical techniques for measuring welfare changes. For measuring producer surplus, it is not necessary to estimate the supply curve. For measuring consumer surplus, it is essential to estimate the demand curves. These conventional techniques of measuring changes in value serve as a springboard for understanding non-market techniques of economic valuation.

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To estimate use values, economists employ market resource valuation methodologies. For those resources for which markets exist, economists typically rely on directly observable behavior in the form of market transactions to reveal preferences or the value that individuals place on goods and services and their willingness to pay to avoid loss of such goods and services. The standard method for measuring the use value of resources traded in the marketplace is the estimation of producer and consumer surplus using market price and quantity data.

## MEASURING PRODUCER SURPLUS WITHOUT ESTIMATING SUPPLY

Sometimes the measurement of changes in producer surplus does not require complicated econometric modeling to estimate the supply curve (see Chapter 2, Concepts in Environmental Valuation). Careful measurement of all the opportunity costs of production in alternative situations can be used to estimate the change in producer surplus. Consider the hypothetical case in which habitat degradation results in a reduction of striped bass available to the commercial fishery in Chesapeake Bay, a reduction in catch from 8,000 to 5,000 pounds a day. The ex-vessel price, below, refers to the price paid directly to the harvesters for whole fish.

Prior to the reduction in stock size the state of the fishery was estimated as follows:

Catch rate per day (pounds) = 8,000

Ex-vessel price = \$0.70/pound

Variable costs per pound = \$0.40

Total days fished in season = 16

Total revenue =  $16 \times 8,000 \times 0.70 = \$89,600$

Total variable cost<sup>5</sup> =  $16 \times \$0.40 \times 8,000 = \$51,200$

Producer surplus = Total revenue minus total variable cost  
=  $\$89,600 - \$51,200 = \$38,400$

To simplify the analysis, we assume that the harvesters will not change their fishing behavior, at least in the short run, due to the

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<sup>5</sup> Variable costs or costs which vary with output. Fixed costs are not included because, by definition, they do not change in the two scenarios. Thus, even if we bothered measuring them, they would be netted out when comparing the two scenarios.

decrease in stock size. However, reduced stock size can affect harvesters by lowering their catch rate and increasing their variable costs of production. After the reduction in stock size, the state of the fishery is:

Catch rate per day = 5,000

Ex-vessel price = \$0.70 (note: for simplicity we assume no price change)

Variable costs per pound = \$0.50 (uses more fuel searching for fish)

Total days fished in season = 16

Total revenue =  $16 \times 5,000 \times \$0.70 = \$56,000$

Total variable cost =  $16 \times \$0.50 \times 5,000 = \$40,000$

Producer surplus =  $\$56,000 - \$40,000 = \$16,000$

The estimated change in producer surplus is  $\$38,400 - \$16,000 = \$22,400$

**Advantages of This Technique.** We have a number that can be compared against the producer surplus created by the activity that resulted in the habitat degradation. For the average fisher, the degradation of striped bass habitat has created a welfare loss of \$22,400 per year. If there are 100 fishers, the estimated welfare loss would be \$2,240,000. In practice the calculation would be more complicated. What will be the predicted response of harvesters due to the reduction in stock size? Will some harvesters drop out of fishing or go after a different species? If so, what is their producer surplus in these alternative activities?

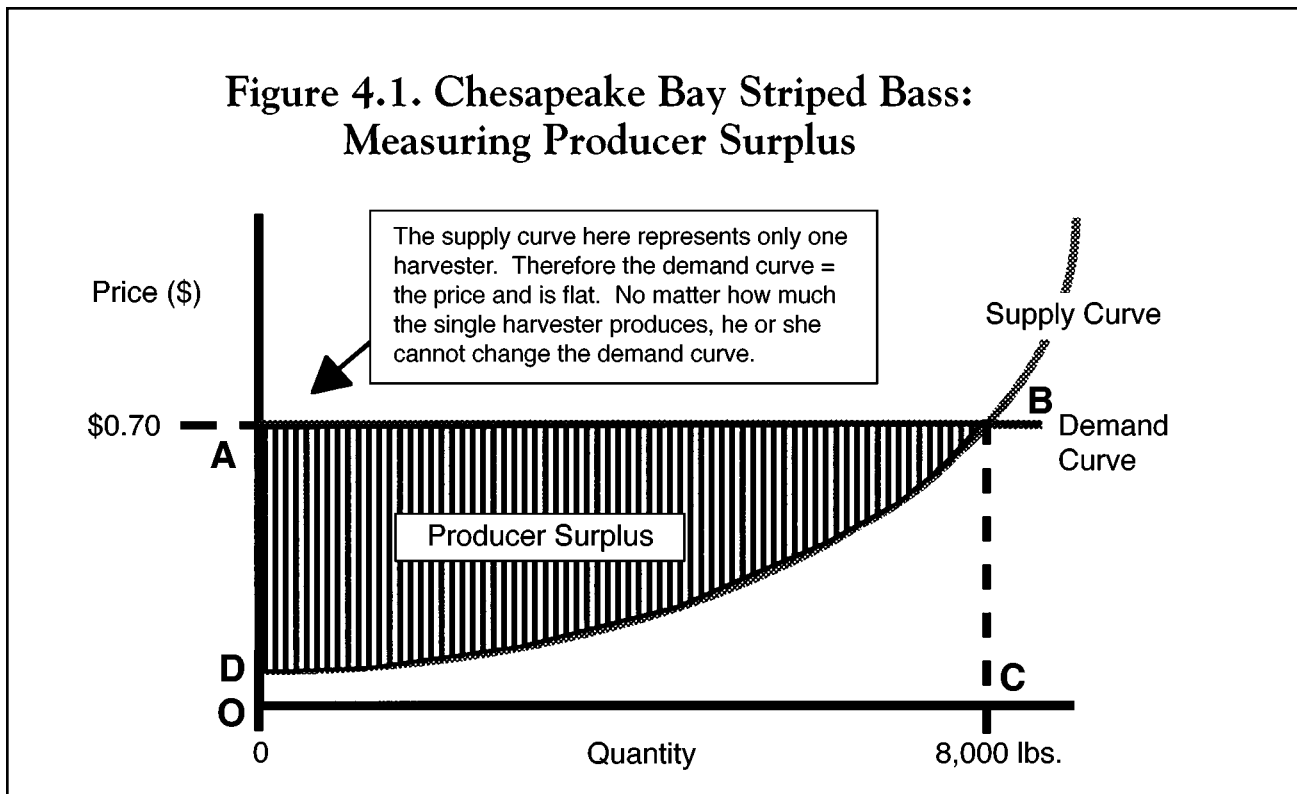
**Disadvantage of This Technique.** Such an analysis may be problematic because of difficulties in accurately predicting the changes in cost and earnings due to environmental change and in fisher behavior. Also, the prices and cost of inputs and outputs (true opportunity costs) may diverge from accounting costs. This is particularly a problem with fisheries because of the common property nature of the resource. The intricacies of that problem are beyond our study of environmental valuation.

**Data Needs.** The data required for such an analysis include detailed costs and earnings for a representative fisher. Such information could be obtained from an industry survey.

# MEASURING PRODUCER SURPLUS BY ESTIMATING SUPPLY

Econometric (statistics of economics), techniques can be used to estimate the industry supply curve — these techniques are an alternative to the previous methods for directly calculating changes in producer surplus. The method is directly linked to the previous approach for measuring producer surplus because the industry supply curve is another way of representing the variable costs of production that that method employs. The area under the industry supply curve (to any given quantity) is equal to the industry's total variable cost to produce that quantity.

From Figure 4.1 we can geometrically determine the producer surplus: draw a rectangle connecting the price of striped bass (Y-axis) and the quantity caught (X-axis) through its point on the supply curve (OABC). The area of this rectangle is simply price times quantity or total revenue, the same as in the previous example. If we subtract from this rectangular area, the area under the supply curve (area of ODBC, equal to total industry variable costs when producing

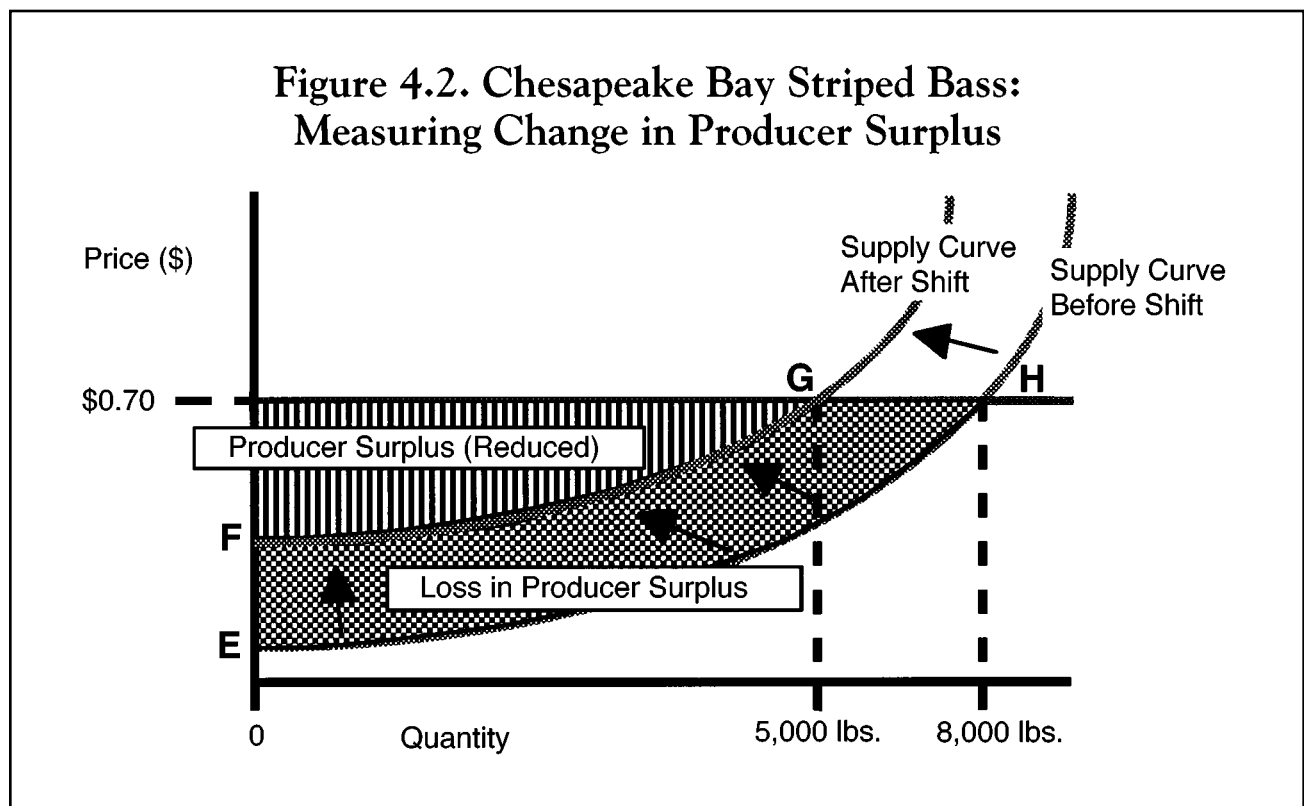


that quantity), the remaining area (ABD) is equal to the producer surplus from the previous method.

The same exercise can be done to describe the situation after the decrease in the size of Chesapeake Bay striped bass populations. The reduction in stock size causes a shift left in the industry supply curve because supply is dependent on the size of the stock. The difference between the areas of the producer surplus triangles with and without the environmental impact is the change in producer surplus (Figure 4.2) or welfare loss (area EFGH).

**Disadvantage of This Technique.** The major problems associated with this technique include the need to account for all the factors that affect the supply curve over time (e.g., technical change in fishing and regulations) to isolate the effect of the environmental welfare loss.

**Data Needs.** The data required for this analysis include time series data on input and output prices, landings, and stock abundance.



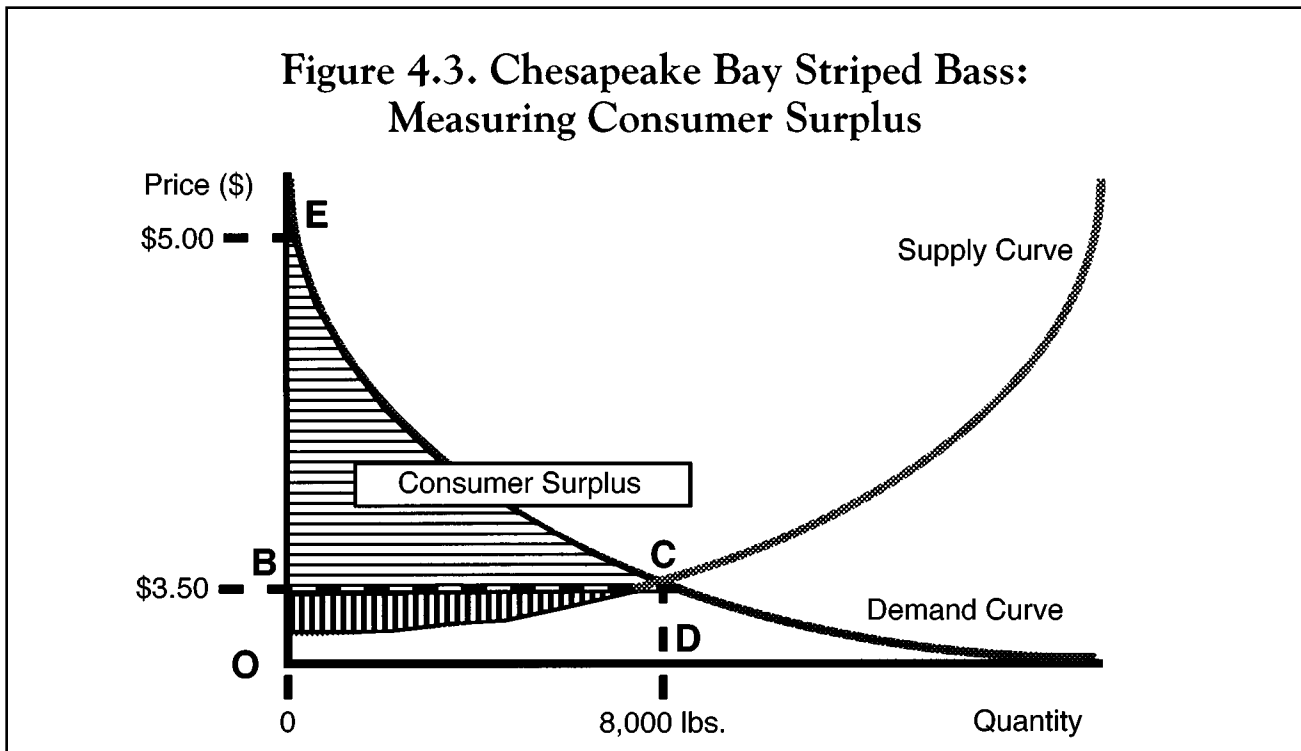
## EMPIRICAL TECHNIQUES FOR MEASURING CONSUMER SURPLUS

As in the case of producer surplus, econometrics can also be used to estimate consumer demand and thus changes in consumer surplus. The area under the demand curve is equal to the consumer's total willingness-to-pay. Suppose that initially fish consumers must pay \$3.50 per pound at the retail fish market. At that price 8,000 pounds of fish are purchased. A simple calculation tells us:

$$\text{consumer expenditures} = \$3.50 \times 8,000 = \$28,000$$

From Figure 4.3 we can draw a rectangle (area OBCD) connecting the price of striped bass (Y-axis) and the quantity demanded (X-axis) through its point on the demand curve. The area of this rectangle is simply price times quantity or total expenditure, the same as calculated above.

Some consumers may be willing to pay more than \$3.50 per pound for their fish, but everyone pays the same price in the store. The area under the demand curve captures the information about the total amount consumers would be willing to pay for the various quantities offered. By subtracting what they actually pay, we obtain an es-



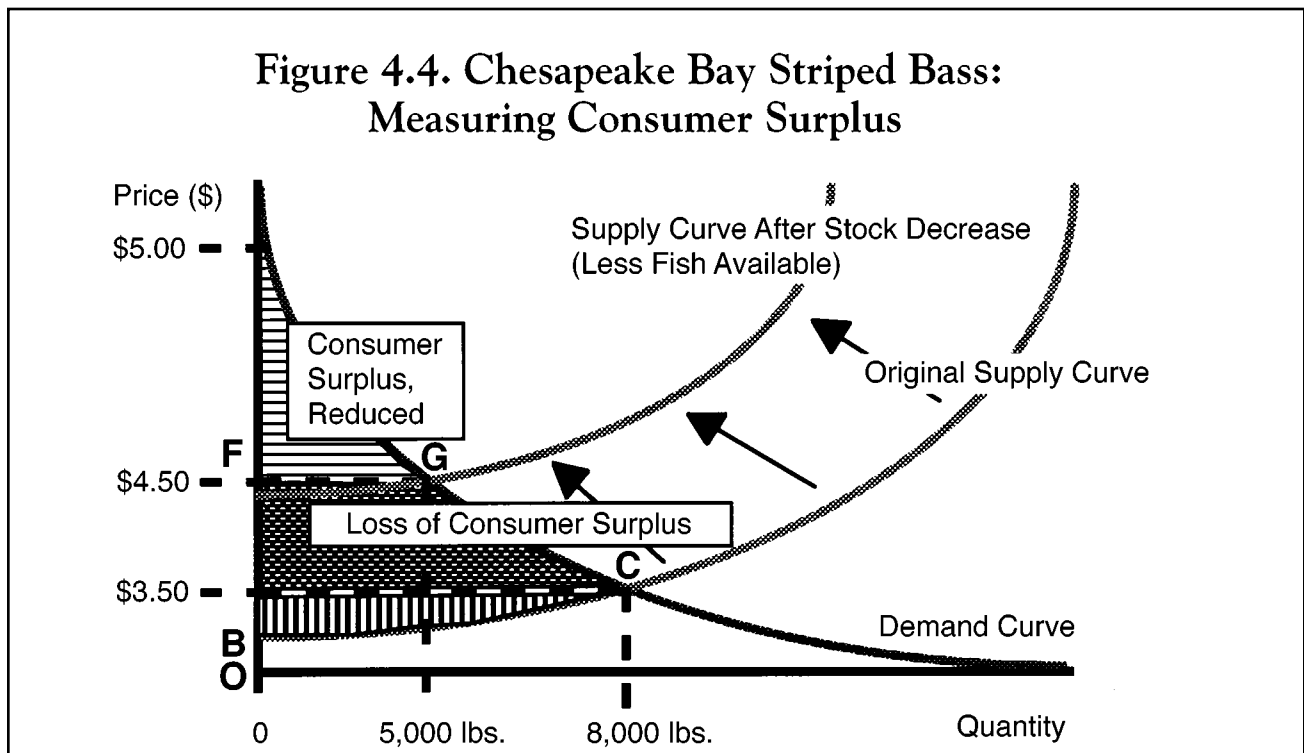
estimate of their net welfare from the consumption of striped bass. In our example, the total area under the demand curve (area OECD) out to 8,000 pounds is the consumer total willingness-to-pay (\$34,000). Subtracting what the consumers must pay (\$28,000) from their total willingness-to-pay, the consumer surplus is equal to \$6,000 (\$34,000 – \$28,000) — this is the area BEC.

This same exercise can be done to describe the situation after the decrease in the size of Chesapeake Bay striped bass populations. As outlined previously, the reduction in stock size will cause a shift left in the industry supply curve, causing the price of striped bass to rise (Figure 4.4). The difference between the areas of the consumer surplus triangles with and without the environmental impact is the change in consumer surplus (area BFGC).

Suppose now that with the decrease in stock size and subsequent reduction (8,000 to 5,000 pounds) of striped bass being harvested consumers see an increase in the retail price from \$3.50 to \$4.50 per pound. A simple accounting shows:

$$\text{consumer expenditures} = \$4.50 \times 5,000 = \$22,500$$

In this new situation, the total area under the demand curve out to 5,000 pounds is the consumer total willingness to pay (\$23,750). Subtracting what the consumer must pay (\$22,500) from their total



willingness to pay, the new consumer surplus is equal to \$1,250. The estimated change in consumer surplus is then:

$$\$6,000 - \$1,250 = \$4,750$$

or a loss of \$4,750 to society.

***Disadvantage of This Technique.*** The major difficulty with this approach is that effects from changes in supply must be separated from the effects on demand; and shifts in demand, if any, must be accounted for over time.

***Data Needs.*** The data required for this analysis are time series information on market price for the product and quantity consumed, along with measures of other factors that affect demand.

## SUMMARY

For environmental goods or services traded in markets, standard economic techniques of measuring supply and demand and determining changes in producer and consumer surplus can be applied using market price and quantity data. There is no difference in the techniques suggested here and measuring the economic value of any non-environmental good or service. In the next chapter, we demonstrate techniques economists have developed to deal with the situation when goods and services and other benefits do not result from market transactions.

# 5

## MEASURING THE VALUE OF NON-MARKET GOODS AND SERVICES

Without the observable price and quantity data that are available when goods or services are traded in the market, economists have devised innovative techniques for measuring changes in value for natural resources and the environment. Three of the techniques, travel cost, random utility and hedonics use information to indirectly determine what a market might reveal in value if it did exist. The contingent value technique attempts to measure the change in value directly.

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Some goods and services like recreational fishing and wildlife viewing are not traded in a well functioning, traditional market. That is, they are not supplied by private firms and consumers do not pay market prices. Nonetheless, individuals benefit from their use and, therefore, the loss of such environmentally related goods signifies welfare losses to these individuals. Conceptually, the same measure of benefit applies to market and non-market goods, that is, the maximum amount an individual would pay to avoid losing, or gaining, access to the good. Since these are non-market benefits, typically, there is no producer, or the consumer is both the producer and consumer. Thus, measures of non-market benefits are concerned with estimates of consumer demand and consumer surplus. There are a variety of methods that have been developed to measure this value concept in the absence of markets.

## Non-Market Valuation Techniques

In the absence of ownership and efficient pricing, we need special techniques to place consumer preferences for natural resources and environmental goods and services on common ground with the demands for more conventional commodities. Three types of procedures have been employed to measure these demands.

- ▶ Travel cost and random utility models, which are based on expenditures and travel behavior for recreational opportunities
- ▶ Hedonic methods of decomposing prices of market goods to extract embedded values for related environmental attributes
- ▶ Experimental methods for eliciting preferences, either by using hypothetical settings, called contingent valuation, or by constructing a market where none existed

*Travel cost models, random utility models, and hedonic methods are indirect measures based on observable behavior. Experimental methods, or contingent valuation, are based on direct surveys of individuals.*

## INDIRECT MEASUREMENT TECHNIQUES

Indirect techniques rely on observable behavior to deduce how much something is worth to an individual even though it is not traded in markets. These methods produce value estimates that are conceptually identical to market values, but they must be measured more

creatively since market data are not available. Indirect techniques include travel cost models, random utility models, and the hedonic pricing method.

## ► TRAVEL COST MODEL

**Overview.** The travel cost method is, in general, employed to estimate recreational values. This technique assumes that visitors to a particular site incur economic costs, in the form of outlays of time and travel expenses, to visit the site. In effect, these economic expenditures reflect the “price” (albeit implicit) of the goods and services provided by the site, and are an indirectly observable indication of the minimum amount that a visitor is willing to pay to use the site (with all its associated attributes).

By observing the characteristics of individuals visiting the site — for example, the specific attributes of their trip to and from the site as well as the total number of visits — economists are able to estimate the “derived demand” for the site. That is, for any given or implicit price, the derived demand relationship will determine the number of visits consumers will “purchase” at that site.

The travel method technique has a number of applications — it can be used, for example, to measure the effects on a consumer’s willingness-to-pay because of changes in access costs to a recreational area, or the elimination of a site, or changes in environmental quality.

**Advantages of This Technique.** The travel cost technique is relatively uncontroversial because it mimics empirical techniques used elsewhere in economics. Economists generally tend to prefer techniques of this sort because they are based on actual behavior rather than verbal responses to hypothetical scenarios. In the travel cost model, individuals are actually observed spending money and time, and their economic values are deduced from their behavior. In appropriate circumstances, this model can often be applied without enormous expense.

### Issues that Require Attention in Travel Cost Modeling

- **Costs, because time costs are often critical in recreational consumption**
- **Characterizing the quality dimensions of the site and taking proper account of substitute sites and their characteristics**
- **Estimating both the individual’s decision as to whether to use the site and his or her decision as to how much to use it**

***Disadvantages of This Technique.*** The greatest disadvantage of travel cost and other indirect techniques is that they can not be employed unless there is some easily observable behavior that can be used to reveal values. Thus, in the case of measurement of nonuse values these methods are inappropriate. In the case of nonuse values, there is no observable interaction between the individual and the resource in question

Travel cost models are also technically and statistically complicated. Understanding the conceptual measure requires understanding the connection between consumer surplus (measures of changes behind demand curves) and the “maximum willingness to pay” concept. In addition, data must be employed to statistically estimate increasingly sophisticated econometric models that take into account such factors as sample selection problems and non-linear consumer surplus estimates. Finally, the resulting estimates sometimes have been found to be rather sensitive to arbitrary choices of the functional form of the estimating equation and the treatment of time. Though much technical work has been dedicated to improving these methods, they will continue to be subject to the problems that plague all empirical economic estimation.

***Data Needs.*** While the early travel cost models used information on the proportions of visitors from increasingly distant zones of origin from which their travel occurred (called “zonal models”), current methodology requires data on individual travelers. Typically this information is collected through surveys. On-site surveys can provide heavy sampling of users, but these need to be augmented with surveys of the general population in order to learn what proportion of the population uses the resource. A survey of the general population also provides data on the characteristics of the resource users as well as information that helps the economist estimate the participation decision.

Unfortunately, a travel cost study is best at assessing the current situation. To analyze the gains or losses from changes in the recreational resource, economists need to conduct travel cost studies under varying circumstances or they need a way of extrapolating the effects of change. Ideally, an important recreational resource could be subject to periodic travel cost studies, so that the effect of differing conditions of the resource could better be estimated. This is especially true if one is measuring the damages from a disaster such as the effects of an oil spill on recreational boating. Economists would find invaluable a travel cost study that had been completed before the disaster.

## Estimating the Value of Recreational Bird-watching: Travel Cost Model

Suppose a development project calls for filling a wetlands area, an area that is a major bird-watching site for the region. In this case the valuation question might be: What would be a money measure of the lost value of observing birds in this area due to the development? The answer could be used as input to a benefit-cost analysis of the proposed development.

The first step in such an analysis is to survey participants on bird-watching trips about trip expenses. The second step would examine the relationship between the number of participants and trip expenses such as in the table.

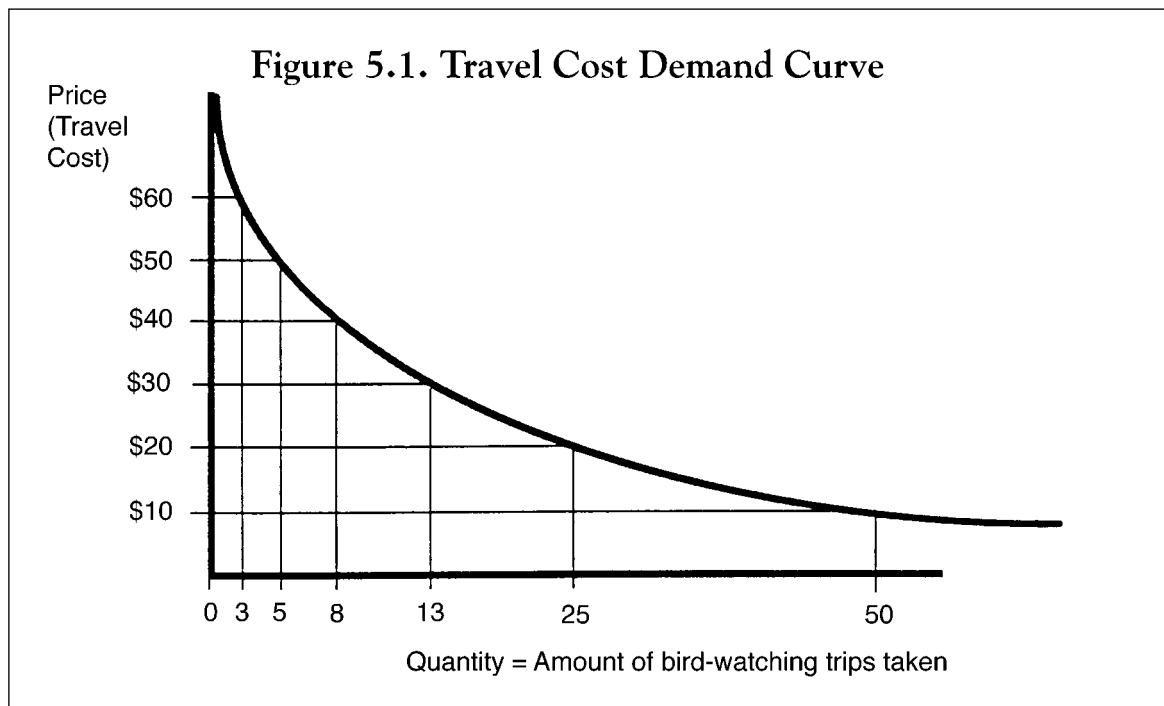
In the absence of such ideal studies, researchers would find any information on the level of use of the resource beneficial (e.g., historical information on number of users, their location of residence, and frequency of use). Moreover, any information that would help shape the sampling method would be valuable (e.g., when the resource is most heavily used and by whom).

As with all environmental valuation, the researcher's most difficult job is connecting the environmental event with the effect on the user. Any insights here are invaluable. In the development case, the analysis would need to be accomplished as a hypothetical case. To use results from a travel cost model, researchers need to know how recreationists would be affected by the development activity and how that effect would translate into changes in behavior.

From this and other data collected about the individual participants, we can estimate a travel cost demand curve with the travel cost as the price and the number of trips as the quantity shown in Figure 5.1. This demand curve will also be a function of other information collected from the individuals that help to explain their bird-watching behavior (e.g., income, ethnicity, education, etc.). We must also make adjustments econometrically

Table 5.1. Travel Cost Data.

Trip Expense Range	Number of Trips
< \$10	50
\$10-\$19	25
\$20-\$29	13
\$30-\$39	8
\$40-\$49	5
\$50-\$59	3



for the non-participants, the people who might go bird-watching in the area under different circumstances (e.g., if they had lower travel costs).

The travel cost demand curve applies to a representative individual from a particular geographic region or socio-economic class. It is not the aggregate demand curve. To get an aggregate value measure, individual consumer surplus must be augmented by a population expansion factor which this individual represents.

This curve represents the recreational demand for bird-watching prior to the development. If bird-watching is completely eliminated at this site, then the total consumer surplus is lost. However, the more likely consequence is that the quality of the bird-watching trip will be lowered. We will need to predict how the demand curve will shift, and then measure the consumer surplus with and without the shift.

### ► *RANDOM UTILITY MODELS*

**Overview.** Though conceptually similar to travel cost models, random utility models do not focus on the number of trips recreationists make to a given site in a season; rather, they focus on the choices of recreationists among alternative recreational sites. This type of model is particularly appropriate when substitutes are available to the individual so that the economist is measuring the value of the quality characteristics of one or more site alternatives.

**Advantages of This Technique.** The same advantages that apply to travel cost models are applicable with random utility models. Many economists consider this method as the state-of-the-art in recreational demand modeling. Relative to the travel cost model, this approach deals well with substitute sites and environmental quality considerations.

**Disadvantages of This Technique.** The approach has all the disadvantages of the travel cost method, though it is much more data intensive.

**Data Needs.** Because a researcher needs to know what alternative sites are considered by recreationists, as well as recreational behavior with respect to all these alternative sites, the data requirements are greater. In addition, accurate measurements of the characteristics of alternative sites are important.

## Estimating the Value of Recreational Bird-Watching: Random Utility Model

The superiority of the random utility model approach over the standard travel cost method will be evident. In a hypothetical example (Table 5.2), suppose Site I is the birdwatching area proposed for development. However, there are two other relevant sites in that area, each having its own characteristics with regard to the experience the bird-watcher will have. These experiences are represented in the example by a species diversity index and a

Table 5.2. Multiple Sites with Quality Differences.

Site Attributes	Site I Proposed Fill Site	Site II	Site III
Species Diversity Index	5.2	4.8	3.6
Bird-Spotting Index	8.7	5.9	6.3

bird-spotting index. The greater the diversity of species and the more likely the individual will see unusual birds, the greater the value of the recreational experience. Because of locational differences and the value of time, each individual will incur different costs to go to each site. Table 5.3 summarizes the pattern of visits to the different sites by three different individuals. The data in these two tables are the type typically used to determine the value of access to the site, or changes in quality at a site. These data provide us with observable information about how individuals make tradeoffs between the quality of the site and the cost of accessing it. In the travel cost model, we only have one site, so it is difficult to determine how individuals respond to quality changes unless the quality of that site has changed over time.

Note that the random utility model requires data about participation at the study site as well as relevant alternative sites. Site characteristics are also implicitly considered in the decision model. In the example, we looked at a species diversity index and an index of number of bird spottings per hour as the relevant characteristics that vary across sites.

Table 5.3. Trip Expenditures and Number of Trips Taken (Example of data from three individuals in our sample).

Individual		Site I	Site II	Site III
1	Travel Costs	\$10	\$20	\$30
	Number of Trips	4	2	0
2	Travel Costs	\$15	\$8	\$40
	Number of Trips	0	5	1
3	Travel Costs	\$20	\$20	\$20
	Number of Trips	5	2	3

## ► *HEDONIC PRICING METHODS*

**Overview.** The hedonic pricing method is another technique to determine environmental value. In its earliest applications, these techniques were intended to capture the willingness-to-pay measures associated with variations in property values that result from the presence or absence of specific environmental attributes, for instance, air pollution, noise, or water views. By comparing the market value of two properties which differ only with respect to a specific environmental attribute, economists may assess the implicit price of that amenity (or its cost when undesirable) by observing the behavior of buyers and sellers.

A variation on the approach of comparing the effects of an environmental attribute would involve comparing the price of a single piece of property over successive sales. By correcting for other factors that might influence the value of the subject property, economists are able to isolate the implicit price of some amenity or bundle of amenities which have changed over time. The price of a house may be affected by factors such as the number of bedrooms, the square footage, the existence of a pool, the proximity to local schools, shopping, highways. The price may also be affected by the proximity to, or quality of, environmental amenities. Air quality has been found to be a determinant of housing prices in Los Angeles; whether or not a property abuts a woodland may also matter. Hedonic methods can also be used to estimate the effect of certain disamenities on the price of a house, for instance, the impact on the price of a residential property adjacent to an area affected by a spill or some proposed unfavorable development.

The process for estimating an hedonic price function that relates housing prices to the quantities of various characteristics is reasonably straightforward. However, it is much more difficult to derive value measures from these estimated functions. Only under very restrictive assumptions can values be obtained directly from these estimated functions. In most cases, a two-stage procedure that depends on information from multiple markets is necessary.

**Advantages of This Technique.** The hedonic techniques, like travel cost and random utility models, depend on observable data resulting from the actual behavior of individuals. Market data on property sales and characteristics are available through real estate services and municipal sources and can be readily linked with other secondary data sources.



**Disadvantages of This Technique.** Most environmental incidents will have only small, if any, effects on housing prices. Even where effects do exist, it may be difficult to estimate them using econometric methods because many factors, many of which are correlated, influence housing prices. For example, a house located near a factory with emissions that reduce air quality may be in a poorer section of town where schools are not as good and there are few other amenities like parks. Even when implicit prices for environmental amenities can be estimated, it is usually very difficult to obtain measures of value from these models. The connection between the implicit prices and value measures is technically very complex and sometimes empirically unobtainable.

**Data Needs.** Data needs include prices and characteristics of houses sold in the housing market of interest. In particular, a measure or index of the environmental amenity of interest is needed.

## DIRECT TECHNIQUES

### ► CONTINGENT VALUATION METHOD (CVM)

**Overview.** The most obvious way to measure nonmarket values is through directly questioning individuals on their willingness-to-pay for a good or service. Called the contingent valuation method, it is a survey or questionnaire-based approach to the valuation of non-market goods and services. The dollar values obtained for the good or service are said to be contingent upon the nature of the constructed (hypothetical or simulated) market and the good or service described in the survey scenario.

The contingent valuation technique has great flexibility, allowing valuation of a wider variety of non-market goods and services than is possible with any of the indirect techniques. It is, in fact, the only method currently available for estimating nonuse values. In natural resources, contingent valuation studies generally derive values through the elicitation of respondents' willingness-to-pay to prevent injuries to natural resources or to restore injured natural resources. Since the first published contingent valuation study on valuing outdoor recreation appeared in 1963, more than 1,400 related documented papers, reports, and books have been published.

In contingent valuation methods, randomly selected samples or stratified samples of individuals selected from the general population

are given information about a particular problem. They are then presented with a hypothetical occurrence such as a disaster and a policy action that ensures against a disaster; they are then asked how much they would be willing to pay — for instance, in extra utility taxes, income taxes, or access fees — either to avoid a negative occurrence or bring about a positive one. The actual format may take the form of a direct question ("how much?") or it may be a bidding procedure (a

## A Sampler of Contingent Valuation Questions

- ▶ Would you approve of the wetlands protection program if it reduced your income by some dollar amount (\$5-1500, posted price varied on questionnaires) per year in order to have your bag or catch preserved at current levels (or 50% or 25%), rather than have your bag or catch reduced to zero because of continued marsh loss? (Circle one letter.)

a. Yes                      b. No

Source: Bergstrom, J.C. et al. 1990. Economic Value of Wetlands-Based Recreation. *Ecological Economics* (2):129-147.

- ▶ Suppose that the Terrebonne wetlands were to disappear tomorrow and that persons like yourself had a chance to save this particular area. What would you reasonably estimate to be the maximum you would be willing to pay each year in order to guarantee the use of this area for you and your household?

\$0-\$15 __	\$45-60 __	\$90-100 __	\$200-250 __
\$15-30 __	\$60-75 __	\$100-150 __	More than \$250 __
\$30-45 __	\$75-90 __	\$150-200 __	

Source: Farber, S. 1988. The Value of Coastal Wetlands for Recreation: An Application of Travel Cost and Contingent Valuation Methodologies. *Journal of Environmental Management* (26):299-312.

- ▶ What amount on the payment card, or any amount in between, is the most you (your household) would be willing to pay in taxes and higher prices each year to continue to keep the nation's freshwater bodies from falling below the boatable level where they are now? In other words, what is the highest amount you (your household) would be willing to pay for Goal C each year before you would feel you are spending more than it's really worth to you (all members of your household)? (Note: Payment card is income dependent and shows average household public expenditures on various public programs such as roads, education and defense.)

Source: Mitchell, R.C. and R.T. Carson. 1989. *Using Surveys to Value Public Goods*. Baltimore. Johns Hopkins University for Resources for the Future.

ranking of alternatives) or a referenda (yes/no) vote. Economists generally prefer the referenda method of eliciting values since it is one most people are familiar with. The resulting data are then analyzed statistically and extrapolated to the population that the sample represents.

Contingent valuation studies are conducted as face-to-face interviews, telephone interviews, or mail surveys. The face-to-face is the most expensive survey administration format but is generally considered the best, especially if visual material needs to be presented. Non-response bias is always a concern in all sampling frames. In other words, people who do not respond have, on average, different values than people who do respond.

## Pros and Cons of Contingent Valuation

### PROS

1. Based in economic utility theory and can produce reliable estimates.
2. Most biases can be eliminated by careful survey design and implementation.
3. Currently the only method available to measure important nonuse values associated with natural resources.
4. Has been used successfully in a variety of situations.
5. Is being constantly improved to make the methodology more reliable.

### CONS

1. Estimates of nonuse values are difficult to validate externally.
2. Stated intentions of willingness to pay may exceed true feelings.
3. Results may appear inconsistent with tenets of rational choice
4. Respondents may be unfamiliar with the good or service being valued and not have an adequate basis for articulating their true value
5. Respondents may express a value for the satisfaction ("warm glow") of giving rather than the value of the goods or service in question
6. Respondents may fail to take questions seriously because the financial implications of their responses are not binding.

***Advantages of This Technique.*** In principle, contingent valuation methods can be used to estimate the economic value of anything, even if there is no observable behavior available to deduce values through other means. It is the only method that has any hope of measuring “existence values,” i.e., the value that individuals place on simply knowing the natural resource exists in an improved state. This is because since existence values are not connected with use and all other methods depend on observing actual behavior associated with the resource.

Though the technique requires competent survey analysts to achieve defensible estimates, it is not difficult to understand. The responses must be statistically analyzed, but require no more than the understanding of a mean or median value.

***Disadvantages of This Technique.*** When conducted to the exacting standards of the profession, contingent valuation methods can be very expensive because of the extensive pre-testing and survey work. In addition, while this technique appears easy, its application is fraught with problems, for example, the possibility of strategic bias by respondents or structural problems in questionnaire design. Moreover, question framing, mode of administration, payment formats, and interviewer interactions can all affect results.

Many questions have been raised about the reliability of the contingent valuation method for the calculation of nonuse values particularly in regard to natural resource damage assessment under OPA. Because this subject is complex and contentious and has ramifications not applicable to the use of CVM in applications other than damage assessment, it is not discussed here.

***Data Needs.*** The quality of a contingent valuation questionnaire depends upon the amount of information that is known beforehand about the way people think about the resource in question. Information on who uses the resource and who knows about it are critical. When the contingent valuation method is applied to use values, the economist undertaking the survey will want to sample populations most likely to use the resource. The key point is that while all the information necessary for assessing an individual's value of the resource is collected in the survey, the economist needs help in identifying a representative sample and information to allow extrapolation to the population.

## Illustration of Contingent Valuation Methodology

Suppose development along the coast of New Jersey would result in impacts to coastal waters that will lower the quality of recreational activities. It is estimated that such development might lower recreational fish catches by (100, 50, 25%), increase beach closings, and lessen the quality of the recreational boating experience. A number of environmental groups have proposed a program that will mitigate impacts of the development on recreation. It is to be funded by a tax on individuals such as yourself and would be (\$5-1,500) per year. Given that the development will occur, and specifically relating to fishery catch, are you willing to fund the mitigation program at this cost to you? (A “yes” answer requires respondent to specify the amount of his/her willingness-to-pay for mitigation to prevent various levels of catch reduction.)

- a. yes
- b. no

**Table 5.4. Willingness-to-Pay for Mitigation.**

Individual's cost for mitigation	Percent Responding Yes to Reduction in Catch		
	100% Reduction	50% Reduction	25% Reduction
\$5-25	100%	100%	95%
\$25-50	88%	78%	65%
\$50-75	51%	45%	40%
\$75-100	22%	15%	12%
\$100-200	8%	6%	4%
\$200-300	7%	7%	6%
\$300-400	5%	2%	1%
\$400-500	2%	1%	1%
\$500-750	1%	1%	1%
\$ 750-1000	0%	0%	0%
>\$1000-1500	0%	0%	0%

This data can be used to econometrically determine the mean willingness-to-pay for the mitigation program (mean=\$160). The aggregate measure would be determined by multiplying the mean willingness-to-pay by the appropriate sample size. In this case, we might only be interested in fishers, beach goers, or boaters (n=10,000): Willingness-to-pay = \$160 x 10,000 = \$1,600,000 per year.

# 6

## BENEFIT TRANSFER

Application of environmental valuation techniques may be expensive, particularly for local decision-making where research budgets are limited. Benefit transfer offers a lower cost alternative to performing a full-scale study for any particular issue.

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**B**enefit transfer is an application of a data set developed for addressing one particular environmental or natural resource valuation question to another context. Given the expense and time associated with estimating values of non-market natural resources and services, benefit transfer can be a reasonable method for determining such values. Benefit transfer applications can be divided into three classes:

- Estimates based upon expert opinion (e.g., the transfer of average net willingness-to-pay or proxy values)
- Estimates based on observed behavior (e.g., transfer of the entire demand equation)
- Estimates based upon preference elicitation mechanisms, i.e., the contingent valuation method

Benefits transfer are considered to be valid under well-defined conditions. Factors to consider in conducting a benefit-transfer decision include some of the following considerations:

## GENERAL ASSUMPTIONS

- For what purpose were the original value estimates generated?
- What user group(s) were considered in generating the initial estimate (e.g., duck hunters versus all citizens in an area)?
- Did the existing study address a specific or unique problem that may have influenced the magnitude of the estimates obtained (e.g., during a period of heightened concern for the resource in question)?
- Have general attitudes, perceptions, or levels of knowledge changed in the period since the existing study was performed in a way that would influence the value of the benefit estimate? Are these values likely to be consistent over time?
- If the value being considered is for a generic resource category (e.g., common songbirds), are the species considered in the original study relevant to the case at hand?

- Were adjustments to the data made in the existing study? For example, were outliers deleted? Were any adjustments made for perceived biases?
- Does the existing study consider the same or a similar geographic area? Are the demographic and socio-economic characteristics of the two areas similar?

## METHODOLOGY

- If the source being used presents a composite of existing values based on an earlier literature review, what methods were used to derive these composite values and what was the nature of the underlying studies?
- Were baseline conditions (e.g., ambient water quality) in the existing study similar to baseline conditions in the case at hand?
- Were variables omitted from the original study that are believed to be relevant to the case at hand? To what extent does such omission prohibit the transfer?
- If current best research practices were not used to generate the value estimate(s), can the estimate(s) be adjusted to reflect changes in the state-of-the-art?

## ECONOMIC METHODS/EVALUATION

- Was the study used to generate the value estimate published in a peer reviewed journal, or did it receive other forms of peer review?
- How is the original study viewed in the professional community? How was the study viewed by its sponsor?

## RESOURCE

- How does the resource that was affected compare to that considered in the referenced study (e.g., is the species of concern



more common in the policy study area than in the initial study area)?

- What was the nature of substitutes in the initial study area, and how does this compare to the policy study area (e.g., are alternative recreational opportunities more or less available in the policy study area)?
- Was the original analysis conducted to value all organisms of a given species, a sub-population, individual members of the species, or some other grouping?

Decision-makers should consider all available estimates, each based on the factors described above. Once a final set of values has been chosen, consideration should be given to their general magnitudes. If the existing value estimates differ significantly, or if values generated using alternative models differ significantly from one another, consideration should be given to whether they differ in a predictable and consistent manner. In some cases it may be possible to combine these estimates formally through meta analysis.<sup>5</sup> In all cases, more defensible benefit estimates will result from comparative analysis.

In many cases the defensibility of the transferred economic benefit estimate will depend on the quality of the underlying research. However, no globally accepted, standard criteria are available to judge the quality of existing studies. The professional and academic community can provide guidance with regard to the current minimum conditions for quality assurance of the benefit transfer.

The Economic Analysis and Research Branch of the U.S. Environmental Protection Agency, Office of Policy Planning and Evaluation has prepared *The Environmental Economics Database*, a collection of references for national resources and environmental amenity valuation studies collected over several years. Computer disks of the database are available.

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<sup>5</sup> Smith, V.K. 1992. On Separating Defensible Benefit Transfers from "Smoke and Mirrors." *Water Resources Research*, 28(3):685-694.

# 7

## THEORY AND APPLICATION: RECONCILING DIFFERENCES

In the practical application of environmental valuation, issues such as choosing a discount rate, dealing with intergenerational transfers and equity, and decision-making under risk and uncertainty can become important to the outcome and interpretation of the analysis. This chapter provides a brief introduction to these topics. Arguments about the appropriate discount rate can unduly obscure the underlying message that there is an economic value to natural resources and the environment.

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Valuation of natural resources and environmental amenities can meet with difficulty under certain conditions. For example, if the use of a particular resource is impossible to reverse, the economic and social impacts over a long period of time must be considered. Such a consideration in turn raises the question of discounting or, more generally, the efficiency and equity of resource use in the long run. Moreover, where information about the costs and benefits of alternative uses is particularly poor, perhaps because of the long period to which it must apply and the non-market character of some of the uses, decisions should take this uncertainty into account.

This section briefly examines these issues from a conceptual view. Unfortunately, theory does not spell out the precise quantitative adjustments that would be required in applying these issues to estimate benefits and costs in empirical work. The major point is this: the traditional benefit analysis of resource use and allocation as a basis for public decision-making is only one part of the decision process which must be accompanied by subjective notions of risk-taking and equity. A benefit-cost analysis in isolation should not be the sole basis for decision-making.

## DISCOUNT RATES

When gains or losses from either a program or action accrue to individuals over time, discounting methods are typically used. Discounting is a procedure that deducts future values of a particular good — the aim is to determine the present value of the stream of benefits or costs in relation to the benefit or costs at different times in the future, i.e., benefits or costs occurring in different magnitudes at different dates in the future.

The basic principle of discounting is that a dollar received or paid next year is worth less than a dollar received or paid this year. For example, a dollar received this year may be deposited in a savings account earning, for example, 5 percent interest. On the one hand, at 5 percent interest, the dollar will be worth \$1.05 the next year. Looked at from the discounting perspective, one dollar received or paid next year is only worth approximately \$0.95 today. The *discount rate* in this situation is 5 percent, the interest on savings accounts. Other market interest rates, such as interest on bonds or corporate portfolios, may be used as discount rates as well. Such rates are based on the *private opportunity cost principle* or *private time preference*.

Discounting may reflect other social or psychological considerations. For example, many people exhibit "impatience." Understandably, they may value recreational experience more highly now than if

they were promised the same experience ten years from now. The reasons are many — the immediate desire for pleasure and the relief from stress are only two. The result of preferring present consumption or change in the state of the world is positive discount rates. Alternatively, a concern for future generations might lead to the opinion that values in the future are worth as much as values today, implying a zero discount rate.

In general, the application of discounting in a social value context incorporates the more complex concept of *social time preference* and is often very difficult to determine. The problem of measurement parallels that of market and non-market goods. The private rate of time preference is revealed in markets, but the social rate is not. With respect to natural resources, the fundamental issue is one of defining a discount rate which reflects society's collective preferences regarding resource utilization or retention. The discount rate in the natural resource or environmental arena can be thought of as a measure of the opportunity cost of not having immediate access to a resource.

Suppose a decision must be made on whether or not to implement an oyster reef program in Chesapeake Bay. Assume a one-time startup cost of \$100,000 (Table 7.1). The benefits associated with the program are projected for three years in increased returns to the local oyster industry: \$15,000 in 1994, \$80,000 in 1995, and \$25,000 in 1996. Discounting will be crucial in determining whether the reef program is an efficient use of society's resources.

**Table 7.1. Discounted Net Present Value (NPV) of Oyster Reef Program.**

Year	1993	1994	1995	1996	NPV
Benefits of Reef Program	\$0	\$15,000	\$80,000	\$25,000	–
Reef Development Cost	–	\$0	\$0	\$0	–
0% Discount Rate	–	–	–	–	\$20,000
3% Discount Rate	–	–	–	–	\$14,041
5% Discount Rate	–	–	–	–	\$9,775
7% Discount Rate	–	–	–	–	\$5,269
10% Discount Rate	–	–	–	–	–\$1,950

Without discounting (or a zero discount rate), the net present value of the reef program is \$20,000 and the program may be consid-

ered economically efficient. With a 5 percent discount rate, the net present value is \$9,775. However, with a 10 percent discount rate the program results in a net loss of \$1,950, suggesting an inefficient use of resources. Which discount rate is “correct”? The answer depends.

Difficulties arise in choosing the “correct” rate of discount. From the example, it is clear that the larger the discount rate, the more weight that is put on the present relative to the future. Large discount rates give less weight to environmental benefits or damages that don’t accrue immediately but only in the long term. Real rates of between 0 and 8 percent appear regularly in the economics literature. Some have even argued for negative discount rates to reflect the implicit interest of future generations in resource management decisions.

Despite the extensive literature, a consensus does not yet exist on an appropriate procedure for discounting costs and benefits of public programs and regulations. It is clear, however, that the characteristics of natural resources (e.g., slow-growing, renewable, and typically held in public trust) necessarily imply that they should be treated differently than other private capital assets.

## IMPACTS ACROSS GENERATIONS

We referred earlier to distributional implications of different outcomes. What happens when the distributional implications span generations? How do we compare situations when one generation gains and another loses? Discounting at some market-based rate of interest is commonly used to express future costs and benefits in terms of present monetary value, assuming that a value received now is worth more than the same value provided at some future date. Obviously, standard discounting procedures will weight the effect on the current generation far more heavily. Thus, some critics feel that discounting results in greater resource exploitation or use of natural capital now, at the expense of future generations. Is there an ethical basis for this discrimination against future generations?

Some economists have proposed that decisions affecting the future should be made with decision-makers placed behind a “veil of ignorance” about which generation they belong to. This impartiality criterion suggests equal use of irreplaceable resources across generations, implying a zero discount rate. But with a zero discount rate, if enough generations are involved, use of non-renewable resources

(such as oil) approaches zero for any given generation. Likewise, irreversible development (such as building a dam in a unique natural area) is essentially precluded. Furthermore, a zero discount rate may foreclose future options by undervaluing investments that produce wealth and new technology that would be of great value to future generations.

Clearly, some compromise is needed between a zero discount rate, which would preclude many resource uses and perhaps prevent valuable technological advances, and a typical market rate that reflects only the atomistic time preferences of the current generation. This compromise has been called a *social rate of discount*; its argument is that the government in this role should consider the wishes (the values) of both current and future generations. Because the welfare of future generations depends on current consumption patterns, the government should assure protection of future welfare by policies that force sufficient resource conservation. In essence, the government would proclaim what it deemed to be an appropriate discount rate.

Another argument takes a more democratic approach, recognizing that the government is run by and for the current generation; thus, any saving for the future must rely on the values of the current generation. The basis of this argument is that most citizens have a set of held values that include a concern for the larger group (including the future) as well as concern for self. If people do value the welfare of the future, then what is needed is a way for that value to be expressed and measured — a way that avoids the singular context of the marketplace.

## UNCERTAINTY AND RISK

In practice, environmental valuation must contend with a great deal of uncertainty. One source of uncertainty is in the problem of predicting the consequences of today's environmental policies and actions. Will the reduction in nutrients that enter coastal waters lead to increased fish populations? Will controls on development lead to cleaner estuaries? Another source of uncertainty results from the increasing use of models, both biological and economic, to predict outcomes. Modeling is inherently a source of error, as is the measurement error of data used to calibrate the models.

There is a branch of economics that deals with decision-making under uncertainty that should be an integral part of any environmental valuation exercise. Uncertainty surrounding environmental mea-

*Models are like maps that try to chart a complex territory in which the landscape cannot be completely known — they depend on variabilities in human nature and ecosystems themselves.*

surements can be introduced explicitly into background analyses by three methods:

- Direct enumeration, which requires us to list all possible outcomes
- Probability calculus, which employs formulae for the computation of such statistics as the means and variance of a probability distribution
- Stochastic simulation, which is also known as Monte Carlo simulation or model sampling

While it is clear that the decision-maker should be given as much information as possible about the probability distribution of potential outcomes of environmental actions, there are no hard and fast rules as to the “correct” way to incorporate this information.

Risk is closely related to the notion of uncertainty, focusing on the outcome that is affected by uncertainty. Every project or policy decision has risk associated with it. There is always some probability that costs and benefits will not be exactly what are expected. For example, the major risk factors inherent in coastal wetlands projects are attributable to imperfect scientific knowledge of biophysical relationships, such as uncertainty about salinity effects on cordgrass growth, and probabilistic natural phenomena, such as varying meteorological and hydrological events.

A typical method of accounting for risk is to adjust discount rates upward for projects or decisions with more risk. An alternative is to establish risk rankings of projects or decisions, along with other measures of anticipated benefits. Decision-makers may select actions with lower net benefits, if they are more certain of the outcome. This is an example of risk aversion which enters into the decision process.

## **IRREVERSIBILITY**

For many environmental risks, the possible negative impacts are irreversible in the sense that they cannot be undone by subsequent actions, for instance, the possible ecological effects of global warming and species extinction.

The possibility of irreversible effects makes current policy decisions particularly important, since recovery from poor decisions is not possible. In other words, we must live with the consequences of cur-

rent policy choices without the possibility of future rectification. In general, the benefits of risk reduction are likely to be greater, if the possible negative effects of a risky activity are irreversible, than they would be if those effects could be offset, or reversed, by subsequent actions. For example, the introduction of a non-indigenous species such as the Pacific oyster to an estuary or bay in the Mid-Atlantic is riskier when the consequences are irreversible than when they are not.

The major implications of the existence of intertemporal conflict and uncertainty with respect to the use of the natural environment is that it will be most efficient to proceed very cautiously with any irreversible action.





# CASE STUDIES

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## ABOUT THE CASE STUDIES

The case studies in this section represent a unique learning tool for applying the economic valuation techniques presented in the text of this handbook to real-world situations. Although some of the cases have been modified and have been placed in a hypothetical context, they closely mimic actual scenarios. In reading and responding to the exercises that follow each case study, the users of this handbook can apply what they have already learned or return to the text to refresh their understanding of the techniques to be used. Typically, at the workshops where facilitated training has been given, a participant will take part in two case-study sessions on the second day of the training. These case-study sessions are conducted by a workshop leader or by other individuals with particular subject matter expertise.

In putting together this handbook, the authors have been guided by the need to make it truly national in scope. We have included cases dealing with questions that might arise in all regions of the Nation. While the cases deal with a specific state or regional context, they can be applied throughout U.S. coastal areas. In fact, we have learned that workshop participants sometimes learn more easily from materials with which they do not have familiarity. We hope you will use all of these case studies to expand your understanding of the economic value of natural resources. The authors are grateful to the following people for assisting in the development of these materials:

Case Study 1: Oyster Restoration in Chesapeake Bay  
William Zieburtz of CH2M Hill.

Case Study 2: Salmon Habitat Restoration in Alaska  
Rebecca Baldwin, formerly regional economist with the U.S. Forest Service, Alaska Region.

Case Study 4: Coastal Barrier Island Preservation in North Carolina  
William Zieburtz of CH2M Hill.

Case Study 5: Artificial Reef Program in Lake Erie, Ohio  
Leroy Hushak, Sea Grant Associate Director, Ohio State University and David Kelch, District Specialist of the Ohio Sea Grant College Program.

Case Study 6: Red Snapper Fishery Management in the Gulf of Mexico  
Wayne Swingle of the Gulf of Mexico Fishery Management Council.

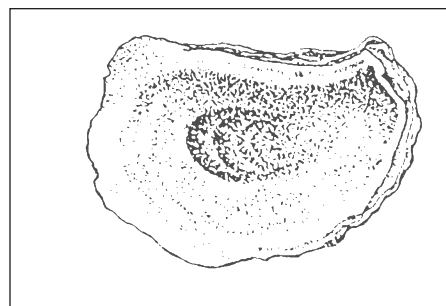
Case Study 8: Nonpoint Source Pollution Control in California  
Leigh Taylor Johnson, San Diego Area Marine Advisor, and Erika McCoy, Program Representative, University of California Sea Grant College Program, Cooperative Extension Service.

## OYSTER RESTORATION IN CHESAPEAKE BAY

### Background

Since the mid-1800s the Chesapeake Bay has been a major producer of oysters to an extended market reaching as far away as California and England. During the 56-year period after 1834 when the business of packing oysters for shipment to the interior was established in Baltimore, Maryland, the average annual harvest from the Bay was 7 million bushels per year, or 392 million bushels for the period. This massive yield from both the Maryland and Virginia portions of the Bay was almost entirely the result of natural production, that is, there was little farming of oysters.

Sometime after the turn of the century, Maryland's oyster harvests dropped below that of Virginia. This change in comparative productivity may have resulted from several factors: development of widespread private leasing of Bay bottom grounds in Virginia while in Maryland public grounds remained the primary source of harvesting; growth of power dredging in Virginia, which was highly restricted in Maryland; overfishing of public beds in Maryland; and increasing destruction of oyster reefs and their consequent smothering by siltation. In the early 1900s, Virginia became the largest producer of oysters in the Chesapeake Region and on the entire Atlantic seaboard.<sup>1</sup>



### Situation

The near-decimation of oysters in the Chesapeake Bay by protozoan diseases has stirred interest in importing a disease-resistant species of oyster for restoration of the fishery. Historical differences between the Maryland and Virginia oyster industries, however, complicate the problem of restoration. Competing interests between the commercial fisheries of both states as well as considerations of the role oysters play in the Bay's ecological health must be taken into account.

<sup>1</sup> Hargis, W.J. and D.S. Haven. 1988. The Imperilled Oyster Industry of Virginia. Special Report No. 290 in Applied Marine Science and Ocean Engineering. Virginia Sea Grant Marine Advisory Services.

In 1954, Chesapeake harvests rose dramatically in response to a 15 percent increase in ex-vessel price, which was itself the result of a decrease in mid-Atlantic harvests. However, this boom did not last for long. In 1959, the protozoan pathogen *Haplosporidium nelsoni* (MSX) invaded the Chesapeake Bay and, soon after, *Perkinsus marinus* (Dermo) — both have been responsible for catastrophically killing most of the oysters in high-salinity regions of the Bay. In Virginia, leaseholders, or private growers, hold a majority of their leased bottoms in the high salinity areas affected by MSX and Dermo — public grounds are in the lower-salinity waters. Unlike Maryland watermen, who have depended for their harvests primarily on publicly open grounds, Virginia's private industry has been virtually decimated.

In spite of the MSX invasion in the Bay, oyster production in Maryland in the 1960s increased for a short period. A major reason for that increase was the discovery of pre-historic fossil shell sources and the development of a dredge to extract the shell for use as a substrate to “catch” natural oyster seed. Subsequent employment of these resources by the State of Maryland was commonly referred to as the “repletion program.”<sup>2</sup>

Prior to the repletion program, state legislation had required processors to make 10 percent of their shucked shell available for purchase by the state in order to ensure the availability of substrate for future oyster production. The legislation also provided funds for state shell-planting activities. The discovery of additional shell sources provided a cheap alternative to freshly shucked shell and yielded significant production increases. Maryland's oyster production doubled from around 1.5 million bushels to some 3 million annually. The increase in importance of the repletion program relative to natural oyster set helped transform the oyster fishery from traditional natural resource gathering into a “put-and-take” state fishery.<sup>3</sup> Watermen were temporarily relieved of the constraints of nature alone and no longer solely dependent on the “recycling” of processed oyster shell.

The use of relatively inexpensive dredged shell also changed the philosophy of oyster management in Maryland from maintenance of a collapsing industry to revitalization, through repletion, of a potentially valuable one. The state switched from its regulatory role of oyster manager to a champion of production growth. Although production began to wane in the late 1960s and has continued to do so, until about 1981 Maryland oyster production remained over 2 million bushels. During this time there was concern that the market could not absorb, at an acceptable price, more than about 2.5 million bushels. In this new scenario, the market, not nature, became the constraining element.

Since the 1980s oyster production has been suffering from the reappearance of MSX and, especially, Dermo. Maryland's harvest has declined from over 2.5 million bushels during the 1980-

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<sup>2</sup> The nature of oyster reproduction is such that young larvae require a hard substrate on which to attach; oyster shell provides such a material. However, if the harvested shell is not replaced in the Bay by a suitable substrate, there is a strong likelihood that the future availability of oysters will be reduced.

<sup>3</sup> Lipton, D.W., E.F. Lavan, and I.E. Strand. 1992. Economics of Molluscan Introductions and Transfers: The Chesapeake Bay Dilemma. *Journal of Shellfish Research* 11(2):511-519.

1982 season to under 250 thousand bushels in the early 1990s. As a result of the decline in supply, ex-vessel prices have risen.<sup>4</sup> In spite of the increased ex-vessel prices, the effect of the loss of production on the income of the Chesapeake watermen has been significant. Unlike past battles with MSX and Dermo disease, this most recent outbreak has not been relieved by the repletion program. Lipton, Laval and Strand explain that the sporadic nature of the protozoan infections have made it difficult to develop a comprehensive strategy for oyster repletion.

## Proposal to Revitalize Oyster Production

In contrast to the steep decline of oyster landings in Chesapeake Bay, oyster production on the west coast of the United States grew between 1982 and 1988 by 600 thousand pounds. The source of this production increase is hatchery production of the introduced species *Crassostrea gigas* (originally from Japan). Because of evidence that *C. gigas* is more resistant to MSX and Dermo, there has been strong interest in introducing this species into the Chesapeake Bay to test its hardiness. Virginia growers, in particular, are interested in introducing such a non-native species of oyster into their waters in an effort to revive their leased grounds and their processing industry. Maryland watermen, who harvest public grounds, have generally opposed introductions even though public grounds are not nearly as productive as they once were. In the meantime, harvesters in both Maryland and Virginia have turned to alternative resources — in Maryland, to softshell clams; in Virginia, to hardshell clams; in both states, to more intensive fishing effort for blue crabs, beginning earlier in the season and lasting later. Other watermen have left commercial fishing entirely.

The decision on whether or not to introduce *C. gigas* or some other non-native oyster into the Chesapeake Bay is not as straightforward as it may appear. Several factors must be considered including the costs and benefits of such an action. The net benefits to the different groups affected by the introduction must be estimated. These benefits may be economic or ecological in nature. Other significant considerations in the decision process are the uncertainties involved.

## Benefits of an Introduction

Among the expected benefits from the introduction of *C. gigas* are those to commercial harvesters and consumers. From the Virginia industry's perspective, the argument in favor of introducing a non-native species is based on the expected economic benefits, for instance, increases in income levels and employment, as well as in increases in producer surplus or economic rent.

The measurement of producer surplus is assessed as the revenue net of costs. In this case, culturing, processing, and harvesting costs are taken into account as well as the opportunity cost of a

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<sup>4</sup> Harvest prices are strongly influenced by the supply of the oyster yields. When both Maryland and Virginia harvests were low prior to 1960, real prices, the actual prices adjusted for the general level of inflation, were high. The tremendous increase in Maryland's production in 1966 caused real prices to drop by as much as 40%.

producer's labor — what he or she could earn in the next best employment opportunity.

As Lipton, Lavan and Strand point out, if the introduction of *C. gigas* is for the purpose of restoring a public fishery, the net benefit to producers will also depend on how the resource is managed. If an open access management regime is maintained, then net benefits to producers will be less than if a bottom leasing program or limited entry program on public grounds is instituted. Simply replacing one species with another does not necessarily eliminate the human-induced factors that caused the decline of the native species.

Consumers of oysters may also benefit from the introduction of *C. gigas* or some other non-native molluscan into the Chesapeake Bay implying further increases in social welfare. Increases in consumer surplus may occur with expected increases in the quantity of oysters available and decreases in price. Consumer welfare measures are assessed based on the demand for the introduced oyster. It is questionable, however, to what extent consumers are aware of or care about the oyster species they consume. It is entirely possible that the introduction of *C. gigas* into the Chesapeake will have negative net benefits: one reason is the negative publicity surrounding the health and safety aspects of eating molluscan shellfish. Consumer demand for the product may be highly inelastic so that a slight increase in the available quantity will be accompanied by a large decline in price.

In addition to market-oriented benefits from oyster introduction, there are potentially significant ecological functions and services that oysters may enhance, ultimately leading to long-term benefits to society. Historically, the oyster was the dominant benthic organism in the Chesapeake Bay: according to many ecologists, as reef-forming organisms, oysters played a major role in ecosystem dynamics.<sup>5</sup> Restoration of the oyster is seen therefore as highly desirable from an environmental perspective. The oyster's filter feeding functions could serve to filter the Bay's large amounts of algae, which could perhaps help reverse eutrophication of the Chesapeake ecosystem. Related improvements in water quality might ultimately provide ecosystem benefits in terms of improved fisheries, aesthetics and recreation and could lead to avoided costs of sewage treatment or depuration facilities.

## Costs of a Species Introduction

The costs of introducing *C. gigas* or any other non-native mollusc into the Chesapeake Bay include direct costs such as the actual costs of performing the introduction, monitoring, and maintenance. In addition, there are costs associated with the introduction in the form of research dollars. That is, before an introduction is implemented, research must be conducted to determine the impact and probability of success of such an action.

Another critical cost is the risk of environmental injury resulting from species introductions. The history of molluscan introductions demonstrates that they can ferry in unintended or nuisance species that could potentially outcompete or displace a desirable native species. There are numer-

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<sup>5</sup> Newell, R.I.E. 1988. Ecological changes in Chesapeake Bay: Are they the result of overharvesting the American Oyster, *Crassostrea virginica*? In Understanding the Estuary: Advances in Chesapeake Bay Research Consortium. Newell estimated that prior to major harvesting (pre-1870) of oyster beds, oysters filtered the entire water column in 3.3 days, while in 1988, the turnover time would have been 325 days. He further estimated that the pre-1870 populations may have been capable of removing 23-41 percent of the 1982 phytoplankton carbon production, but by 1988, they could remove only 0.4 percent.

ous examples in terrestrial and aquatic environments.<sup>6</sup> In addition, the introduction of a non-native species such as *C. gigas* could have unforeseen, detrimental ecological impacts.

The magnitude of the risks involved in introducing a non-native species into the Chesapeake Bay is as yet undetermined. However, it is clear that an introduction poses fewer risks for Virginia's oyster fishing industry than for Maryland's. Unlike Maryland's oyster fishery, which though much diminished is still viable, Virginia's oyster industry is failing. Thus, Virginia's industry does not risk the devastation of native species with the unintended, negative ecological consequences of an introduction. An introduction in Maryland's waters, on the other hand, puts the native *Crassostrea virginica* potentially at risk.

## Dealing with Risk and Uncertainty

Compounding the debate over *C. gigas* introduction into the Chesapeake Bay is the natural ecological connection between the industries of the two states. It is likely that introductions in Virginia waters will eventually affect Maryland waters. The decimated state of Virginia's fishing industry compels its oyster producers and managers to pursue the introduction or transfer of a molluscan species in an effort to save the industry. The less urgent circumstances surrounding Maryland's industry impels its producers and managers to act more cautiously. These contrasting agendas inhibit consensus among the two states as to the appropriate course of action. The use of economics in the decision process could enhance the possibility of a resolution; towards this end, the uncertainties of an introduction can be considered within the benefit-cost framework.

Two principle methods of doing a benefit-cost analysis are through *expected net benefits* and *game-theoretic* approaches. In the expected net benefits approach, the distributions about the costs and benefits are used and the value of net benefits are calculated. Conceptually, the procedure is straightforward. However, the distributions about net benefits are not easy to ascertain, particularly when considering future events. As a result, a higher discount rate is often used with more risky selections.<sup>7</sup>

Game theory<sup>8</sup> can also be applied to the uncertainty involved in the decision on whether or not to allow an introduction. The game theory method is based on the two choices presented — to allow or not to allow an introduction. The approach offers the option of taking either a conservative or a more risky position with regard to possible damages from unintended negative consequences or environmental costs. The conservative position utilizes the minimax principle in which the strategy that minimizes the maximum possible losses is chosen.<sup>9</sup> The more risky position

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<sup>6</sup> Rosenfield, A. and R. Mann. 1992. Dispersal of Living Organisms into Aquatic Ecosystems. Maryland Sea Grant College, College Park, Maryland.

<sup>7</sup> Lipton, D.W., E.F. Lavan, and I.E. Strand. 1992. Economics of Molluscan Introductions and Transfers: The Chesapeake Bay Dilemma. Journal of Shellfish Research 11(2):517.

<sup>8</sup> Bishop, R.C. 1978. Endangered Species and Uncertainty: The Economics of a Safe Minimum Standard. American Journal of Economics 60(10):10-19.

<sup>9</sup> Ciriacy-Wantrup, S.V. 1968. Resource Conservation: Economics and Policies. Berkeley and Los Angeles: University of California Division Agricultural Sciences.

makes use of probability distributions of net benefits and compares the expected value of the introduction and no-introduction scenarios, choosing the action with the greater expected value. Clearly for each strategy, measures of the consequences of introductions and damages must be made. This procedure must determine how the stream of net benefits should be discounted over time and the characteristics of the uncertainty of these measurements.

## Exercise

The debate over the introduction of *C. gigas* or some other non-native oyster into Chesapeake Bay waters is highly political and full of uncertainties. Watermen are unwilling to abandon an industry that has been a fundamental element of the region's economy and culture for over a century. Virginia watermen, in particular, see molluscan introductions as a means to revitalize the failing industry. However, the uncertainty of the effects of an introduction clouds the issue. Another complication is the fact that the decision will have effects that cross jurisdictional boundaries.

The decision whether or not to allow an introduction is not isolated to the specific, individual oyster beds within the two states of Maryland and Virginia. The Chesapeake Bay ecosystem is not confined, of course, by political boundaries. Any decision that is made must take a multi-jurisdictional approach that transcends artificial divisions.

Suppose that you are a member of a Chesapeake Bay economic development council. You are tasked with developing recommendations on a Bay wide oyster development plan. Consider the role of environmental valuation in your analysis. Using the following questions as a guide, outline the study you would request of a local economist.

1. What values associated with oyster resources and services should be analyzed?
2. What techniques would you recommend in order to determine the values of these resources and services?
3. What are the limitations to the existing methodologies in this case?
4. What additional information do you need in order to determine the expected net economic benefits of a *C. gigas* introduction plan?
5. What discount rate would you recommend in a benefit-cost analysis of a *C. gigas* introduction plan?
6. Suppose that new technological developments offer alternative methods of oyster enhancement (e.g., bio-technological or bio-engineering of a native species immune to MSX or Dermo). What role can environmental valuation play in assessing these alternatives?



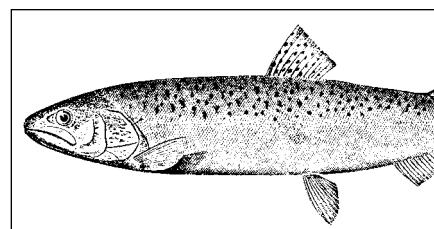
# SALMON HABITAT RESTORATION IN ALASKA

## Background

Alaska's salmon fisheries account for sizeable contributions to the state's economy. In 1990, commercial harvests, which were 94 percent of the 733.1 million pounds landed in the United States, were valued at \$546.7 million. This amount does not account for the added value of its recreational and subsistence fishing. The health of the salmon fishery, then, is vitally important to economic health. The salmon fishery is influenced by many factors, environmental and human — from highly variable ocean conditions to the timing of harvesting, the levels of that harvesting, the impact of land-use practices on freshwater and estuarine habitats, which can be critical for spawning.

Pacific anadromous salmonids include five species of salmon that are comprised of a large number of stocks originating from specific watersheds. Salmon juveniles or smolts spawned in streams migrate to the ocean and then generally return to their natal streams to spawn. Because forestry practices can directly influence the quality and quantity of freshwater habitat, primarily through harvesting of timber and associated road building activities, their management is particularly important for the health of salmon returning to their home streams.

Even with salmon health generally high, with record harvest levels, and with a large proportion of the land base relatively undisturbed, specific stocks could still be in decline if forest practices remove too much of the riparian vegetation or degrade channels. Under certain conditions, a given run of salmon could be considered for listing as endangered under the Endangered Species Act, which includes provisions for listing "distinct population segments."



## Situation

**Harvesting of Alaskan forests can impact salmon habitats and lead directly to reduced spawning of smolts. A hypothetical example is presented in which a proposed regulation calls for a riparian buffer zone along critical stream habitat.**

## Hypothetical Alaskan Watershed

The following example provides a set of assumptions about the economics of logging and salmon harvests — the exercise then poses a number of questions that consider issues of value. To begin with, suppose that harvesting within the Tough Choices watershed would generate 6,700 million board feet of timber with a pond log value of \$401 per million board feet — pond log value reflects not just the price of the standing timber but also the costs incurred in bringing the timber to the mill, for instance, logging, road construction, and transport. Assume that by building the access roads across the watershed and by removing the trees, this timber sale will fragment the riparian habitat into patches and cause a reduction in the full capacity of the spawning ground for the coho stock that inhabits the creek. This stock of salmon would show an expected decline relative to the amount of habitat lost.

The impact of tree clearance would also affect the food web, for example, local bear and eagle populations that depend on salmon stocks could be adversely affected. Such impacts could have ripple effects, for instance, declines in recreational viewing which might be impacted because of tree harvesting and road-building. We will suppose that the only functions attributed to these trees is either commercial harvest or as an input into stream integrity and fish production, or negative effects. The value of the salmon consists of its commercial and recreational value (in current and future fisheries), as well as its subsistence and cultural value to the residents of the State of Alaska.

As part of this hypothetical example, we assume that biologists have developed an expected relationships between land clearance and the capacity of the spawning ground associated with the stream. If all the commercial timber proposed is harvested, then the spawning capacity will be reduced by 90 percent of its original capacity. If only 20 percent of the trees are harvested, a 10 percent reduction in fish capacity is expected. For every 10 percent increase in timber harvest from that level on, there will be a corresponding drop of 10 percent in fish spawning capacity. In addition, consider the following information:

Spawning capacity: 9000  
Smolts per spawner: 106  
Ocean survival to maturity: 43%  
Commercial harvest rate: 47%  
Freshwater recreational harvest: 16%  
remainder available to spawn for future cycles

Ex-vessel Price: \$1.42/lb  
Average weight of salmon harvested: 12 lbs  
Anglers' WTP: \$15.92 per additional fish caught

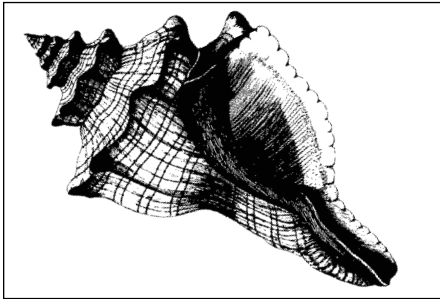
## Exercise

Given the background and information provided above and keeping in mind the various perspectives regarding “value,” analyze a proposed regulation calling for a 300-foot riparian buffer zone along critical salmon streams.

Questions to consider include:

1. Are there any additional value associated with the timber and salmon resources not mentioned?
2. What measurement techniques would you employ to determine relevant values?
3. What additional data (aside from that provided) might you need to carry out empirical analysis?
4. What discount rate would be appropriate in the determination of net present value?
5. Society involves many individuals, and projects such as this often affect the welfare of individuals differently. The implicit assumption in constructing the estimates of costs and benefits in this example is that the welfare of all individuals is weighted equally. What if you were to eliminate this assumption and address the issues of equity and fairness? How might your decision change if you take future generations explicitly into consideration? How might you go about doing this?
6. Consider the issue of irreversibility. How might the potential for species extinction change your decision process and recommendation? How might you integrate the potential risk of irreversible outcomes into your analysis?

# FLORIDA KEYS NATIONAL MARINE SANCTUARY



### Situation

With the Florida Keys ecosystem threatened by point and non-point source pollution, alternative management strategies outlined in the Florida Keys National Marine Sanctuary Plan have focused on the cost-effectiveness of different issues or activities for achieving sustainable use of the Florida Keys National Marine Sanctuary: boating, fishing, recreation, land use, water quality, zoning, and education. This case study focuses on different strategies of zoning.

### Background

The marine ecosystem of the Florida Keys is the only complete tropical marine ecosystem in the continental United States. It includes extensive aquatic habitats such as coral reefs and seagrass beds. Ninety percent of the region's commercially important species use these habitats for shelter, food, or nurseries during at least one stage of their life history. Several species of threatened and endangered sea turtles are found in the Keys, including hawksbill, loggerhead, leatherback, green, and Kemp's ridley. In addition, dolphins and endangered manatees frequent the area, as well as countless species of sea and shore birds. Another aspect of the area's marine environment is the submerged cultural and historic resources, for example, submerged Paleo-Indian sites, nationally registered lighthouses, and wrecked ships going back several hundred years.

The Keys ecosystem is threatened by impacts from a number of different sources, indirect and direct. Indirect impacts contributing to the decline of the reefs and seagrass beds include polluted runoff from over-developed islands; heavy metals and other toxins which contaminate the reefs; excess nutrients from human sewage, fertilizers, detergents, and animal wastes which create algal blooms; pesticides; offshore oil and mineral mining; and saltwater/freshwater imbalances. Direct impacts include vessel

groundings, diver damage to coral, and boating traffic (anchor and prop dredging) which destroys seagrass beds, and destructive fishing methods.

To protect the Keys marine ecosystem, Congress enacted the Florida Keys National Marine Sanctuary and Protection Act of 1990.<sup>1</sup> The legislation to provide comprehensive protection to the Keys' marine environment was prompted by recognition in the late 1980s of human impacts that threatened sanctuary resources. The sanctuary area extends approximately 220 miles southwest from the southern tip of the Florida peninsula and encompasses a 2,600-square nautical mile area of submerged lands and water surrounding Monroe County, Florida.

Protected areas and marine sanctuaries are not new to the Florida Keys area. The Key Largo and Looe Key Marine Sanctuaries were established in 1975 and 1981, respectively, and according to the Act, they will be incorporated into the new Florida Keys Sanctuary when the management plan is adopted. Numerous State and Federal parks and reserves are also located within the boundaries of the Sanctuary.

The existing regulations of current jurisdictional responsibilities allow sport and commercial fishing with hook and line; taking of spiny lobsters and stone crabs in accordance with the fishery management plan; and swimming, snorkeling, scuba diving, photography, and recreational boating. Regulations prohibit removing or damaging natural features, non-permitted marine life, or archaeological and historical resources; dredging, filling, excavating, and building; anchoring in a manner that damages coral; discharging harmful substances into the water; spear fishing or using wire fish traps; and handling or standing on coral formations. Specific regulations already in place as a result of the Florida National Marine Sanctuary Protection Act prohibit all oil drilling and exploration within the Sanctuary and the operation of tank ships or other vessels greater than 50 meters in Areas To Be Avoided, which were designated in response to the region's many historical groundings.

In addition to creating one of the largest national marine sanctuaries, the Act also requires the National Oceanic and Atmospheric Administration (NOAA), which administers the National Marine Sanctuaries program, to prepare an environmental impact statement and a comprehensive management plan for the Sanctuary with implementing regulations to govern the overall management of the Sanctuary and to protect Sanctuary resources and qualities.

## The Local Economy

The Florida Keys economy is dependent on a healthy ecosystem. In 1991, Florida Keys' and Monroe County's gross earnings were \$853 million. The activities that contributed most to those earnings were recreation and tourism, commercial fishing, and retirement communities. These activities combined make up more than 80 percent of the local economy. Over three million tourists visit the Keys annually, participating principally in water related sports such as fishing, diving, boating, and other ecotourism activities. In fact, 61 percent of the recreation and tourist activities are water-related — the Keys have been hailed as the most important dive destination in the world. In addition, multi-million dollar fisheries for spiny lobster, stone crab, grouper, and snapper have supported local and regional economies for generations. Commercial fishing is the fourth-

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<sup>1</sup> The information presented in this case study was obtained from existing sources, primarily from NOAA's Florida Keys National Marine Sanctuary, Draft Management Plan/Environmental Impact Statement. While the Draft Management Plan/EIS examines several issues, this case study gives particular emphasis specifically to zoning issues and de-emphasizes other issues that were addressed in the Draft Management Plan/EIS.

largest industry in the Florida Keys region and represents 9 percent of Monroe County’s private-sector employment. Case Table 3.1 provides more information about the value of specific services provided by the ecosystem and economic impacts.

**Case Table 3.1. Overview of Economic Situation.**

Economic Value of Florida Keys		Economic Impacts	
Service	Value	Activity	Impact
Annual non-market user value of water-related activities	\$660 million	Gross earning provided by tourism industry	35% (\$309 million)
Asset vlue of the Keys for water related activities (1990 dollars)	\$22 billion	Gross earnings provided by retail trade	18.7% (\$160 million)
1990 ex-vessel value of commercial fishing in sanctuary	\$46 million	Population with jobs that either directly or indirectly support outdoor recreation	51%
1986 ex-vessel value of Monroe County’s seafood landings	\$27.4 million	Monies provided by commercial fishing	\$17 million
Value of seafood landings at the harvesting, wholesale, retail and restaurant levels	\$14.8 million		

## NOAA’s Proposed Alternative Management Plans

In fulfillment of the mandate to prepare an environmental impact statement and a comprehensive management plan for the Sanctuary, NOAA developed and assessed five alternative management plans. These plans represent different levels of regulatory control over Sanctuary resources and restriction of uses, with Alternative I being the most restrictive (total restriction of uses, except for research) and Alternative V the least restrictive (no action). The purpose of NOAA’s proposed Alternative Management Plans is to ensure the sustainable use of the Key’s marine environment by achieving a balance between comprehensive resource protection and multiple, compatible uses of those resources.

Each of the five alternative plans are comprised of a series of management strategies that focus on the pertinent issues or activities considered to have potential resource impacts, positive or negative. These issues or activities include:

1. Boating
2. Commercial and Recreational Fishing
3. Recreation
4. Land Use
5. Water Quality
6. Zoning
7. Education

For each issue, the potential impact themes of habitats, species, use and users, and water quality were examined.

## Economic Impact Assessment

The purpose of the of the Florida Keys National Marine Sanctuary and Protection Act is to provide for multiple uses of the Sanctuary as well as to ensure that its natural resources are protected for the future.<sup>2</sup> However, due to the implementation of management strategies, such as zoning, the Act may also result in the displacement of some Sanctuary users and consumers.

Because the numerous users, consumers, and administrators of the Sanctuary have diverse and sometimes contradictory interests, a thorough examination and comparison of the Management Plans under consideration is essential. NEPA requires the assessment of environmental impacts in an Environmental Impact Statement. An analysis of the economic impacts, costs, and benefits of the proposed plans is an important part of this assessment, especially in light of the Keys' economic dependence on revenue generated from marine-related activities, and the value of the services provided by the ecosystem.

An economic impact assessment was conducted as part of the Draft Management Plan/Environmental Impact Statement. However, a net economic benefit analysis, examining the socio-economic implications of proposed actions by comparing economic costs and benefits, was not conducted. The economic impact assessment summarizes the potential impacts of proposed management strategies on various user groups and the local economy, for example, sales, employment, income. The socioeconomic impacts associated with the management strategies were assessed by issue, as outlined above and discussed in qualitative terms. The key strategies within each issue were assessed in terms of impact on user groups and expected socioeconomic costs and benefits.

Cost information for the analysis was based on negative impacts such as expected losses in user values, income, or employment. The cost information used in this assessment was provided by federal, state, and local officials with responsibilities in the Keys. Low- and high-range estimates were given for both capital and annual operating costs and costs for each proposed manage-

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<sup>2</sup> The Coral Reef Coalition. Inside the New Florida Keys National Marine Sanctuary.

ment strategy. Information on the effects of proposed actions on human activities was also derived as part of the process to develop a Sanctuary resource protection zoning scheme.

## Resource Protection Zones — Zoning Categories

This section describes the findings of the assessment of social and economic implications for zoning strategies proposed in the Alternative Management Plans. Zoning, as noted in the previous section, is one of the issues that has potential resource impacts.

The development of a management plan, then, provides the opportunity to establish different regulations for separate areas within the Sanctuary. Thus, one of NOAA's tasks under the Act is to consider temporal and geographic zoning to ensure protection of Sanctuary resources.

Zoning schemes were developed to ensure the protection of Sanctuary resources. The intent was to reduce both damage to those resources and threats to environmental quality, while allowing uses that are compatible with resource protection. The zones are intended to protect habitats and species by limiting consumptive and/or conflicting user activities, thus enabling resources to evolve in a natural state with minimal human influence.<sup>3</sup> Zoning will permit customary activities to continue in some areas, while other areas will be designated for preservation, research, or restoration. The resource protection zoning scheme proposes five types of resource protection zones (these are then described briefly):

1. Wildlife Management Zones
2. Sanctuary Preservation Areas (SPAS)
3. Existing Management Zones
4. Special-Use Zones
5. Replenishment Reserves

**WILDLIFE MANAGEMENT ZONES.** This strategy would affect user groups participating in wildlife observation or seeking access to these areas. Users participating in wildlife observation would see a small socio-economic benefit due to greater assurances of continued wildlife and habitat protection. However, most of these zones are already within national wildlife refuges and are under restrictions established by the U.S. Fish and Wildlife Service. As a result, the strategy is likely to have minimal socio-economic impacts on Sanctuary users.

**REPLENISHMENT RESERVES.** These reserves will encompass large diverse habitats and are intended to provide genetic protection for marine life. The goal is to increase the productivity in adjacent marine areas and enhance biodiversity. Sanctuary regulations will strictly limit resource use and consumption in these habitats. Some users, such as commercial lobster fishers, sport fishers, and tropical fish collectors will be displaced. However, compatible recreational activities will be permitted. Although these zones would prohibit commercial and recreational fishing, they are expected to have an overall benefit by protecting spawning and recruitment stocks from overfish-

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<sup>3</sup> National Oceanic and Atmospheric Administration. (December 1994). Florida Keys National Marine Sanctuary, Draft Management Plan/Environmental Impact Statement. V2, pp. 194.



ing, promoting genetic diversity within the fishery, producing “spill-over” benefits to other non-protected areas through the migration of organisms across boundaries, and providing important baseline data for use in managing fisheries in other areas. The zones become slightly larger and/or more numerous moving from Alternative IV to Alternative II.

**SANCTUARY PRESERVATION AREAS (SPAS).** These zones will focus on the protection of shallow, heavily used reefs where user conflicts occur and where concentrated visitor activity leads to resource degradation. As with Replenishment Reserves, the groups that will benefit are those that value an abundance and diversity of marine wildlife, including commercial and recreational fishers and participants in water-related recreation activities. However, tropical fish collectors, lobster fishermen, recreational fishers and spear fishers displaced from these areas will be negatively impacted.

**EXISTING MANAGEMENT AREAS.** Because these areas are already established by federal, state, or local authorities with competent jurisdiction in the Sanctuary, this strategy will have minimal socio-economic impact.

**SPECIAL-USE ZONES.** This strategy will have negligible socio-economic impacts on users because only a small number of areas will be established. Academic and scientific communities will be the primary beneficiaries of this zone type.

The socio-economic information generated by this analysis was used along with the environmental impact assessment data in the selection of a Preferred Management Alternative.<sup>4</sup>

## Exercise

While an economic impact assessment does provide some useful information in the evaluation of management alternatives, it does not provide more comprehensive information about the overall result of a given project or policy change. All of the proposed management strategies assessed in the NOAA plan affect some aspect of Sanctuary resources, either directly or indirectly.

Sanctuary resources (both natural and historic) can be considered assets that produce a flow of goods and services with both market and non-market values to users and non-users. The concept of non-market value is significant to the Keys and its economy. The area’s natural resources are considered public resources, not common property or privately owned. Tradeoffs between the effects of strategy implementation on economic values and economic impact are also pertinent to the Keys. Restrictions may increase the costs of consumptive use; however, protecting a resource may not only increase its quality and value but also have a long-term economic benefit to both consumptive and non-consumptive users.

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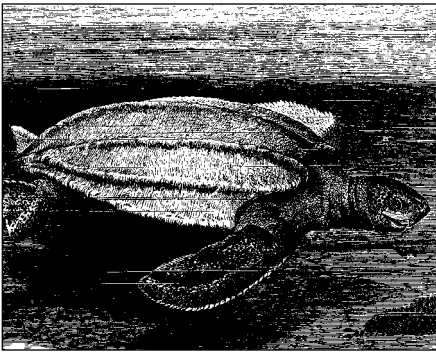
<sup>4</sup> Alternative III was chosen as the Preferred Management Plan. Volume I of the Florida Keys National Marine Sanctuary, Draft Management Plan/Environmental Impact Statement provides a description of the strategies recommended in the Management Plan. According to the selection committee, the positive environmental impacts and associated beneficial economic impacts of the Preferred Alternative (Alternative III) outweigh any potential negative impacts. Of the five alternatives, the one selected most closely meets the resource protection goals, while facilitating current Sanctuary users and user activities.

Some of the proposed Sanctuary Preservation Areas will displace current commercial and recreational fishers as well as tropical fish collection to non-zoned areas. This displacement may result in increased costs to fishers and consumers as well as decreased sales, employment, income, and tax revenues for the local economy dependent on this activity. However, the protection provided to these areas may have economic value to non-consumptive users. Furthermore, if resource degradation can be halted or reversed, there may be long-term benefits for consumptive users. While the existing economic assessment attempted to take these types of tradeoffs into account for each management strategy, it would be more informative to carefully consider how such an analysis is in fact operationalized. Such a consideration is one to examine in this exercise.

Reread this case study noting the economic values and costs that could be compared in a benefit-cost analysis.

1. What techniques would you recommend be used to measure the value of services identified above?
2. What types of resource values are missing?
3. What data would you need to conduct these studies?
4. Give particular attention to the effects on displaced fishers versus fishers who are not displaced, as well as to the various other tradeoffs that are made.
5. How does this information differ from the impact assessment on Resource Protection Zones provided by NOAA?

## COASTAL BARRIER ISLAND PRESERVATION IN NORTH CAROLINA



### Situation

A barrier island with a small year-round population and a large number of seasonal home owners has the potential of greater development. The island is also home to a unique forest community as well as other rare fauna. State plans to purchase large tracts of the island for preservation must consider the economic impact of shutting down further development that such preservation would entail and the alternative of purchasing a similar tract for preservation on another island.

### Background

Old Baldy Island is a coastal barrier island in North Carolina.<sup>1</sup> It is situated at the mouth of the Cape Buffalo River, approximately three miles off the coast of Northport and about 30 miles south of Wilmatown, the fourth largest city in the state. Old Baldy Island is the largest and southernmost of a series of small islands connected by extensive salt marshes that form an area known as Smith Island. It comprises approximately 13,000 acres including upland, tidal marshes and creeks, shallow bays, and marshland. The island is 3-1/2 miles long and 1-1/2 miles wide and features a moderate climate often referred to as subtropical. The Old Baldy Island Lighthouse, built in 1817, serves as the Island's landmark — it is North Carolina's oldest lighthouse.

Located on the island is the Old Baldy Planned Unit Development, primarily a second home development; it is somewhat of an island retreat in that its access is limited to a privately operated ferry system which provides access to the mainland. While there are a limited number of year-round residents (approximately 60 at present), some 1,200 families have homes there. The neighborhood is less than 50 percent developed.

**THE MARITIME FOREST.** Old Baldy Island is home to a maritime evergreen forest. It is a globally imperiled forest community located on old stabilized dunes and flats protected from saltwater flooding and the most

<sup>1</sup> While this case study is based on a real situation, place names and some facts have been modified for the purposes of the example.

extreme salt spray. Encompassing approximately 355 acres, it is the largest in the state and still has undeveloped, natural transition zones from ocean to sound. The topography is that of a dune ridge and swale system: the ridges are broad and they slope gently into even broader swales, which can be wet or dry, depending on local drainage patterns. The natural communities associated with the Phase I site include salt marsh, interdunal ponds, pine lowlands, palmetto lowlands, and non-forested freshwater wetlands.

While the State has been working closely with local officials to minimize impacts from development on the maritime forest, even low-intensity development on Old Baldy Island will tend to fragment the high-quality maritime forest communities. The proposed actions would preclude even lower density development.

A special Maritime Forest Advisory Committee, set up by the North Carolina Coastal Resources Commission in 1990, recommended that the few remaining high quality tracts of maritime forest be acquired and managed for conservation purposes. The committee ranked the undeveloped maritime forest on Old Baldy Island among the top two or three maritime forests in North Carolina in terms of natural area values such as ecological integrity, uniqueness, diversity, rare species, size, and historical significance. Nags Head Woods and Buxton Woods are the two other areas of significant natural value and these two areas have already been acquired for conservation purposes.

**VEGETATION.** The Island is home to several species of plants that are unique. One of these is a plant commonly known as the Old Baldy Blue Curl, a small indigenous plant in the mint family. A significant feature of the forest is the many extremely old trees; they include palmettos, pines, cedars, oaks, and dogwoods. The undergrowth throughout the forest is quite dense with many vine species. The most common of the understory shrub layer are Red Bay, Wild Olive, *Prunus caroliniana*, and French Mulberry. The Island also harbors two moss species, Beach Moss and Cuban scheliessmund that are recognized as “critically imperiled species.” Other plants that fall within the “critically imperiled species” designation are the Tough Bumelia and the Piedmont Flatsedge. Finally, the dunes and cape at Old Baldy are host to a newly identified species, Dune Blue Curl, which is a candidate for state and federal protection.

**WILDLIFE.** Old Baldy Island is North Carolina’s most popular nesting area for the endangered loggerhead sea turtle, which lays its eggs along the island’s 14-mile oceanfront. The Old Baldy Conservancy has a successful sea turtle conservation program which claims a 95 percent hatch rate. Other fauna of the island complex include alligators, raccoons, large numbers of tern and gulls, over-wintering brown pelicans, and migrating peregrine falcons. The freshwater ponds and marshes are used heavily by water birds, as are the extensive marshes, tidal creeks, bays, and mudflats. Nearby Battery Island is North Carolina’s largest breeding rookery for egrets, herons, and ibises.

## Proposal for Preservation

To preserve maritime forest, the state of North Carolina is considering purchasing land currently scheduled for development. In Phase I of the proposed preservation plan, the State will ac-

quire approximately 125 acres of the remaining core maritime forest. In Phase II, the State will work to acquire as much of the remaining undeveloped maritime forest and associated wetlands as possible. It is anticipated that Phase II will include the purchase of additional areas along the undeveloped estuarine shoreline. North Carolina is also considering acquisition of an ocean front section that would protect a portion of the island from ocean to sound.

The Old Baldy Phase I Purchase Tract is an irregular shaped area of 96.80 acres. The Purchase Tract can be generally characterized as a gently rolling and heavily wooded maritime forest. The plan would include a Maritime Forest Protection Overlay District, protective salt spray shear zone vegetation, forest wetlands, and relic dunes and dune ridges. In addition, there would be a prohibition against the removal of trees and shrubbery (except as necessary), the filling of wetlands and ponds, and on-street parking. In addition, all construction would need to be contained to prevent runoff. To protect against the potential of introducing harmful exotic plants, only permissible plants would be allowed. The maximum lot coverage for structures, including all impervious surfaces, would not be allowed to exceed: (1) 25 percent of a building lot less than 9,000 square feet; (2) 50 percent of a lot less than 9,000 square feet in residential lots; (3) 60 percent of a commercial service or multi-family lot.

## Economic Considerations

Implementing the proposed Old Baldy Island Phase I purchase would reduce the community's ad valorem tax base by approximately \$10 million, the purchase price of the land. Based on the current rate of development and the type of development that has occurred, approximately 50 housing units with property values of approximately \$7.5 million would be added per year, if there are no restrictions. Because of the seasonal nature of most of these residences, each of the additional residential units, if developed, would be anticipated to result in \$250 per month in direct expenditures in the local community during the winter season (October-February) and \$1,000 per month during the summer season. It has been estimated that the addition of more than 200 new residential units would result in the need for increased local public servants including one additional police officer, one fireman, and several municipal maintenance staff persons.

## Exercise

The Old Baldy purchase is only one active maritime forest preservation option available to the State of North Carolina. Another is to purchase a similarly sized tract of maritime forest land on Little Barrier Island, also in North Carolina. The purchased land would become a nature preserve protected from development. The Old Baldy Little Barrier Islands are very similar — the main differences are smaller loggerhead sea turtle nesting areas and the absence of palmetto palm trees and beach moss on Little Barrier Island. Little Barrier Island also lacks the historical significance of Old Baldy Island, home of the Old Baldy Island Lighthouse and Captain Charlie's Station cottages built in 1903.

Little Barrier Island has extremely limited development, with no existing plans for additional construction activity. For this reason, purchasing the land is estimated to cost \$2 million. Since

the land on Old Baldy Island is scheduled for development, its purchase price is expected to be roughly \$10 million, the appraised value of the land. Given this information consider the following questions:

1. Suppose your agency is trying to decide between purchasing the land described above on Old Baldy Island and the similarly sized tract of maritime forest land on Little Barrier Island in North Carolina. Which tract of land would you recommend trying to purchase?
  - a. What additional information would you want?
  - b. Does the schedule for development affect your decision?
  - c. What operations other than purchase might be available (zoning, legislation, takings)?
2. Which economic approach in this handbook would you typically use in evaluating the Old Baldy Island maritime preservation proposal?
3. How would the various economic approaches be of use to others in the decision process?
  - a. Developers
  - b. Local agencies making decisions regarding supporting public investment decisions
  - c. Interest groups
  - d. Public at large
  - e. Federal regulators/decision-makers
4. The residential development on Old Baldy is “upscale,” but is protected by covenants and zoning restrictions. Transportation around the island is restricted to electric golf carts. Plants may not be introduced unless they are on a list of permissible shrubbery. Restrictions also exist limiting all impervious structures. You have responsibility for the enforcement of zoning laws related to the environment. Two homeowners have approached you with a proposal. One, for aesthetic reasons, prefers not to pave his driveway. The other wishes to purchase her neighbor’s “right to pave” in order to build a tennis court on her property. Proponents of this proposal applaud the flexibility that allowing “tradable paving rights” affords. Property values could rise if residents are permitted to build tennis courts and other amenities on their land. They also note that less pavement would exist than if the two homeowners had paved driveways. Those opposed to the change argue that existing residents originally did not have a choice between paving a driveway, building a tennis court, and selling their rights. Further, they argue, the right to pave is an intrinsic part of the property and cannot be transferred. Finally, they fear that this is an attempt to abolish paving limitations altogether.
  - a. Should residents be allowed to sell paving rights?
  - b. How would you deal with the right of a future homeowner to pave his driveway if the previous owner has already sold the rights?
  - c. Should your agency attempt to regulate the price for which paving rights will sell? If so, what will you consider in setting that price?
  - d. What problems might arise from setting such a price?

## ARTIFICIAL REEF PROGRAM IN LAKE ERIE, OHIO

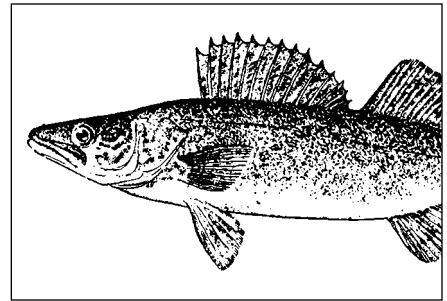
### Background

Artificial reefs are synthetically constructed underwater structures — they may be rock, sunken ships, auto bodies, rubber tires, and wood. Designed for structureless bottom areas in either fresh or salt water environments, they provide habitat for fish, habitat that includes food, shelter, protection, and spawning areas. Drawn by the new habitat, fish concentrate in these areas. Often artificial reefs are strategically placed at various depths and are built to particular heights to attract a specific species of fish.

Artificial reef construction may be a community effort, with technical assistance provided by state and federal agencies. Recreational fishing reefs are placed near access areas such as launch ramps and marinas and in locations where they will not interfere with navigation and commercial fishing activities.<sup>1</sup> Artificial reefs have been constructed all along the U.S. coast in salt water and in many inland lakes and reservoirs. Artificial reef programs have been implemented in many coastal states, e.g.,

Georgia, Florida, California, Texas, Alabama, Virginia, New Jersey, South Carolina, and Delaware.

Studies indicate that when artificial reefs are constructed with proper materials, placed in good locations, and developed with a specific purpose and plan, they can enhance sustainable fisheries. Research in South Carolina, for example, attributes increases in time spent fishing and catch rates to the presence of artificial reefs. In many areas, new aquatic communities created by the artificial reefs draw increased numbers of recreational and commercial fishers and scuba divers — one result is travel and tourism dollars brought in by visiting anglers and their families, thus leading to positive economic impacts to local communities.



### Situation

**Artificial reefs can be used for enhancing fisheries and economic activity by providing the structure for new fish habitats. Reefs placed in different locations in Lake Erie are demonstrating that improved fisheries habitats lead to increased recreational fishing.**

<sup>1</sup> Kelch, D. O. and J.M. Reutter. 1991. Lake Erie's Artificial Reef Program. Ohio Sea Grant Program, OHSU-FS-021.

# Artificial Reef Program

Ohio's Lake Erie is the warmest, shallowest, and most productive of the Great Lakes; its western basin is known as the "walleye capital of the world" and produces more walleye per hectare than any other lake in the world. Historically, the western basin walleye fishery has made up the major component of Ohio's primarily recreational sport fishery.<sup>2</sup> As a result, Ohio's north coast has developed into a major recreational economy. The historical predominance of the walleye fishery within the western basin of Lake Erie is also the result of easy access to areas where the fish congregate.

Unlike the western basin, the central basin is deeper and larger — it also lacks the productive bottom structures that provide habitat for fish. These features, combined with the fact that schools of walleye are often located further from shore, make the walleye more difficult to locate in the central basin. Access for boat anglers is another difficulty: the rocky bluff and high bank terrain of the central basin impedes the construction of marinas and launch ramps, which are readily available to boat anglers in the western basin. As Kelch and Reutter point out, while there are many excellent fishing areas in the central basin, not all are within safe running distance for smaller boats. Fishery managers have recognized that construction of artificial reefs strategically located in areas easily accessible to boat anglers could attract greater numbers of anglers in the central basin. Furthermore, if the artificial reefs yield the expected results — attracting fish and thus increasing angler participation and catch rates — the fishery's role in helping develop a recreational economy in the Central Basin communities could be enhanced.

Ohio began an artificial reef project in 1986. While artificial reefs have been planned for the entire shoreline of Ohio, the central basin presently is the key area of development for reasons outlined above. The U.S. Army Corps of Engineers has granted permits for five sites. To date, two reef structures have been constructed — the Lorain County reef and the Cuyahoga County reef. The purpose of the reef project is to create a demonstration project to evaluate the productivity and feasibility of reef construction in other areas of Lake Erie and the other Great Lakes. Evaluation of the demonstration project's effects on recreational activity and the expected effects of similar reef structure in other coastal areas are priority needs for sustainable coastal development policy of the central basin.

The Lorain County reef consists of two reef structures, one about 370 meters long and the second about 183 meters long. The Cuyahoga County reef, also known as the Cleveland site, is made up of one reef structure 213 meters long in 8.5 meters of water and a series of unconnected sandstone "rubble piles" in deeper water. The reefs were constructed from scrap rock and concrete and are located within close proximity to ports of shelter, an advantage for smaller vessels.

The Ohio artificial reef project plans to construct additional reefs in Lake and Ashtabula Counties, but the construction is awaiting scientific evaluation of the completed structures. The only evidence available regarding the ecological and economic benefits of the artificial reefs has been anecdotal information from various anglers who report successful fishing within proximity to

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<sup>2</sup> Lake Erie's total 1993 fish harvest yielded 12.9 million pounds of fish, only 4.3 million pounds of which were caught by commercial fish producers. The bulk of the harvest (8.6 million pounds) were caught by recreational sport and charter boat anglers.



the reefs and some underwater videos taken in 1989 and 1990. No formal scientific data demonstrating the success of the structures has been gathered. According to Dave Kelch, District Specialist with The Ohio State University's Sea Grant Program and the project's director, research is needed for both the scientific community's acceptance of the artificial reefs and for interested shoreline communities.

## Costs and Benefits of the Artificial Reef Program

**COSTS.** Ohio's Artificial Reef project has been financed by the local communities, fishing public, local government, local business and industry, and fishing tackle companies. Donations exceeded \$100,000, the majority of which has been used to pay marine contractors for materials placement (more than 7,000 tons of material were used to build the reefs at the Lorain site and a total of about 6,800 tons were used to construct the reefs at the Cleveland site). Much of the project supervision, fund raising and donation procurement, and materials site inspection was conducted by volunteers from the North Central Sea Grant Advisory Committee. Overall project supervision and monitoring was the responsibility of the Sea Grant District Specialist, which resulted in no monetary outlay for these services.

According to Kelch and Reutter, only \$10,000 of state and federal dollars were made available. Because of the donation of material, dollars, services, and labor, exact costs for the construction of artificial reefs are difficult to assess. Estimates are that the cost of placement varied from \$6 to \$14 a ton (based on 1984 to 1989 costs) depending on the contractor. Small, non-union contractors fees averaged \$7.50 a ton, while unionized contractor fees were as much as \$14.8.

**BENEFITS.** One rationale for the Ohio Artificial Reef project is to improve the integrity of the central basin area. In the past, eastern Ohio waters have been plagued by heavy pollution. At one time the situation was so bad that the surface of the Cuyahoga River ignited. Since then, environmental enhancement measures have significantly improved water quality. Residents of the central Lake Erie region wanted assurance that the central basin could provide water-related recreational pleasures similar to those available in the western basin. The construction of artificial reefs has been perceived as an effective strategy to improve the area's character.

Additional gains to local small boat anglers are also expected: anglers should experience increases in recreational fishing value as a result of the new, productive, quality fishing sites within close proximity to sheltered ports. In addition, communities as a whole should benefit from some increases in tourist-related activities resulting from improved sportfishing opportunities.

## Preliminary Analysis and Evaluation of the Artificial Reef Program

While scientific analysis of the effects of artificial reefs on fish production has not been conducted, data on angler hours and catch rates indicate that walleye harvests have increased substantially over the last two decades (Case Table 5.1).

Two research efforts began in 1992 to evaluate the success of the artificial reefs. The aim of

**Case Table 5.1. Walleye sport boat harvest in Ohio, 1975-1993.\***

Year	Walleye (thousands)
1975	86
1976	638
1977	2,171
1978	1,596
1979	3,288
1980	2,165
1981	2,932
1982	3,013
1983	1,846
1984	4,038
1985	3,730
1986	4,400
1987	4,438
1988	4,890
1989	4,192
1990	2,283
1991	1,578
1992	2,082
1993	2,669

\*Fish Ohio. Division of Wildlife. 1993. Ohio's Lake Erie — 1993 Sport and Commercial Harvests.

one was to determine the fish concentration ability of the reefs; towards this end, an underwater video assessment was conducted at the Lorain artificial reef site. This effort involved monthly dives at both the reef site and a non-reef control site to identify and enumerate fish as well as to determine habitat differences. Analysis reveals that the 1992 and 1993 total seasonal numbers of fish were significantly higher at the reef site than at the control site. Thus, the reefs appear to be effective as a fish concentration device.<sup>3</sup>

The second research effort to evaluate the effectiveness of the reefs sites was designed to identify changes in social and economic values resulting from the artificial reef project. In 1992, survey data were collected from a random sample of individuals at various launch sites and marinas regarding their recreational use and expenses on Lorain County waters. Initial analysis reveals that 87 percent of the 466 respondents (55 percent response rate) knew about the reef and 64 percent of these individuals used the reef during 1992.

The typical respondent made 20 trips to Lorain County waters during 1992 and 7.1 of those trips involved fishing out at the artificial reef for at least part of the trip. Of those respondents who traveled less than 40 miles to Lorain County, more than two-thirds used the artificial reef. Of those who traveled 40 or more miles to Lorain County, less than one-half used the artificial site. These figures indicate that the artificial reef use is dominated by local sport anglers, as intended.<sup>4</sup>

## Exercise

This case study suggests that there are significant potential economic benefits beyond positive economic impacts from the construction of artificial reefs. Fishery managers of the Lake Erie region have expressed satisfaction with the artificial program thus far. It has been highly visible and generated much enthusiasm within the local sport-fishing community. Many believe that the reef has also helped improve the integrity of Lake Erie's central basin. Given the information pro-

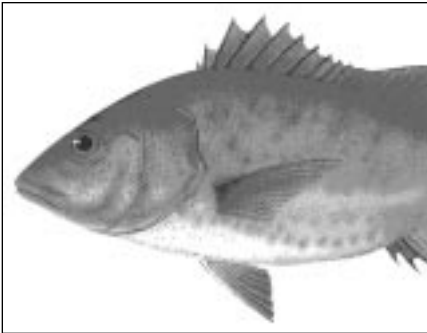
<sup>3</sup> The Cleveland site is currently being investigated utilizing the video technique.

<sup>4</sup> Glenn, S.J., D.O.Kelch, and L.J. Hushak. 1994. Economic Evaluation of the Lorain County Artificial Reef in 1992: An Overview. Ohio Sea Grant Program. Technical Summary OHSU-TS-022.

vided above, outline the economic analysis that you would recommend be included in an environmental impact statement of other similar reef programs. Use the following questions as a guide:

1. What type of economic analysis would be appropriate in determining whether to proceed with an artificial reef project?
2. Some believe environmental valuation, which would assess the benefits of artificial reef projects to society, should be standard protocol in all planned artificial reef projects within the Great Lakes. Do you agree?
3. Assuming adequate cost information exists, what sorts of value information would you need to assess in order to conduct a benefit-cost analysis of an artificial reef project?
4. What methodologies or techniques would you recommend for each of the value categories identified above?
5. Fish and fishers move. How would you account for this movement in your analysis of changes in commercial or recreational fishing values?
6. Which of the various economic approaches described in this handbook would be used by different stakeholders in the policy decision process?
  - Developers
  - Local agencies making decisions regarding public investments
  - Interest groups
  - Public at large
  - Federal regulators/decision makers
7. How would economic information be developed and presented by each group?

# RED SNAPPER FISHERY MANAGEMENT IN THE GULF OF MEXICO



## Situation

Declines in red snapper stocks in the Gulf of Mexico have impacted commercial and recreational fishers. Among the potential management plan options is the use of Individual Transferrable Quotas (ITQ). While ITQs have been employed within the commercial fishery sector, questions arise as to their applicability within the recreational sector.

## Background

In 1984 the Gulf of Mexico Fishery Management Council implemented the Reef Fish Fishery Management Plan — its goal was to manage the reef fish fishery with the Gulf for attaining the greatest overall benefit to the nation. In 1988, a National Marine Fishery Service (NMFS) stock assessment indicated that red snapper was significantly overfished and that reductions in fishing mortality rates of as much as 60 to 70 percent were necessary to rebuild red snapper stocks to a recommended 20 percent spawning stock potential ratio. The 1988 assessment also identified shrimp trawl bycatch as a significant source of juvenile red snapper mortality.

In response, the Fishery Management Council amended the 1984 Fishery Management Plan. The 1990 Amendment 1 provided for a commercial quota of 3.1 million pounds of red snapper. In 1991, the Total Allowable Catch (TAC) was set at 4.0 million pounds with a commercial quota allocation of 2.04 million pounds and a recreational daily bag limit of seven fish (1.96 million pounds). The 1991 Regulatory Amendment also contained an intent by the Council to establish a 50 percent reduction of the offshore shrimp trawler fleet snapper bycatch in 1994.

Despite the intent of the 1991 Regulatory Amendments, the effort capacity for the commercial red-snapper fishery continues to be excessively high, given current quota levels, as evidenced by the 2.04 million pound quota (1992) being filled in just 53 days. Under Amendment 6 of the Reef Fish Fishery Management Plan, a quota increase to 3.06 million pounds provided some benefits but did not prevent a derby fishery from developing. Under the same quota, the 1994 season lasted for 77 days.

In reaction to the current conditions in the red snapper fishery the Gulf of Mexico Fishery Management Council is now considering a proposed Amendment to the existing Reef Fish Fishery Management Plan<sup>1</sup>. Alternatives in this amendment include a proposal to establish a comprehensive effort management program for the red snapper fishery. The alternatives under consideration include:

1. No action (a system with additional effort controls beyond those currently allowed in the Fishery Management Plan's framework procedure for setting total allowable catch)
2. License limitation
3. Individual Transferable Quotas

## Individual Transferable Quota Management System

The Council has identified an Individual Transferable Quotas scheme as the preferred alternative. An ITQ program would involve issuing either a certain poundage or percentage of the total annual commercial allocation of red snapper to each qualifying owner or operator, based on his or her historical landings in the fishery. This poundage or percentage would be that person's initial share. Shares would be the property of the shareholder, probably subject to annual administrative fees for issuing coupons and for transfers of shares. Shares or quota coupons would be transferable. Under an ITQ system, a "bycatch" allowance for red snapper would not be needed—anyone who wanted to sell *any* red snapper would be required to have quota coupons in the amount of red snapper landed for sale.

The expectations are that an ITQ program will result in increased revenues to the fishing industry as well as decreased total costs of harvesting. In addition, ITQs will afford fishermen greater flexibility by adjusting their share holdings and determining when they will go fishing. Fishermen who choose to exit the fishery may receive economic benefit if they sell their share of harvest privilege.

Under limited access alternatives, fishers would receive specific privileges to participate in the red snapper fishery based on an initial allocation scheme. Fishers who desire to subsequently enter or increase their participation in the fishery could do so only in conjunction with another fisher who decreases his or her participation or leaves the fishery. Thus, allocation of the commercial quota among users would be self-adjusting and ideally would be independent of measures to achieve or maintain the biological goals of the Fishery Management Plan. Unlike limited access, open access systems have no limits on the number of fishers in the fishery or the amount of fish

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<sup>1</sup> GMFMC. 1994. Draft Amendment 8 and Environmental Assessment (Effort Management Amendment) to the Reef Fishery Management Plan of the Reef Fish Resources of the Gulf of Mexico

any fisher can harvest in a season. Allocation among commercial fishers and total annual harvest are treated as a single combined issue and are controlled by limits on short-term effort or vessel trip limits to spread out the harvest.

## Costs of an ITQ System

Costs under ITQ management will be higher than under the other proposed alternative systems largely due to the need for increased enforcement and the extensive records and tracking system for coupons (or similar accounting devices) and ITQ shares. If law enforcement can be increased only to the level necessary to enforce current regulations or license limitation systems, then the additional cost is estimated at \$450,000 (Case Table 6.1). However, for “full” compliance, defined to be a compliance level of about 90 to 95 percent, the cost will be \$1,540,000. Therefore, depending on the level of compliance desired or necessary to realize a substantial portion of the benefits which are possible under an ITQ program, the enforcement costs will be covered by the range just described.

The public burden costs will be \$67,000 initially and \$64,000 annually thereafter. The National Marine Fisheries Service’s (NMFS) costs to design and maintain the ITQ system are estimated to be \$230,000 for the first year and then \$145,000 annually. The estimate of total costs for the ITQ program, which includes the Council and NMFS administrative costs will range from \$1.17 to \$2.26 (Case Table 6.2) million the first year and from \$659,000 to \$1.75 million annually, depending on the level of law enforcement. Case Tables 6.1 and 6.2 summarize the differences in cost between maintaining the status quo or imposing license limitations on the fishery.

## Benefits

Changes in revenue to the commercial red snapper fishery are predicted based on historical prices and expectations of how different management systems will affect overall prices. In brief, the status quo is expected to result in an overall price decline of \$.15 to \$.40 per pound. The license limitation program is not expected to have much effect on current prices. The ITQ system can be expected to generate a price increase ranging from \$.85 to \$1.35 per pound based on the level of law enforcement. No information is available on the changes in benefits to recreational fishermen.

## Exercise

The Gulf reef fishery is a multispecies fishery with two major user groups, namely, the recreational and commercial sectors. In 1991, the recreational sector caught about 52 million pounds of fish in the Gulf, of which no less than 13 million pounds may be considered reef fish species under the management unit of the fishery plan. For this same year, about 1.6 million individuals (coastal and non-coastal) participated in marine recreational fishing in the Gulf region, and about

Case Table 6.1. Costs associated with different management regimes for red snapper.

	Status Quo	License Limitation	ITQ
Council/NMFS administrative costs	\$339,884	\$339,884	\$339,884
Initial public burden cost to apply for permits	2,000	3,000	3,000
Annual public burden costs to maintain management system	28,000	32,000	64,000
Initial NMFS costs to design and implement management system	0	20,000	85,000
Annual NMFS costs to maintain management system	30,000	42,000	145,000
NMFS law enforcement costs to achieve acceptable compliance <sup>1</sup>	450,000	450,000	450,000 to 1,540,000
Coast guard enforcement	N.A. <sup>2</sup>	N.A.	N.A.
Start-up plus first year	849,884	906,884	1,171,884 to 2,261,884
Continuing annual cost	508,000	524,000	659,000 to 1,749,000

<sup>1</sup> Current level of expenditure is estimated at \$400,000. Additional \$450,000 is required for any of the major alternatives.

<sup>2</sup> To be estimated.

SOURCE: Gulf of Mexico Fishery Management Council, Draft Amendment 8 and Environmental Assessment to the Reef Fish Fishery Management Plan for the Reef Fish Resources of the Gulf of Mexico, 1994.

15.5 million fishing trips were made by the recreational fishers. There are no current estimates on the economic value of the recreational reef fishery in the Gulf.

In 1991, the commercial sector landed approximately 21.1 million pounds of reef fish with an ex-vessel value of \$34.6 million<sup>2</sup>. In 1992, the commercial reef fish sector was composed of about 2,214 reef fish permitted vessels. Because of the moratorium on issuance of additional commercial permits implemented in May 1992, the number of permitted vessels could not significantly be more than the 1992 number. This moratorium is intended to remain in effect through 1995 unless earlier supplanted with a comprehensive limited access management system or extended by the Secretary of Commerce upon recommendation of the Gulf Council.

A major question facing the Gulf of Mexico Fishery Management Council is this: If an ITQ program for red snapper is developed, how will the initial quota be allocated between commercial and recreational fishers? All of the existing ITQ systems are designed to manage fisheries that are dominated by commercial fishing. There is no reason, however, why ITQs could not be used in recreational or combined commercial/recreational (or mixed) fisheries such as the red snapper fishery. As in commercial fisheries, problems of unlimited entry and inefficient allocation to low valued users can be overcome through the transfer of catch rights in the recreational fishery.

Theoretically, recreational fishers who have a high value for the resource could buy catch rights from other recreational fishers or from commercial fishers. Similarly commercial fishers could increase their individual share of total allowable catch by buying catch rights from recreational fishers. These sales of catch rights could be for part or all of a year or for the duration of the ITQ system. Although each group has a different motive for participating in the fishery, transfers of shares between different user groups would direct the share of rights to the most valued use. As a result, all harvest shares could be owned by either commercial or recreational fishers if they are willing to buy the harvest rights. If fishery managers decide that they want to preserve some portion of the total catch for a particular group of users then some of the catch shares can be exempt from trading.

The Council has three options. It can create ITQs for: (1) the commercial fishery only with recreational harvest regulated through bag limits and season closures; (2) a single class of ITQ shares for both commercial and recreational sectors with no restrictions on transfers between commercial and recreational fishers; or (3) two separate classes of ITQ shares — one for the commercial sector and one for the recreational sector. Separate subgroups within a recreational share class for certain groups of recreational fishers such as headboats, party boats, or other identified recreational groups could be established.

The rationale for these subgroups would be to protect certain recreational groups such as headboats or to protect stocks in specific areas. Alternatively, the initial allocation of ITQ shares could be used to address specific distributional concerns about recreational share ownership and allow full transferability to determine the most desirable pattern of share ownership.

Suppose that you are on the Gulf of Mexico Fishery Management Council. You are tasked with establishing a preferred option regarding initial allocation of ITQ shares within the current red snapper fishery. Consider the role of environmental valuation in your analysis of options. Us-

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<sup>2</sup>Waters, J. 1992. Economic Assessment of the Commercial Reef Fishery in the U.S. Gulf of Mexico. NMFS Beaufort Laboratory, Southeast Fisheries Science Center, Beaufort, NC.



Case Table 6.2. Costs and benefits from alternative forms of management for red snapper.

Cost or Benefit	Status Quo	License Limitation	ITQ
Change in expected annual revenue based on quota of three million pounds	Decrease of \$450,000 to \$1,200,000	Not much change	Increase of \$2,550,000 to \$4,050,000
Change in cost of harvesting	Significantly higher	Not much change	Significantly lower
Effect on stock recovery affecting long-term revenues:	Low enforcement effort	Negative	None None
	High enforcement effort	Negative	None Positive
Public and private costs to implement	\$849,884	\$906,884	\$1,171,884 to \$2,261,884
Continuing public private annual costs	\$508,000	\$524,000	\$659,000 to \$1,749,000
Relative overall change in net benefits	Significantly negative	Not much change	Significantly higher but similar for each level of law enforcement.

SOURCE: Gulf of Mexico Fishery Management Council, Draft Amendment 8 and Environmental Assessment to the Reef Fish Resources of the Gulf of Mexico, 1994.

ing the following questions as a guide, outline the study you would request of the Council staff economist or outside contractor.

1. What information would be needed regarding the economic benefits of each allocation strategy in order to make a well-informed decision?
2. What natural resources services should be analyzed?
3. What techniques would you recommend in order to determine the values of these resources and services?
4. What are the limitations to the existing methodologies in this case?
5. What discount rate would you recommend in a benefit-cost analysis of each allocation alternative?
6. Based on your hypothetical stakeholder perspective, the information given, and your hypothetical “back-of-the-envelope” benefit-cost calculations, what option would you recommend as the preferred allocation option?

## WETLAND RESTORATION IN LOUISIANA



### Situation

**Coastal wetlands in Louisiana play an essential role in the vitality of commercial and sport fishing and recreational hunting. But these wetlands are being devastated by a host of continuing human activities that range from population growth to artificial levees for flood control to the mining of offshore oil fields. Wetland restoration is critical and poses difficult choices that must take into account short and long-term costs.**

### Background

The Louisiana coastal zone is one of the Nation's foremost geological, biological, and cultural resources. Containing 40 percent of the country's coastal wetlands, it includes 2.5 million acres of marshes (fresh, brackish, and saline) and 637,400 acres of forested wetlands. The Louisiana coastal zone, created by the Mississippi River, is the most active deltaic land mass in North America, draining 40 percent of the 48 contiguous states and substantial areas in the Canadian provinces.<sup>1</sup>

Between 50 to 75 percent of Louisiana's residents live within 50 miles of the coast. These inhabitants benefit from the numerous resources and resource services that wetlands provide. They are the source of livelihood to a substantial number of people including fishers and foresters. Even those who do not depend economically on marshes benefit from the hurricane and flood protection they provide through absorption of storm surges and mitigation of flood damage. The coastal zone also serves valuable water quality treatment functions.

<sup>1</sup> Coastal wetland formation: The land forms within the coastal zones (with the exception of salt domes) were formed as a result of the dynamic interactions between river deposition, waves and currents, and subsidence. Over the past several thousand years, the Mississippi River has periodically changed course. This "delta switching" causes some areas of land to build while others deteriorate. When the river shifts into a new channel, land is built rapidly. The river builds a delta out into shallow shelf areas until its course becomes long, sinuous and inefficient, at which time it changes course to follow a shorter, more efficient route to the Gulf. It is this change which switches the location of the delta. The periodic switching has resulted in a series of delta lobes in various stages of abandonment and deterioration. These lobes, deprived of riverine sediment, slowly break up and erode. However, because a new delta was always building, a natural balance between sinking and accretion existed. At any one location there could be land gain or land loss. In fact, for the past 5,000 years, there has been a net coastal land gain in the Mississippi deltaic plain of between one and two square miles a year. However, the natural cycle of deltaic development — the continuous building and eroding of river basins — is no longer operative today due to human intervention (Coastal Resources Program-Louisiana Department of Transportation and Development. 1978. The Value of Wetlands in the Barataria Basin).

While the natural beauty and abundant wildlife of the wetlands attract tourists from all over the country, the region possesses a unique cultural diversity that includes Native Americans, European immigrants, and Cajun ancestry.

Commercial importance of the Louisiana coastal wetlands includes major economic activities related to commercial fishing, recreational hunting, and sport fishing. Fishing is Louisiana's oldest industry and its prominence is directly attributable to the area's extensive marsh and estuarine system.<sup>2</sup> The region supports the largest coastal finfish and shellfish fisheries in the country, producing two billion pounds of fish and shellfish annually. The Louisiana Wildlife and Fisheries Commission issued over 63,000 commercial fishing licenses in 1985, including almost 16,000 commercial shrimp licenses. The recreational hunting and fishing activity of the region are also substantial. The Louisiana coastal zone leads the Nation in trapping of fur-bearing animals and operates a highly regulated harvest of alligator skins.<sup>3</sup>

## Coastal Wetland Decline — Causes and Conflict

For decades artificial levees, managed by the U.S. Army Corps of Engineers with Congressional, State, and public support, have confined the Mississippi River to its present channel, preventing a change of course and the associated development of new delta regions. The purpose of the levees is to contain overflows for navigation and flood control. However, the ecological balance and productive capacity of the adjacent wetlands are adversely affected by the lack of additional fresh water and nutrient-rich material. The river control structures confine the sediments to the river channel and transport it to deep Gulf of Mexico waters so that most of these sediments are discharged over the edge of the continental shelf, forever lost to the sediment-starved coastal zone. In addition, the Mississippi's tributary dams and other activities have significantly reduced the sediment load carried by the river.

In addition to flood control activities, another major cause of coastal erosion is construction of navigation, oil recovery, and access canals. Canals adversely impact the wetlands by interfering with sheetwater flow, allowing destruction by wave action, reducing nutrient exchange, decreasing interface, and increasing salinities. Spoil banks, created by the deposition of material dredged from the canals also result in wetland deterioration. Approximately 8 percent of the marshes in coastal Louisiana have been converted to canals and associated spoil banks.<sup>4</sup> Other activities, such as land reclamation projects for agricultural, urban, and industrial purposes, have also destroyed many acres of viable wetland. The pollution from toxic chemicals and oilfield brines contributes to wetland degradation as well.

Wetland loss due to flooding as a result of subsidence-related sea level rise is another problem. Sea level rise occurs as land forms shrink, resulting in a relative rise in water level. Scientific evidence exists which suggests that sea level rise may accelerate significantly due to atmos-

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<sup>2</sup> *Ibid.*, p. 36.

<sup>3</sup> U.S. Department of the Interior. 1994. *The Impact of Federal Programs on Wetlands, Vol. II. A Report to Congress by the Secretary of the Interior.* Washington, D.C., p. 143.

<sup>4</sup> Coalition to Restore Coastal Louisiana. 1987. *Coastal Louisiana: Here Today and Gone Tomorrow? A Citizens' Program for Saving the Mississippi River Delta Region to Protect Its Heritage, Economy, and Environment.* Draft for public review, p. 10.

pheric warming resulting from the greenhouse effect.<sup>5</sup> These rises would lead to increased flooding and additional loss of coastal wetlands.<sup>6</sup>

The cumulative impact of human activities and natural processes on the coastal zone has been devastating. At the turn of the century, coastal Louisiana contained 4.07 million acres of wetlands. By 1978, 22 percent of the wetlands had been lost. Conservative estimates indicate that another 3 million acres have been lost since then. Current loss rates are estimated to be about 0.75 percent per year. It is projected that if losses are not reduced, another 167 million acres of Louisiana coastal wetlands will disappear or be converted by the year 2000. These predictions indicate that the Gulf shoreline will advance inland as much as 33 miles in some areas. About 1,200 businesses, residences, camps, schools, storage tanks, electric power substations, water control structures, and pumping stations would require protection or relocation. Furthermore, the U.S. Army Corps of Engineers estimates that without action to reverse projected wetland losses commercial fish and shellfish harvests will decline by 30 percent by the year 2040.<sup>7</sup>

The threatened disappearance of Louisiana coastal wetlands have potentially staggering economic, cultural, and environmental consequences. The loss of habitat for coastal fish, shellfish, and wildlife species would be colossal. The loss for social and cultural functions which depend on proper ecological functioning of the coastal zone would also be devastating. Furthermore, the present Louisiana coast would become uninhabitable as flooding moves further inland.

## Coastal Wetland Restoration Management Plan

The prospective losses of wetland functions and services have motivated implementation of a wetland restoration policy. That policy is based on the belief that technological ingenuity and management can separate wetland destruction from some of the causes of that destruction, navigation, flood control, oil and gas production, and urban development. The short-term costs of employing advanced techniques and restoration strategies will undeniably be substantial; the long-term costs, however, of not employing environmental engineering technologies and not implementing management and restoration strategies may be far greater. A restoration program might concentrate on three tasks:

1. Enhancement of sediment and fresh water input into the coastal zone and capture of resuspended sediments
2. Repair or restoration of disturbed wetlands and barrier island transacted by exiting canals
3. Phase-out and halt to construction or expansion of canals.

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<sup>5</sup> Some scientists predict that sea level rise by 2075 may range from 38 to over 200 centimeters depending on the global level of combustion of fossil fuels and emissions of other greenhouse gases.

<sup>6</sup> Coalition to Restore Coastal Louisiana, *op. cit.*, p. 10.

<sup>7</sup> U.S. Department of the Interior, *op. cit.*, p. 154.

# Benefits and Costs of Wetland Restoration Strategies

A wetland restoration policy for the Louisiana wetlands coastal zone must manage all of its uses, both short term and long term. One key factor in developing a plan — recognition of the conflicts over multiple uses and societal tradeoffs — is determining the economic value of the wetlands. Economic values provide a basis for realistic appraisal of the wide-ranging social impacts generated by various proposed restoration developments. Thus, the overall benefits and costs of maintaining and restoring Louisiana's coastal wetland resources must be assessed.

A benefit-cost analysis can be conducted by assigning a dollar value to a unit-acre of wetland. However, the economic value of the services provided by wetlands is difficult to appraise due to the lack of a market mechanism for directly pricing those functions. For example, the benefits derived from the wetland's provision of food for commercial fish species and fur-bearing animals have often been ignored. Other values typically disregarded because of the difficulty in assigning economic value are recreational opportunities provided by the wetlands, such as hunting, crabbing, bird watching, swimming, and camping.<sup>8</sup>

Furthermore, the economic value of the protective services provided by wetlands, for instance, storm and flooding protection and the absorption of urban and agricultural waste products, are also difficult to assess, as are the option value and existence value. The option value is the amount which non-users place on a unique resource to know that it is there and could be used, while the existence value is the amount which non-users place on the knowledge that the wetlands exist, even if they never intend to use them directly.

Despite the data and methodological limitations, analysts have developed several different methods by which to value wetlands, including (1) economic impact analysis (EIA); (2) willingness-to-pay (WTP); and (3) energy analysis (EA). These methodologies attempt to place economic value on wetland-related activities and services. In general, some of the major services provided by wetlands can be classified into the following categories: commercial fishing, recreational fishing, commercial trapping, and recreation (subdivided into economic impact expenditures for recreation and the estimated value of user benefits related to recreational activity), and storm protection.

**GROSS ECONOMIC CONTRIBUTION ANALYSIS.** The gross economic contribution analysis for wetland valuation focuses on the question of gross impact on the economy. In other words, values for major activities associated with wetlands are estimated on the basis of gross benefits to the economy. A per-acre value for each of the wetlands-dependent activities is determined, and the respective values are summed to derive the total estimated monetary worth of a wetland acre in its natural state. Case Table 7.1 presents the estimated gross economic contribution of a wetland acre in Louisiana's Terrebonne Parish.<sup>9</sup>

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<sup>8</sup> Coastal Resources Program-Louisiana Department of Transportation and Development, *op. cit.*, p. 85.

<sup>9</sup> For consistency within the case study, the name of this coastal area has been changed. See the source, Coastal Resources Program-Louisiana Department of Transportation and Development, *op. cit.*, for additional information.

**Case Table 7.1. Estimated Gross Economic Contribution of a Wetland Acre in the Terrebonne Wetlands.**

Activity Director	Annual Return Per Acre	Present Value Per Acre
<b>Fishing and Hunting</b>		
Commercial fishing	\$286.36	\$5,540.42
Non-commercial fishing	3.19	46.40
Commercial trapping (Pelts and meats)	11.69	170.05
<b>Recreation</b>		
Economic impact of recreation expenditures	60.08	873.89
Economic value of user benefits from recreation	104.33	2,428.17
<b>Total</b>	<b>\$465.65</b>	<b>\$9,058.93</b>

**WILLINGNESS-TO-PAY (WTP).** The willingness-to-pay approach to wetlands valuation is based on the concept of consumer surplus — this is a measure of the amount a consumer would be willing to pay to continue receiving the good or service, over and above what the consumer is already paying. Thus, in the case of the Louisiana wetlands, WTP estimates the value of the wetlands based on an evaluation of society’s willingness-to-pay to avoid the loss of an acre of wetlands or wetland area. Theoretically, this estimate represents the maximum society would pay rather than do without. WTP assumes that the resources employed to produce the good are not part of the value of the resource but are transferable to other uses. The difficulty with the technique is in obtaining true estimates from all the potential beneficiaries for all the direct and indirect goods and services provided by the wetlands. Costanza and Farber used WTP to assess the value of the Terrebonne Parish wetlands in Louisiana.<sup>10</sup> Case Table 7.2 summarizes their estimates of the WTP valuation wetland service categories. Column 2 shows the annual values on a per-acre basis. The authors note that it may not be appropriate to place the storm protection values on a per-acre basis.

<sup>10</sup> Costanza, R. and S. Farber. 1985. The Economic Value of Wetlands in Terrebonne Parish, Louisiana. Final Report to the Terrebonne Parish Policy Jury.

Case Table 7.2. Summary of WTP valuation of Terrebonne Wetlands, using 1983 dollars\*.

Valuation Category	Annual per Acre Value of Wetlands	Per Acre Present Value at Various Discount Rates	
		8%	3%
(1)	(2)	(3)	(4)
Commercial Fishery	\$25.37	\$317.00	\$846.00
Trapping	12.04	151.00	401.00
Recreation	3.07	46.00	181.00
Storm Protection	128.30	1,915.00	7,549.00
Total	\$168.30	\$2,429.00	\$8,977.00
Option and Existence	NA	NA	NA

\*The present values for recreation and storm protection assume population growth rates of 1.3%

Source: R. Costanza and S. Farber. 1995. *The Economic Value of Wetlands in Terrebonne Parish Louisiana*. A Final Report to the Terrebonne Policy Jury.

**ENERGY ANALYSIS (EA).** In contrast to WTP, energy analysis looks at the supply side of wetland values, as opposed to the demand side. The method uses the total amount of energy captured by natural ecosystems in primary production as an estimate of their potential to produce economically useful products such as fish and wildlife. The energy captured in photosynthesis is the basis for the food chain that ultimately supports all the production in wetlands, or in any natural system. Therefore, a suitable analysis of the inputs to these systems might provide a convenient index of their ultimate value to society. However, there is no guarantee that all of the products of wetlands are useful to society, and some values to society (e.g., aesthetics and recreational value) are omitted in EA estimates. Case Table 7.3 presents a summary of EA based value estimates for Louisiana wetlands as assessed by Costanza and Farber. These values range from \$6,400 to \$10,602/acre using an 8 percent discount rate to \$17,000 to \$28,600/acre using a 3 percent discount rate. Their “best estimate” for the value of an acre of wetlands is a range: \$2,429 to \$6,400 per acre using an 8 percent discount rate, and \$8,977 to \$17,000 per acre using a 3 percent discount rate.

## Exercise

The activities that have had the most damaging effects on the coastal region are primarily related to the major economic uses of the Mississippi River and coastal zone for navigation, flood



**Case Table 7.3. Gross primary production and energy analysis-based economic value estimates for relevant Louisiana wetland and marine habitats.**

Habitat type	Total Energy Captured Measured by GPP <sup>a</sup> kcal/m <sup>2</sup> /yr	Annual Equivalent Dollar Value <sup>b</sup> (\$/ac/yr)	Net Marsh-Aquatic Change in Annual Value (\$/ac/yr)	Present Value (\$/ac) assuming rate <sup>i</sup> 8%	Present Value (\$/ac) assuming rate <sup>i</sup> 3%
Salt marsh	48,000	624			
Salt aquatic	6,600	86	538	6,700	18,000
Brackish marsh	70,300	914			
Brackish aquatic	5,130	67	847	10,602	28,200
Fresh marsh	48,500	630			
Fresh aquatic	9,300	121	509	6,400	17,000
Coastal plankton	3,600	47 (Average)	631	7,900	21,000
Spoil banks <sup>c</sup>	13,000	169			

<sup>a</sup> GPP is gross primary production. Values are from Hopkins 1979.

<sup>b</sup> Based on conversion factors of 0.05 coal equivalent (CE) kcal/GPP kcal 15,000 CE kcal/1983 dollar and 4,047 a<sup>2</sup>/ac. The overall conversion factor from GPP (in kcal/m<sup>2</sup>, to estimated economic value (in \$/ac/yr) is therefore: (05 x 4047) 15000x.013. See the ONR report for details.

<sup>c</sup> Estimated from values for upland systems.

<sup>i</sup> Rounded to nearest \$100.

Source: R. Costanza and S. Farber. 1995. *The Economic Value of Wetlands in Terrebonne Parish Louisiana*. Final Report to the Terrebonne Parish Policy Jury.

control, oil and gas production, and urban development. For years the manner in which these enterprises were carried out have resulted in wetland sediment starvation and delta destruction. In essence, the Louisiana coastal zone is engaged in an economic-ecologic conflict. The region's abundant variety of resources have allowed a wide diversity of economic activity. The utilization of these resources has led to both economic development as well as ecological degradation. Coastal wetland degradation will continue unless a coastal wetlands policy which restores deltaic functions is adopted.

Suppose that you have been asked to be a member of a task force to develop a wetland restoration policy for Terrebonne Parish. Given the information provided in this case study, consider the following questions:

1. What are some of the advantages and limitations of the "valuation" approaches outlined above?
2. What role can environmental valuation play in regional wetland restoration policy?

3. How would environmental valuation at the regional level differ from the use of economics at the site level?
4. The capitalized value of an annual stream of wetland benefits is highly dependent on the discount rate, which reflects the value which people today put on retention or production of a resource for future use, and the predicted value of coastal wetlands for fish and wildlife, recreation, water quality management, storm buffer protection and other functions in future years. One can expect that the value of the coastal Louisiana wetlands would increase if their resources were to become scarce through lack of proper management. What discount would you suggest be used in this analysis?
5. It has been suggested that, to date, existing legal mechanisms for regulating activities in the Louisiana coastal zone have not been sufficiently restrictive of access and navigation construction projects. A wetland restoration policy must develop more stringent regulatory programs in this regard by imposing mitigation requirements which will fully compensate for direct and indirect land loss where dredging of canals is permitted. Construction of access and navigation canals should be drastically restricted by mandating use of alternative means of access for oil and gas equipment. With regard to urban development, it has been suggested federal subsidies should be suspended (e.g., funds for low-income housing, mortgage insurance, and National Flood Insurance for urban development projects) in environmentally significant wetlands. These expenditures currently offer significant incentives for development that impacts important wetlands. They also set the stage for future federal outlays for damages caused by storms to developments located in naturally flood-prone areas. Strictly on economic grounds, would it make sense (in terms of sound public policy) to withhold incentives for developing areas subject to high flooding risks?
6. Which of the various economic approaches would be used by different stakeholders in the policy decision process? How would economic information be developed and presented by each group?
  - Developers
  - Local agencies making decisions regarding public investments
  - Interest groups
  - Public at large
  - Federal regulators/decision makers
7. How can the various economic approaches aid in developing consensus among stakeholders?

## CASE STUDY 8

# NONPOINT SOURCE POLLUTION CONTROL IN CALIFORNIA



### Situation

Recreational facilities such as marinas and activities such as boating can be sources of dangerous contamination in nearshore waters. Toxic compounds from antifouling paints, batteries, detergents, and sewage are a threat to water quality, living resources, and human health. Management safeguards and other control measures to prevent pollutant runoff could, in the long run, cost less than environmental clean-up costs.

### Background

In the Coastal Zone Management Act (CZMA) of 1972, as amended, Congress declared it to be national policy that state coastal management programs must provide for public access to the coasts for recreational purposes. Clearly, boating and adjunct activities and facilities are an important means of public access. The availability of public access facilities and services such as marinas has helped boating to become a major industry in California. More than 650,000 pleasure boats are registered with the state and during 1986, recreational boaters engaged in an estimated 56 million boating-days.

Boater spending supports a wide range of businesses, among them, boat and equipment manufacturing, retailing, and various types of boating services. A 1986 inventory of 5,035 boating businesses throughout California revealed that these businesses had total gross receipts of \$2.6 billion, employed 40,000 people, and paid \$476 million in payroll. Businesses that support recreational boaters paid over \$191 million in state and local taxes during that year. The direct spending by boaters on goods and services stimulates the entire California economy. Including all the other businesses that support the boating industries in California, the

total economic activity traceable to boating in 1986 was more than \$6.7 billion.<sup>1</sup> Clearly, marinas and other public access facilities and services are integral to California's economy.

However, when these facilities are poorly planned or managed, they can pose a threat to the health of aquatic systems; they can also introduce other environmental hazards. Because marinas are located at the water's edge, there is often no buffering of the release of pollutants to waterways. Adverse environmental impacts may result from the following sources of pollution associated with marinas and recreational boating:

- Pollutants illegally discharged from boats and fueling stations
- Pollutants transported in stormwater runoff from marina parking lots, roofs, and other surrounding impervious surfaces
- Physical alteration or destruction of wetlands and of shellfish and other bottom communities during the construction of marinas, ramps, and related facilities
- Pollutants generated from boat maintenance activities on land and in the water<sup>2</sup>

Recreational boating and marinas are increasingly popular uses of the California coastal zone. In areas such as San Diego Bay, the growth of recreational boating, along with the growth of coastal development in general, has led to a growing awareness of the need to protect waterways. Normal marina operations such as waste disposal, boat fueling, and boat maintenance and cleaning generate contaminant runoff. Moreover, storage areas for the materials required for these activities are also a source of pollutants. Of special concern are substances such as paint sandings and chip-pings, waste oil and grease, batteries, fuel, detergents, and sewage that can be toxic to aquatic biota, or degrade water quality and pose a threat to human health.

Historically, point source wastes from shipyards, boatyards and other repair facilities, and marinas were dumped or washed directly into the San Diego Bay. Environmental legislation over the past 20 years has put an end to these practices. However, large sinks of sand blast material and other paint-containing waste are still present in the Bay's sediments. The effects of these sinks on water quality is not known.<sup>3</sup>

Non-point source pollution continues to be a paramount concern as current boat maintenance activities, such as the use of antifouling paints on boat hulls, generate contaminants that can harm the marine environment. These paints that contain chemical pesticides are applied to the hulls of boats to deter the attachment and growth of aquatic organisms — the buildup of such

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<sup>1</sup> D.M. Dornbusch and Company, Inc. 1988. Economic Impact of the Boating Industry in California. Prepared for the California Department of Boating and Waterways.

<sup>2</sup> U.S. Environmental Protection Agency. 1993. Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters. EPA Document 840-B-92-002, pp:5.2-5.3.

<sup>3</sup> Conway, J.B. and L.P. Locke. 1994. A Final Report on Marine Fouling and Underwater Hull Cleaning in San Diego Bay. Prepared for the California Regional Water Quality Control Board, San Diego Region.

organisms can promote hull corrosion and increase drag.

Biocides from antifouling paints generally enter the marine environment in different ways: (1) through the normal leaching process of paints as they age, and (2) through paint chips abraded from vessels' hulls in the water during underwater hull cleaning. The concern is that the copper-based biocide chemicals released from antifouling paint applied to boat hulls may be deleterious to the marinas' aquatic environment. Because of the poor tidal flushing characteristics of San Diego Bay, copper concentrations can become elevated to levels harmful to aquatic organisms.

Numerous studies have shown that the concentrations of antifouling biocides are highest near marinas and small yacht basins. A recent study assessing the average concentrations of total and dissolved copper in San Diego and Mission Bays found that while ambient copper concentrations appeared to be non-toxic, several marinas did have average dissolved copper concentrations that were above the U.S. EPA's Ambient Water Quality Criteria for saltwater aquatic life.<sup>4</sup>

Another study attempted to measure the deleterious effects (within the water column) of in-water maintenance of boats at recreational marinas. The study revealed that although copper releases can be significant in the immediate vicinity of a boat hull during cleaning, the water rapidly returns to pre-cleaning concentrations. However, the findings were inconclusive as to the extent and degree of dispersal of the contaminant plume and the total load to the Bay from a hull cleaning operation. Other studies have found evidence of elevated levels of copper in the tissues of organisms living in the San Diego Bay. These studies suggest that boat owners should be educated about biofouling processes and antifouling paints so that they can make sound, informed, and environmentally sensitive decisions.

## Nonpoint Source Control Solutions

It is important that marina operators such as those in San Diego Bay recognize that there are alternatives to obtaining permits to pollute. They can take steps to control or minimize the entry of polluting substances into marina waters. For the most part, this control can be accomplished with simple preventive measures such as locating service equipment where the risk of spillage is reduced, providing adequate and well-marked disposal facilities, and educating the boating public about the importance of pollution prevention. Benefits of effective pollution prevention to the marina operator may be realized in terms of lower direct pollution control costs. The costs of pollution prevention could well be lower than environmental clean-up costs.

Section 6217 of the Coastal Zone Act Reauthorization Amendments of 1990 (CZARA) requires coastal states (including Great Lakes states) with approved coastal zone management programs to address nonpoint pollution impacting or threatening coastal waters. States must submit Coastal Nonpoint Pollution Control Programs for approval to both the U.S. Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA). Requirements for state programs are described in *Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance* and are summarized in a separate fact sheet. Some of the

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<sup>4</sup> McPherson, T.N. and G.B. Peters. 1995. The Effects of Copper-Based Antifouling Paints on Water Quality in Recreational Boat Marinas in San Diego and Mission Bays. Prepared for the California Regional Water Quality Control Board, San Diego Region.

management measures outlined in the guidance include practices related to the best possible siting for marinas, best available design and construction, and appropriate operation and maintenance (e.g., solid waste management, liquid waste management, and petroleum control management). Other management efforts might include staff and boater education programs on all areas of non-point source control and best management practices; petroleum station management; improved sewage pumpout systems; and installation of fuel spill controls.

California is currently revising its Nonpoint Source (NPS) Pollution Management Plan pursuant to the 1990 CZARA. For each management measure, a Technical Advisory Committee accepted or modified EPA's management measure as it should be applied to California; for each management measure, the report also addresses applicability, methods of implementation, specific implementors, enforcement mechanisms, triggers of enforcement actions, and the actions that are necessary to begin implementation.

## Costs of Compliance

The California Regional Water Quality Control Board, San Diego Region, could choose to implement some of the operations and maintenance management measures outlined in the *1994 Marina and Recreational Boating Technical Committee Report* in an attempt to improve the quality of San Diego Bay. Implementation of these measures, unlike compliance with cleanup and abatement orders by boatyards, is not expected to impose significant costs on marina operators in the area. The cost of providing recreational boating services will likely increase with implementation of management measures affecting the San Diego Bay marinas.

Nonpoint source control requirements have the potential to delay new facility construction and/or business failures of existing marinas. Some of these costs are expected to be passed along to recreational boaters. In addition to costs passed on to boaters by marinas, boaters may incur costs associated with more expensive non-toxic paints (silicone) and hull cleaners who are licensed, insured, approved under best management practices; higher cost boat maintenance (experienced labor, more frequent cleanings, required draping); and higher cost oil-change services which recycle.

Case Table 8.1<sup>5</sup>, though not directly related to the implementation of boat-cleaning management practices, presents some high estimates of the potential costs to San Diego Bay marinas of selected operation and maintenance practices. While operations and maintenance management measures include waste disposal, education and boat-operation practices, this analysis is restricted to solid-waste disposal practices and liquid-waste disposal practices. The specific costs are associated with purchasing a commercial vacuum to collect debris at hull-maintenance sites, providing covered dumpsters for solid-waste collection, and purchasing liquid waste containers for storing and recycling oil, antifreeze, gasoline, diesel fuel, and kerosene.<sup>6</sup>

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<sup>5</sup> U.S. Environmental Protection Agency. 1992. Economic Analysis of Coastal Nonpoint Source Pollution Controls: Marinas. Original estimates have been adjusted for the purposes of this hypothetical case study.

<sup>6</sup> These cost estimates are based on large-scale repair facilities. Boat maintenance at San Diego area marinas is actually small-scale, general upkeep done on individual boats

**Case Table 8.1. Costs of Selected Operation and Maintenance Management Practices: High Estimates.**

Marina Number	Liquid Waste Management		Commercial Vacuum		Covered Dumpster	
	Capital (\$)	Operating (\$/yr)	Capital (\$)	Operating (\$/yr)	Capital (\$)	Operating (\$/yr)
1	90	112	1,063	19	0	1,620
2	360	174	1,063	93	0	1,620
3	4,080	407	1,063	372	0	7,056
4	4,170	485	1,063	465	0	7,056
5	15,980	1,652	4,252	1,860	0	21,168
6	15,980	1,652	4,252	1,860	0	21,168

**Key Assumptions:**

1. Assume one vacuum is needed for every 250 slips of capacity.
2. Assume one filter must be replaced annually for every 50 slips of capacity. Each filter costs \$93.
3. Assume model marina owners pay for dumpster rental and collection.

Sources: Dickerson, George. Sales Representative for Capital Vacuum, Raleigh, NC. May 13, 1992. Personal communication with Julie Duffin, Research Triangle Institute.

Musgrave, John. Sales Representative for Waste Industries, Inc., Durham NC. May 13, 1992. Personal communication with Julie Duffin, Research Triangle Institute.

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## Benefits of Marina Operations and Management Measures

Numerous benefits are associated with the implementation of nonpoint source marina operations and maintenance management measures. For example, increases in water quality will provide improvements in the integrity of the San Diego Bay environment leading to increased recreational boating and fishing values, aesthetics and nonuse values, and reduced costs for dredging when sediments are less contaminated. The steps in determining the benefits of such control measures include:

1. Determination of the benefit categories which match potential management measures

2. Estimation of the benefits of each management measure in terms of how each measure will affect natural resource parameters. For example, if non-toxic hull cleansing is required, an attempt must be made to determine the linkage between reduction of pollutants such as copper and the improvement of water quality.
3. Determination of how changes in ecological parameters affect human health, recreational enjoyment, and aesthetic appreciation through impacts on market and nonmarket services provided by the Bay. For example, how does an increase in water quality affect the quantity or quality of recreational boating and other uses of San Diego Bay surface water?
4. Translation of these public health, recreational, aesthetic and ecological effects into estimates of monetary values.

In addition, there may be benefits from some best management practices such as the use of underwater hull cleaning. These benefits include increased vessel maneuverability and fuel efficiency as well as the potential for increased paint life with a corresponding decrease in total antifouling chemical discharge.

## Exercise

Given the information provided above, develop an economic argument in favor of or against the implementation of boat-cleaning management measures in San Diego Bay marinas.

1. Do you see a role for environmental valuation in the development of your argument? Would it be most appropriately used in a case-by-case (marina-by-marina) implementation decision basis or as an overall policy decision?
2. What natural resources and resource services do you think should be analyzed?
3. What techniques would you recommend in order to determine the values of these resources and services?
4. What are the limitations to the existing methodologies in this case?
5. Boat-cleaning management measures are only one set of management measures and practices recommended in the EPA nonpoint source pollution control guidance. Using the economic techniques described in the seminar, how would you decide whether focusing on operations and maintenance management actions is appropriate?
6. Would other economic approaches outlined in the seminar be of use to others in the decision process?



- Developers
- Local agencies making decisions regarding supporting public investment decisions
- Interest groups
- Public at large
- Federal regulators/decision-makers

How would this information be developed and presented by each group?

How can these tools aid in the developing consensus among the various stakeholders?

7. There are numerous benefits that can be attached to the implementation of nonpoint-source management measures for marina operations and maintenance. These benefits may not be directly incurred by individual marina operators (though some cost savings may be expected), but are more likely to be felt by the public at large. Should those benefits be weighted similarly in your decision process or should one group or another be weighted more heavily? Should the marina operators be compensated for the capital costs that they will incur to implement the management measures?
8. To describe and measure the benefits of these measures, it is necessary to identify linkages between the measures, the resources of the Bay, and the activities and user groups that derive economic value from the Bay. These relationships are complex and a single measure may affect several different resource services at once. Conceptually, what would those linkages look like? What kind of data would you need to collect to analyze those linkages?

# GLOSSARY

**benefit-cost analysis** — a technique to compare the relative economic efficiency of different states of the world usually brought about by undertaking projects or policies. A comparison is made between gross benefits of a project or policy and the opportunity costs of the action. Benefits and costs are measured as changes in consumer and producer surpluses accruing to individuals in society.

**consumer surplus** — a money measure of an individual or group's welfare from consumption of a good or service or the existence of a particular state of the world. This surplus is the difference between the maximum the individual is willing to pay for consumption of the good and the amount that has to be paid.

**contingent valuation** — a methodology to determine money measures of change in welfare by describing a hypothetical situation to respondents and eliciting how much they would be willing to pay either to obtain or to avoid a situation.

**demand** — in economics, the usual inverse relationship between quantity consumed (or otherwise used or even preserved) and a person's maximum willingness-to-pay for incremental increases in quantity. Market prices often (but not always) reveal the increments of willingness-to-pay. Other factors influencing willingness-to-pay include income, prices of substitutes, and, in recreational fishing, catch rate. Unlike planning where demand refers to the size of the quantity variable, economic demand is a behavioral relationship.

**discounting** — is a procedure to use when comparing value streams (benefits or costs) occurring in different magnitudes at different dates in the future. The procedure "discounts" future values in order to obtain the present value of the stream.

**environmental valuation** — procedures for valuing changes in environmental goods and services, whether or not they are traded in markets, by measuring the changes in the producer and consumer surpluses associated with these environmental goods.

**existence value** — see nonuse value

**gross domestic product (GDP)** — aggregate annual output of the economy before deducting the value of the assets of the economy that have been used up or depreciated in the production process during the year. Gross domestic product provides a summary measure of the Nation's overall economic performance.

**hedonic method** — a methodology for estimating the relationship between the price of a good (e.g. housing) and the characteristics of the good (e.g. number of bedrooms, air quality, proximity to amenities, etc.). Can sometimes be used to value changes in environmental characteristics.

**input-output model** — a methodology that models the linkages between input supplies, outputs, and households in a regional economy that can be used to predict the impact of changes on economic activity (e.g., industry revenues and household incomes) within the region.

**market benefits** — benefits from goods or services bought and sold in normal commerce so that there is a revealed price that reflects consumers willingness-to-pay for the quantity offered and suppliers marginal production costs.

**non-market benefits** — benefits that accrue to individuals for goods, services, experiences or states of nature that are not normally traded in commerce.

**nonuse value** (see also **use value**) — value of knowing that something exists in a particular state even though there is no sensory contact with the resource.

**opportunity cost** — the highest value a productive resource such as labor, capital, land or a natural resource could return if placed in its best alternative use.

**producer surplus** — total revenue minus the opportunity cost of production, including the opportunity costs of the entrepreneurs skills, labor, capital, and ownership of natural resources.

**random utility model (RUM)** — an extension of the travel cost method which explicitly considers individuals participation decisions and the selection among alternative recreation sites.

**supply** — schedule of the quantities of goods and services that a business is willing to sell at various prices. Other factors that affect supply include input prices.

**travel cost method** — a methodology which relies on travel-related costs as a surrogate for price in a non-market situation in order to estimate demand and money measures of willingness-to-pay.

**use value** — value derived from either the consumption of a good, the utilization of a service, or that otherwise involves some sensory contact with the resource. For example, whale-watching is not consumptive but involves visual contact with the whales.

**value** — what one is willing to give up in order to obtain a good, service, experience, or state of nature. Economists try to measure this in dollars.

**welfare economics** — a field of inquiry within the broad scope of economics that is concerned with money measures of individual and social well-being, particularly in changes in well-being due to implementation of public policies.

# LIST OF ACRONYMS

**CERCLA** — Comprehensive Environmental Response, Compensation and Liability Act

**COP** — NOAA Coastal Ocean Program

**CVM** — contingent valuation method or methodology

**EPA** — Environmental Protection Agency

**GDP** — gross domestic product

**ITQ** — individual transferable quotas

**NEPA** — National Environmental Policy Act

**NMFS** — NOAA National Marine Fisheries Service

**NOAA** — National Oceanic and Atmospheric Administration

**OPA** — Oil Pollution Act

**WTP** — willingness-to-pay

## FOR FURTHER READING

(Note: Some of these texts or articles may be technical, but often the introductory material on the various topics in environmental valuation is useful.)

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