NOAA Technical Report NMFS 94 November 1990

An Economics Guide to Allocation of Fish Stocks between Commercial and Recreational Fisheries

Steven F. Edwards

U.S. Department of Commerce

NOAA Technical Report NMFS

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November 1990

U.S. DEPARTMENT OF COMMERCE
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ABSTRACT

The increasingly intense competition between commercial and recreational fishermen for access to fish stocks has focused attention on the economic implications of fishery allocations. Indeed, one can scarcely find a management plan or amendment that does not at least refer to the relative food and sport values of fish and to how expenditures by commercial and recreational fishermen on equipment and supplies stimulate the economy. However, many of the arguments raised by constituents to influence such allocations, while having an seemingly ''economics'' ring to them, are usually incomplete, distorted, and even incorrect. This report offers fishery managers and other interested parties a guide to correct notions of economic value and to the appropriate ways to characterize, estimate, and compare value. In particular, introductory material from benefit-cost analysis and input-output analysis is described and illustrated. In the process, several familiar specious arguments are exposed.

Introduction

Competition between commercial and recreational fishermen for fish, although certainly not new, is intensifying as a direct result of increased demand for seafood, increased participation in marine recreational fishing, and, in many cases, reduced stock sizes. Consequently, fishery managers throughout the United States and the world are increasingly confronted with allocating fish stocks between commercial and recreational fishermen. For example, the federal Regional Fishery Management Councils recently allocated redfish in the Gulf of Mexico, coho and chinook salmon in the Pacific, and billfish species in the northwest Atlantic to these user groups. Allocation of many other shared species, such as sharks, is imminent.

Given the financial stakes in having access to a fish stock, it is not surprising that **economics** receives increased attention when fishery allocations are contended. Unfortunately, many contemporary arguments which are advanced by user groups and related constituencies, while having an apparently reasonable ''economics'' ring to them, are usually incomplete, distorted, and even incorrect. For example, commercial fishermen sometimes characterize sport fishing as the adult-equivalent of play—something devoid of economic value. This ''market value-argument'' is incorrect, however, because it presumes that only markets beget economic value. As another example, game fish status is often advocated for a fishery resource, such as billfish, when revenues from anglers' expenditures on fishing supplies are greater than dockside revenue in the commercial fishery for the same species. Among the mistakes inherent in this ''revenues-argument,'' however, is that it contradicts any rational desire of an angler or business to minimize the costs of fishing.

One danger of these and other biased arguments or perceptions is that they could undermine management which is designed to enhance the economic value that all Americans derive from their publicly owned fish stocks. Indeed, to optimize the economic value of fish used for food and sport is one of the primary objectives of the Magnuson Fishery Conservation and Management Act—an objective that justifies government management of **common property** fisheries. Yet, management which is based on inappropriate (as well as insufficient) economics data and analyses will fall well short of this justification, and it could be challenged and delayed after receiving required professional reviews. Even plans actually approved by higher authorities, such as the Secretary of Commerce in the case of federal fishery management, could later be withdrawn or reversed after the appropriate data are collected and analyzed correctly. Clearly, the need to elucidate the economics of allocation between commercial and recreational fisheries is present, great, and increasing.

Every discipline has unique jargon which facilitates communication among its rank and file, but which also confuses and alienates others. Economics, with its sometimes bewildering confluence with mathematics and statistics, is an extreme example of this problem, especially when applied to fishery allocations. Thus, economists are obligated to make their subject accessible to others if we hope to see economic analyses applied correctly. An understanding of benefit-cost analysis and input-output analysis is particularly important. Accordingly, this guide was written with three purposes in mind: 1) to expose specious economics-sounding arguments common in the public debate of fishery allocation; 2) to offer those with an interest in fishery management a foundation of economic concepts, principles, and methods which are germane to fishery allocation; and 3) to promote sound economic analyses and comparisons of the economic value of commercial and recreational fisheries.

Throughout this guide, bear in mind the distinction between the *quality* of an analysis and its *appropriateness*. The quality of any analysis, such as a stock assessment or a benefit-cost analysis, is constrained by available data, the state of the art in research methodologies, and, of course, manpower and budgets. In contrast, no amount of data or no methodology—no matter how accurate or eloquent—can shed light on the allocation debate when they are inappropriate. Particularly worrisome is the misuse of purely financial information, such as expenditures and revenues, and input-output analysis to assess the economic values of commercial and recreational fisheries.

Instead, what is needed is an understanding of how data on expenditures and revenues can be correctly used, within the context of benefit-cost analysis, to *measure* the economic value of fish in commercial and recreational uses. Accordingly, this guide offers fishery managers, policy makers, and others with an interest in fishery management a foundation in the concepts, principles, and methodology of benefit-cost analysis. However, this guide was not intended to be a handbook or ''recipe'' for the actual execution of benefit-cost analysis by practitioners. Its more modest purpose was to help non-economists, if you will, better understand how to compare the economic value of fish allocated between commercial and recreational fisheries.

The Economic Value section and the Benefit-Cost Analysis section define and illustrate concepts and principles which are fundamental to a basic understanding of benefit-cost analysis. The Economic Value section, which focuses on the foundations of economic value, is a springboard for the Benefit-Cost Analysis section where the elements of benefit-cost analysis, including resource costs, net national benefits, and efficiency, are presented. In the Input-Output Analysis section, input-output analysis, which widely serves as a model of interactions within an economy (one of several methodologies generally referred to as economic impact analysis), is described and critiqued within the context of fishery valuation. Important differences between benefit-cost analysis and input-output analysis are underscored in the Comparison of Benefit-Cost Analysis (BCA) and Input-Output Analysis (IOA) section. The glossary in Appendix A serves as a reference for all these sections.

An example is possibly the best way to illustrate how to compare the commercial and recreational values of fish and to reinforce the characteristics of an efficient allocation of total allowable catch between fisheries. Accordingly, this guide culminates in the Efficient Allocation section with an exercise that highlights the concepts and principles presented previously. Finally, the Summary and Conclusions section briefly summarizes and concludes the guide.

Although written at an introductory level, the reader will be challenged by a host of unfamiliar terms that probably cannot be assimilated casually in one sitting. Indeed, an irony about learning a new subject—any subject—is that introductory material always seems the hardest to grasp simply because it is new and, at times, because preconceptions must be overcome. Consequently, a modest commitment of time and an open mind is requested. For more information on the subject, readers might consult more general introductions to fishery economics that were prepared by McConnell and Norton (1976), Rothschild et al. (1977), Sutinen (1980), and Talhelm (1987).

This guide was also written with economists in mind, however, as well as others who might want more general information. When I sacrificed precision in favor of a simple straight forward presentation of a concept or principle, I tried to make amends in a footnote. In addition, more extensive treatment of technical material was relegated to two appendices. Appendix B covers the elements of input-output analysis in considerable detail, and valuation of a fishery resource in a multimarket framework is presented in Appendix C. Nevertheless, readers who are interested only in acquiring a gut feeling for the issues can stick to the main text.

Finally, although allocation between commercial and recreational fisheries was the primary focus of this guide, the information presented here applies equally well to economic analyses of other types of allocation decisions involving fisheries, including gear conflicts and conflicts between fishing (commercial and/or recreational) and aquaculture, dredging, waste disposal, oil extraction, shipping, and wetland destruction.

Economic Value

Benefit-cost analysis cannot be understood without a solid foundation in concepts of economic value. Accordingly,

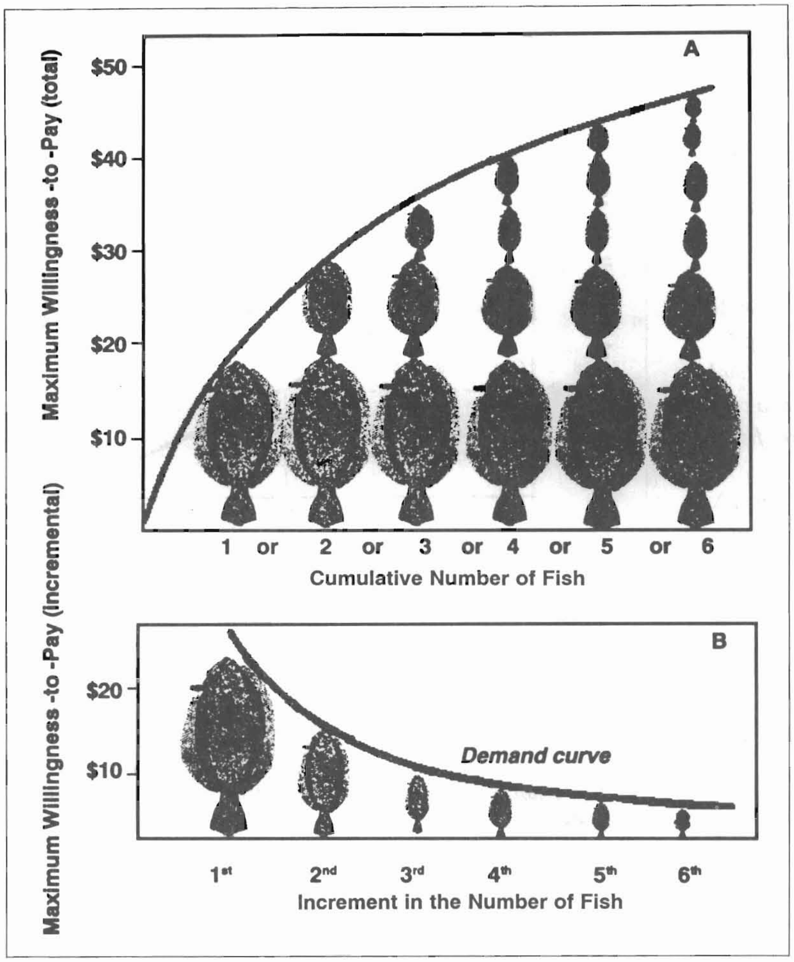

Figure 1
Economic value is determined by the maximum amount that consumers are willing to pay for fish. The increments of value are traced by a demand curve.

this section begins by defining economic value in terms of what seafood consumers and anglers are willing to spend on seafood and sport-caught fish. Next, the relationship between demand and economic value is illustrated. Subsequently, the importance of consumer surplus—the net worth of fish to consumers after expenditures are subtracted from total economic value—is emphasized given its importance in benefit-cost analysis. This section ends with a summary of the salient points.

What Is Economic Value and How Is It Measured?

This section is devoted to defining economic value for use in benefit-cost analysis and to briefly indicating how it is measured. It will be shown that economic **value** is derived ultimately from the tastes and preferences of consumers, where ''consumers'' is defined broadly to include those who eat fish and all anglers (regardless of whether their catch is eaten).[1] In fact, the total economic value of fish is defined and measured in terms of what someone is willing to pay for fish—either for food or for sport—in lieu of spending the same amount of money on other goods and services which satisfy personal needs and wants.

A simple yet powerful proposition is that the most that a consumer is willing to spend on fish increases with each additional fish but at a decreasing rate (assuming, of course, that factors which influence consumption, such as income and preferences for seafood or recreational fishing, remain unchanged). That is, during a specified period of time, such as one week, each additional fish cooked for dinner or each additional fish caught on a fishing trip benefits the consumer, but the additional satisfaction derived from each additional fish gets smaller and smaller. Figure 1A illustrates a hypothetical case in which, for example, the second flounder cooked for dinner is not as satisfying as the first flounder. Alternatively, if this plot were for recreational fishing it would indicate that catching the second flounder is not as enjoyable as catching the first fish.

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[1] To keep things focused on the current allocation issues, other categories of economic value related to nonconsumptive use (e.g., watching salmon and herring runs), indirect use (e.g., watching shows about sport fishing), preservation value (preserving fish for their own good), and bequest value (preserving fish for use by future generations) are omitted. *See* Randall (1987) for a discussion of these benefit categories.

It follows, then, that the consumer is willing to pay for the second fish, but the maximum amount is less than that for the first fish. Similarly, the most that the consumer is willing to pay for the third fish is positive but less than that for the second fish, and so on. Figure 1A illustrates these properties of preferences with a curve that increases gradually from zero as the total number of fish and, therefore, total **maximum willingness-to-pay** increase.

The relationship depicted in Figure 1A between consumption of fish and the maximum that a consumer is willing to pay for fish is simple, but it has several very important implications for economic valuation. Foremost, *total economic value is defined and measured by the maximum that a consumer is willing to pay for the good or service (in our case, fish).* Accordingly, economic value has monetary units.[2]

Second, because the total value curve in Figure 1A answers questions such as, ''What is the total economic value of all three flounder?,'' then the **demand** curve in Figure 1B answers related questions such as, ''What is the economic value of the *third* flounder?'' In other words, a consumer's demand curve traces the most that he/she is willing to pay for each *additional* fish. Therefore, the entire area under a demand curve is equivalent to total economic value. In this exercise, the total economic value of the first three flounder is \$36.67 from Figure 1A, or, equivalently, \$20 + \$10 + \$6.67 = \$36.67 from Figure 1B.

Notice that in every day language ''demand'' refers to frequency of use, such as the quantity of fish consumed, the number of consumers or anglers, and the number of fishing trips. In economics, however, demand is a behavioral relationship which portrays how seafood consumers and anglers alter the quantity of fish used for food and sport in response to changes in costs and a number of other factors which affect willingness-to-pay, such as income, catch rate, the costs of other goods and services which are substitutes for fish, and the amount of leisure time (for anglers). For example, under normal circumstances an increase in income would increase a consumer's ability, and, therefore, willingness to pay for fish. With regard to Figure 1, an increase in the consumer's income would increase, or ''lift'' maximum willingness-to-pay in Figure 1A, causing the demand curve in Figure 1B to shift right. As another example, if the cost of a substitute for flounder increased—perhaps the price of cod fillets or the costs of fishing for, say, bluefish—the consumer's demand for flounder would increase because compared to the substitute, flounder becomes *relatively* less expensive.

Perhaps the most important point implied by Figure 1 is that *economic value and demand exist even when markets and prices are nonexistent.* Markets and prices actually emerge from the collective behavior of consumers and businesses when property rights are well-defined, exclusive, and enforced. When available, prices help to *reveal* the maximum that consumers are willing to pay for fish or fishing. However, prices do not, as is commonly thought, create demand or economic value. Indeed, the opposite is true—demand, or willingness-to-pay, is necessary for markets and prices to emerge. Accordingly, anglers derive economic value from resources such as fish stocks even when access to beaches, piers, and boat launches is not rationed by markets.

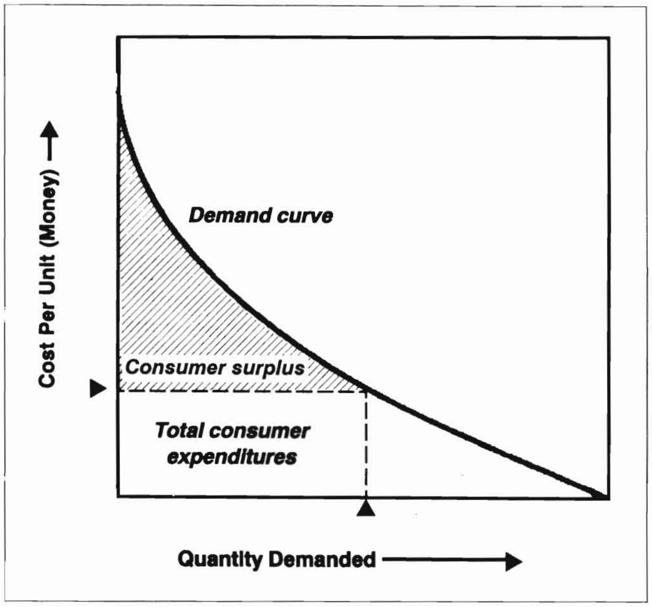

Figure 2
Demand captures consumer surplus and determines total consumer expenditures.

Finally, total economic value is composed of two parts as shown in Figure 2. The rectangle that is delineated from above by the price line is total consumer expenditures. For seafood consumers, total expenditures by the consumer is money spent on seafood in retail markets. For anglers, total consumer expenditures are expenses for gasoline, bait, tackle, boats, charter/party boat fishing, and other fishing supplies that the angler uses to catch fish.

In contrast, the shaded area above the expenditures triangle is the net economic value of fish to the consumer. This component of total economic value is called **consumer surplus**. *Consumer surplus amounts to the value enjoyed by a consumer in excess of what was sacrificed to buy or catch fish.*

The concept of consumer surplus often invites skepticism in fishery managers and policy makers because it is not tangible in the sense that expenditures or revenues involve the exchange of money. Nevertheless, *consumer surplus follows logically from the reasonable properties of consumer preferences depicted in Figure 1 and from the corollary that economic value can*

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[2] Economic value can also be measured in terms of willingness-to-accept-compensation. *See*, for example, Just et al.'s (1982) discussion of Hicksian surplus concepts. Also, Bockstael and Strand (1985) showed that economic values can be measured in terms of time when a time constraint is included in the utility maximization problem.

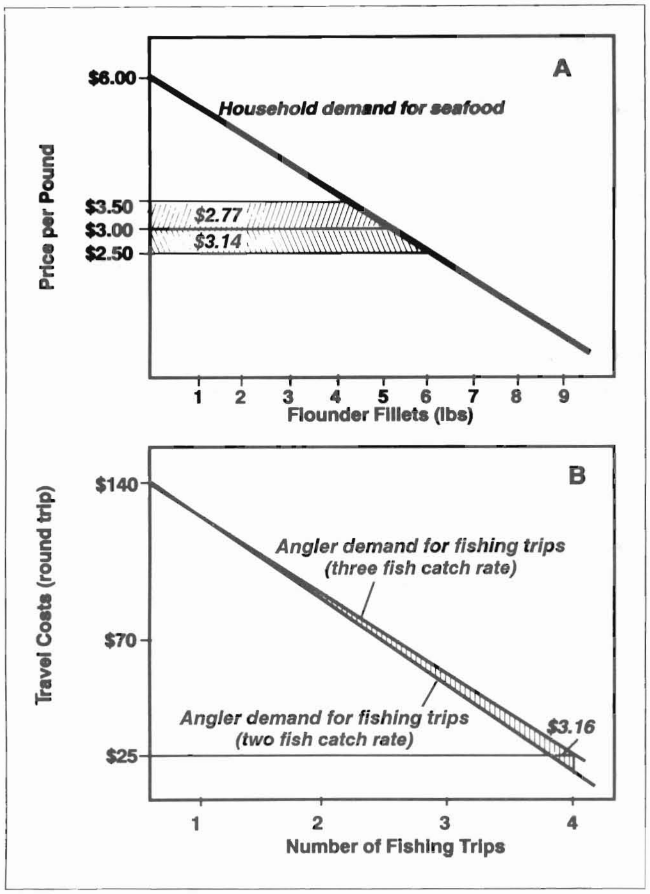

Figure 3
Change in consumer surplus due to (*A*) a change in the price of seafood and (*B*) a change in catch rate.

be measured in terms of willingness-to-pay because people allocate their income among things that satisfy their personal needs and wants.

As further evidence in defense of consumer surplus, consider the value that a seafood consumer would receive if given flounder fillets for free, or the value that an angler would receive if invited to fish for free on a charter boat. Although there is no financial cost to these consumers, they certainly would value these gifts. Alternatively, think of consumer surplus as additional money a consumer would spend on fish but which is not required at current market prices or costs of fishing, and, instead, can be spent on other goods and services that are valued. Similarly, a price reduction on, say, flounder fillets or charter boat fishing leaves consumers with "extra" money that can be spent on more fish or other goods and services that provide additional value.

Consumer surplus is a theoretically sound and real category of economic value—it is not arbitrary and cannot be assumed away. Nor can its role in benefit-cost analysis be overemphasized. *Consumer surplus and, for now, an analogous value category for producers that is somewhat related to **profit**, are the two value categories covered by the "benefit" side of benefit-cost analysis.* Similar to profit, consumer surplus is a benefit in excess of costs.

By way of review, economic value is defined and measured by the maximum that consumers are willing to pay for fish or any good or service, including other natural resources and environmental services and amenities. Total economic value can be decomposed into expenditures, or what consumers must give up to obtain fish, and consumer surplus. Consumer surplus is an essential component of the value that consumers receive from their publicly owned fish resources.

Measuring Economic Value

A few things should be said about how to measure consumer surplus, including economic value derived from the natural environment such as fish stocks. First, the availability of price and quantity data from markets facilitates the estimation of demand curves and, therefore, the estimation of economic value. Usually, **aggregate demand** curves are estimated (in effect, the summation of all individual consumer demand curves), although individual demand curves can sometimes be identified. When faced with a market price, consumers decide, for example, how much fresh fish to buy at a market or how often to order seafood at a restaurant. Statistical methods such as regression analysis can then be used to estimate demand equations based on market data on quantities of fish sold at various prices and on data on income, the prices of substitutes, and other factors which affect willingness-to-pay. For example, the demand model for flounder that is illustrated in Figure 3A was adapted from Cheng and Capps's (1987) report (H-t. Cheng and O. Capps Jr, Agriculture Experiment Station, Univ. Georgia, Athens, GA, unpubl. manuscr., "Demand analysis of fresh frozen finfish and shellfish in the United States" 1987) on household demand for finfish and shellfish. At $3 per pound, **quantity-demanded** by the average household which consumes seafood is between five and six pounds annually, total expenditures are approximately $17.75, consumer surplus is $12.00, and, therefore, total economic value is $29.75. If the price increases to, say, $3.50 because of an allocation rule which, in effect, decreases the amount of flounder that can be sold commercially (or, perhaps because of over-fishing or poor recruitment which reduces stock size), then consumer surplus for the average household decreases by $2.77. Alternatively, a management rule (or increase in stock size) which ultimately increases the amount of flounder sold commercially and leads to, say, a fifty cent reduction in retail price would increase consumer surplus by $3.14.[3] (Notice that

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[3] Cheng and Capps (1987) actually report Engle models. Their expenditure model for flounder was converted to a demand model by dividing both sides by price (dividing the endogenous variable, expenditures, by prices yields quantity).

although the change in price was fifty cents in both cases, the increase in consumer surplus from the price reduction is greater than the loss of consumer surplus because of the inverse relationship between quantity-demanded and increments in maximum willing-ness-to-pay.)

In contrast to markets for seafood, legions of marine anglers actually "produce" their own fish for sport and food. Often their "production" involves renting charter fishing services (including party boats and rentals from marinas), but more frequently the goods and services used to catch fish are purchased directly by the anglers. Nevertheless, angler behavior reveals the economic value derived from fish. For example, travel costs such as gasoline and the costs of bait and fishing supplies and, when applicable, of charter fees taken together are a proxy for the price of fishing in the absence of a market.[4] This information plus information on income, costs of substitutes, and catch rates can be used to estimate angler demand using what has come to be known as the **travel cost method**. The logic is simple—the farther an angler lives from a fishing site, the higher are his/her travel costs. It follows that the number of fishing trips an angler takes will decrease as travel costs increase, everything else held constant. This relationship, along with estimates of how demand changes when the catch rate increases or decreases, can be used to estimate the value of fishing trips and, indirectly, sport-caught fish. For example, the demand curves shown in Figure 3B are based on Agnello's (R.J. Agnello, paper presented at the symposium on demand and supply of sport fishing, Charleston, SC, "Economic valuation of marine recreational fishing," March 14–15 1988) travel cost demand model for flounder fishing trips. The lower demand curve corresponds to a catch rate of two fish per fishing trip whereas the upper demand curve traces higher levels of willingness-to-pay when the catch rate is three fish per fishing trip. If travel costs remain $25 for each trip (the average in Agnello's study), a fishery management rule which increases catch rate from two to three fish per trip also increases the angler's consumer surplus by $3.16. (The similarity to the above results for seafood consumption is coincidental!) Likewise, rules which reduce catch rates will reduce an angler's consumer surplus.

The **contingent valuation method** can be used to estimate the value of fish to anglers, too, particularly when the effects of a proposed management rule on catch rate are uncertain. With the contingent valuation method, researchers design experiments that help anglers to reveal their maximum willingness-to-pay for specific increases in (or to prevent reductions in) catch rates. Depending on how the questions are phrased, the data can be used to estimate changes in consumer surplus directly or to estimate demand curves for sport-caught fish.[5]

Summary

The salient points of this section are

- Total economic value of fish is the maximum that consumers are willing to pay for fish.
- Economic value is *not* contingent on the existence of markets and prices nor on whether a fish resource is used for food or sport.
- Consumer surplus is the net economic value that consumers derive from fish. When consumer surplus is overlooked, fish stocks are grossly undervalued because consumers are ignored.

Benefit-Cost Analysis

The above foundation in economic value is preparation for defining what constitutes a **benefit** and a **cost** in **benefit-cost analysis**. It should become clear in this section that, in the context of benefit-cost analysis, a benefit is a gain of economic value whereas a cost is a loss of economic value. Thus, the more familiar notions of revenues and expenditures must be interpreted very carefully when used to help *measure* benefits and costs of a benefit-cost analysis.

This section first distinguishes between expenditures and the concept of **resource costs**, or the foregone economic value of a resource, such as fish, when it is used for one purpose instead of something else. Next, net national benefits—the focus of a benefit-cost analysis—are defined as the difference between total economic value and resource costs that are "spent" to make fish available to consumers (including anglers). Net national benefits are composed of consumer surplus and its complement, producer surplus, or net economic value attributable to production. Also in this section, the relationship between economic efficiency and net national benefits is highlighted. Finally, the section ends with a brief summary of the major points.

Opportunity and Resource Costs

Expenditures are so easily understood that the concept is hardly worth mentioning except to compare with resource costs (i.e., foregone economic value). Payments for goods and services purchased in markets and taxes for public

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[4] In keeping with the introductory level of this document, the discussion is not complicated by discussing the opportunity costs of time. *See* Bockstael et al. (1987).

[5] *See* McConnell's (1985) chapter on recreational demand modeling for a discussion of, and more references to, the travel cost technique. Also, *see* the books by Cummings et al. (1986) and Mitchell and Carson (1989) for assessment of the contingent valuation method. Finally, hedonic travel cost analysis (Brown and Mendelsohn 1984) and, in general, household production (Bockstael and McConnel 1981; McConnell and Sutinen 1982) can be used to estimate nonmarket (or market-related) demands for sport-caught fish.

services that are not supplied by markets (such as fishery management) are familiar to everyone. *Expenditures are simply financial, or money costs.*

What appears to be confusing from controversies surrounding allocation between commercial and recreational fisheries, however, are the implications of the symmetry between expenditures and revenues. Mathematically, an industry's revenues are equal to its customers' expenditures and visa versa. Accordingly, in purely financial terms the overall effect of an exchange of money is zero. In Figure 3A, for example, at a price of $3 per pound, the household's total expenditures of $17.75 for flounder fillets are revenues for the retail seafood industry. Thus, the household is $17.75 ''poorer'' and the retail outlet is $17.75 ''richer.'' Similarly, at a catch rate of two flounder per trip, the approximately $100 expended by the angler portrayed in Figure 3B are revenues for companies which sell gasoline, bait, tackle, and other goods and services required for fishing flounder. However, the overall effect of the financial transactions between the angler and the suppliers of fishing goods and services is zero—money has simply been transferred, or redistributed.

Expenditures are relevant to benefit-cost analyses only when they can be legitimately used to *measure* losses of economic value when **resources** such as labor, fishing vessels and other capital, and fish and other natural resources are devoted to produce one good or service instead of something else. Because opportunities to produce something else valued by consumers are foregone, the costs involved in making the decision are usually called **opportunity costs**. Thus, fish, such as flounder, which are sold to consumers in seafood markets are also valued by anglers, although the anglers' opportunities to catch and possibly eat the same fish are precluded. The reverse is also true.

Although expenditures could be construed as a purely financial opportunity cost incurred by consumers and businesses (the same dollar cannot be spent on more than one commodity or resource), the focus here remains on the lost economic value of resources. In fact, because of the scope for ambiguity, it makes more sense to refer to resource costs when discussing opportunity costs in the context of benefit-cost analysis. Whereas expenditures imply spending money, resource costs imply ''spending'' resources such as labor, capital, and fish stocks.

Although the concepts are distinct, the differences between expenditures and the opportunity costs of resource use are blurred when the latter are measured. When markets for productive resources are competitive, market prices (including wages) reveal, or give a good indication of, the economic value to consumers of the goods or services that would otherwise have been produced by the same resources. Also, when a change in the use of a resource is too small to effect a price change, total expenditures reveal, or measure, resource costs. That is, when these conditions involving the prices of resources and resource use are satisfied, payments by businesses and anglers to hire, buy, and rent resources to make fish available for consumption are *mathematically* equal to the opportunity costs of the same resources.

Bear in mind, however, that expenditures do not always conveniently measure resource costs—that expenditures and resource costs are conceptually distinct. For example, taxes that redistribute wealth to the poor do not ''spend'' productive resources—they are **transfer payments** of money. Also, prices and expenditures may not accurately measure resource costs when markets are not structured competitively or when the amount of a resource being used affects its price. However, these (and other) exceptions to when expenditures can be used to measure resource costs are technical matters that are beyond the scope of this guide. *See* Gittinger (1982) for a more detailed discussion and comparison of expenditures and the opportunity costs of resource use.

Net National Benefits

Having covered economic value and resource costs, it is relatively straightforward to define **net national benefits**. *In benefit-cost analysis, the net national benefits from using fish are maximum willingness-to-pay (i.e., total economic value) minus all opportunity costs of using resources to make fish available to consumers (including anglers).* Net national benefits are illustrated on Figure 4A with the aid of a standard depiction of demand and **supply** as presented in other pedagogical writings (e.g., Hushak 1987). Assuming that this supply curve traces the incremental resource costs of providing additional fish to consumers (analogous to how a demand curve traces the incremental economic value of additional fish to consumers), then *the area beneath the supply curve is total resource costs, and the area between demand and supply is net national benefits.*

Actually, the phrase 'net national benefits' is troublesome because it is both misleading and ambiguous. It is misleading because the effect of a management rule which allocates a fish stock between commercial and recreational fisheries generally will be felt regionally—not nationally—where the commercial fishermen, anglers, and related constituencies (including seafood consumers) reside. The phrase is also ambiguous because the word, 'benefits,' could refer to purely financial benefits, such as **revenues** or, from a government's perspective, taxes, in addition to economic value as defined above. Thus, the area between the demand and supply curves in Figure 4A is better called **net economic value**. Nevertheless, given its widespread use by economists and others when referring to the economic value of fish stocks (including the Magnuson Act), I shall continue to use the phrase ''net national benefits,'' when speaking of net economic value.

Notice in Figure 4B that the cost line actually divides net national benefits into two parts. The top part is consumer surplus as was already discussed in the Economic

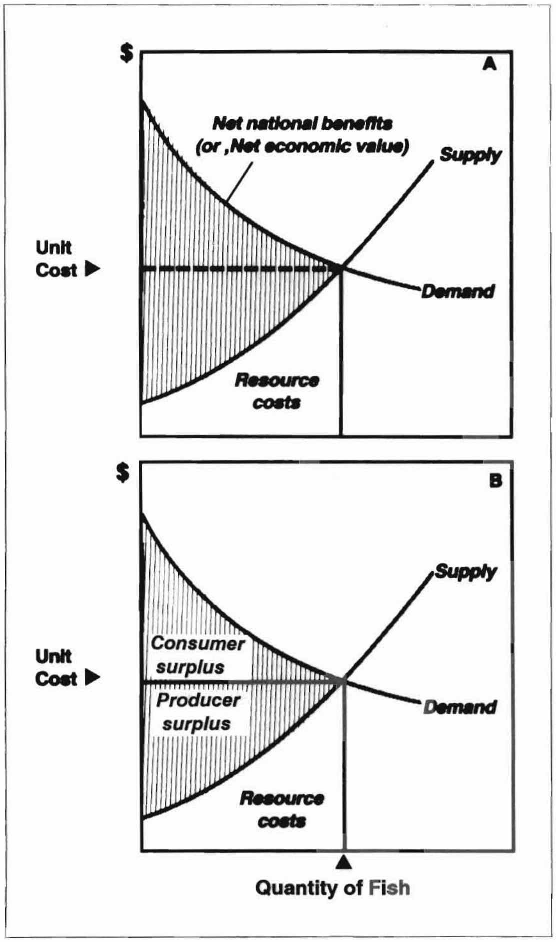

Figure 4
Net national benefits (i.e., net economic value) comprised consumer surplus and producer surplus.

Value section. The bottom part of the area encompassing net national benefits is **producer surplus**. In practice, producer surplus can be *measured* by subtracting the resource costs of providing fish to consumers from total revenues. Producer surplus is not, however, the profit an accountant might measure (i.e., revenues minus expenditures) even when expenditures on resources measure their opportunity costs in other uses. That is, the value of the entrepreneurs' assets, including labor, capital, and land, must also be deducted from revenues when estimating producer surplus.

It may be apparent from this discussion of producer surplus that revenues are not a benefit in the strict sense used in benefit-cost analysis. Although revenue data can be used to help estimate the economic value which is associated with production, all resource costs must be subtracted from revenue in order to estimate producer surplus (the second component of net national benefits). Accordingly, the so-called dockside ''value'' of fish in a landings market actually overestimates the net economic value associated with commercial fishing because resource costs are not subtracted. (And, obviously, revenues do not subsume consumer surplus from seafood consumption.)

In Figure 5, pie diagrams are used to display the elements of net national benefits. In the seafood sector, net national benefits comprise consumer surplus, producer surplus in retail markets, and producer surplus from other suppliers in the marketing chain from commercial fishermen to retailers, because these industries make fish available to consumers. In the sport fishing sector, there is consumer surplus enjoyed by anglers plus producer surplus from the charter fishing industry. The economic values from the respective user groups are purposely drawn to be equal in order to focus on the important concepts and principles and to avoid giving the impression that total net economic value from one use is inherently greater than the other use.

Economic Efficiency

In the context of fishery management, economic **efficiency** relates to the total size of net national benefits from the collective use of a fish resource. In Figure 6, the center pie is supposed to illustrate the combined total net national benefits displayed by Figure 5 for the seafood and sport fishing sectors of the (usually) regional economy. A management rule which increases total net national benefits is said to increase the efficiency of uses of a fish resource—it increases the size of the net economic value pie that commercial fishermen, anglers, fish wholesalers and retailers, the charter fishing industry, and seafood consumers share from a fish resource. Similarly, a policy which *maximizes* net national benefits gleans the most net economic value from a fish resource as is possible given constraints which are outside the control of management. In contrast, a loss in economic efficiency implies a loss of net national benefits, or net economic value.

Notice that losses in economic surplus experienced by one or more groups would be consistent with increased efficiency provided that total net national benefits increase. *In other words, the compensation test for judging whether efficiency is increased is whether ''winners'' of economic value could compensate ''losers'' and still come out ahead.* That is why the ''slices'' of the right-most pie in Figure 6 are not shown. In addition, one or more groups could experience a gain in consumer surplus and/or producer surplus even when use of a fish resource on the whole becomes less efficient. Thus, allocation can affect the relative sizes of the shares of net national benefits as well as the pie's total size.

Before exploring the allocation issue further, it is necessary to report on the increasingly inappropriate use of input-output analysis when net national benefits are estimated. Allocation of a fish stock between commercial and recreational fisheries is revisited in the Efficient Allocation section after input-output analysis is described in the Input-

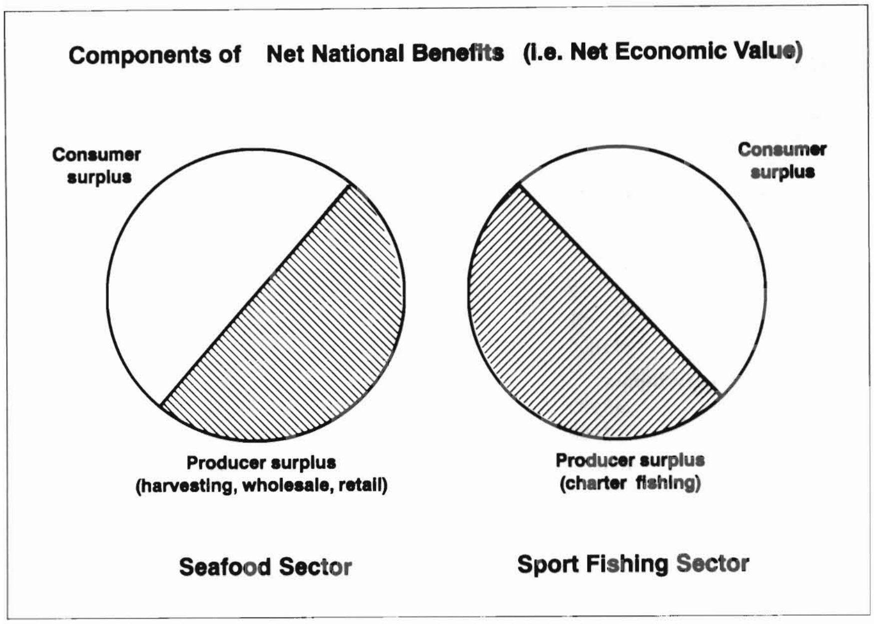

Figure 5
Components of net national benefits (i.e., net economic value) in the seafood and sport fishing sectors.

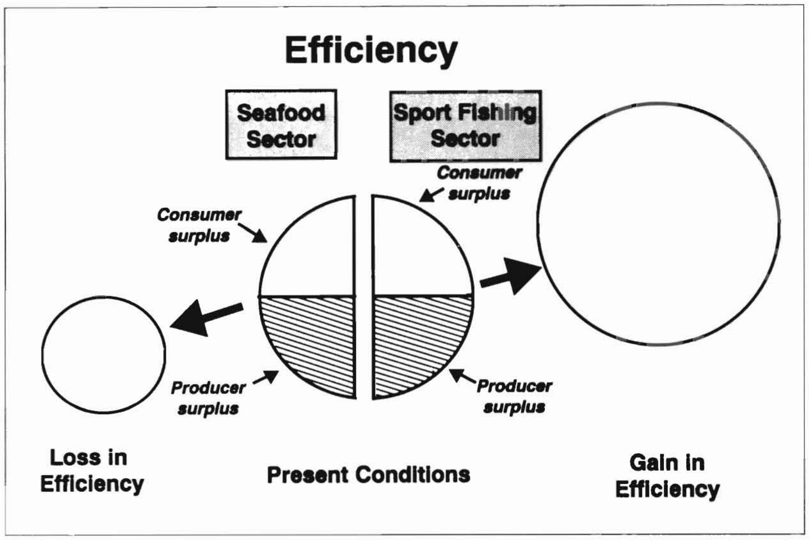

Figure 6
Economic efficiency increases (decreases) when net national benefits (i.e., net economic value) increase (decrease).

Output Analysis section and contrasted to benefit-cost analysis in the Comparison of BCA and IOA section.

Summary

In conclusion, several important concepts and principles are worth repeating:

- In the context of benefit-cost analysis, "benefits" are economic value as defined in the Economic Value section in terms of consumers' maximum willingness-to-pay for fish, and "costs" are the opportunity costs of resources used to make fish available to consumers. In this context, revenues are not benefits and expenditures are not costs (or benefits), although these quantities can be used to help measure producer surplus and resource costs when certain conditions are satisfied.
- In benefit-cost analysis, net national benefits are total economic value minus total resource costs. Net national benefits, which are comprised of consumer surplus and producer surplus, are synonymous with net economic value.
- Any action which increases net national benefits from the use of fish resources is said to increase efficiency, even if consumer surplus or producer surplus for some groups decline. Likewise, when net national benefits decline, efficiency goes down, and Americans suffer a loss of economic value from the use of their publicly owned fish stocks.

As emphasized in this section, data on expenditures and revenues must be interpreted cautiously before they can be used to measure economic value. This caution extends

Table 1
Transactions flow table ($ millions).

	Purchasing sectors (i.e., intermediate demand)			Final demand expenditures		
	Commercial fishing	Recreational fishing	All other industries	Households	Exports	Output
Producing sectors						
Commercial fishing	0	0	7	0	3	10
Recreational fishing	0	2	1	4	3	10
All other industries	2	2	43 000	38 000	18 996	100 000
Primary inputs						
Value-added	7	3	49 992	0	—	
Imports	1	3	7 000	10 000	– 17 004	—
Total inputs	10	10	100 000	48 004	1 998	100 020

to the use of expenditures and revenues in input-output analysis, the subject of the next section.

Input-Output Analysis

Benefit-cost analysis is used to determine whether a fishery regulation would increase or decrease efficiency. Although a benefit-cost analysis is not necessarily limited to the entire Nation, this scope is appropriate when the Federal Government affects use of a natural resource that is, in fact, owned by all citizens. Nevertheless, benefit-cost analysis is flexible enough to be limited to a particular region of the country, or, if national in scope, it could be partitioned to isolate effects on particular regions or groups. As emphasized above, however, most of the effects of a fishery management plan on consumers and industries are probably felt regionally. Therefore, limitations on scope are not necessary in many cases.

In contrast, **input-output analysis** (and related methodologies generally referred to as **economic impact analysis**) is used to determine how the same regulation would change regional **income** and other economic "activities," particularly revenues, expenditures, and employment. For example, input-output analysis is often used by manufacturers and local and state governments to determine how fishery regulations might affect *their* share of markets and revenues, including taxes. Despite the disparate purposes, and despite the ambiguous relationship between changes in these economic activities and changes in consumer and producer surplus, input-output analysis is often improperly disguised as a surrogate for benefit-cost analysis.

In order to explain why input-output analysis cannot assess changes in net economic value, a basic understanding of the methodology is required. Accordingly, this section begins with the foundations of input-output analysis, including a simple exercise to illustrate several points. Subsequently, several common misconceptions and pitfalls which characterize improper applications of input-output analysis are highlighted, including the scope for exaggerating the multiplier effects of new expenditures by consumers. Along the way, reasons for why constituencies might understandably promote input-output analysis for their own benefit are pointed out. Keep in mind, however, that legitimate uses of input-output analysis are not being challenged. *Rather, this section repudiates using input-output analysis as a surrogate for benefit-cost analysis.*

Elements of Input-Output Analysis

Input-output analysis begins with a parsimonious accounting of financial links among industries, households, export markets, and, often, the public sector. The links are measured in terms of expenditures on the **inputs** (both resources and manufactured products that are intermediate to the production of final products purchased by consumers) which are used to manufacture goods and services; revenues from the sale of products (i.e., **output**) and from taxes; and, income, or payments for labor and ownership of capital and privately-owned natural resources such as land. In practice, industries within a "region" (could be a town, county, state, or nation), such as seafood processing or tackle manufacturing, are combined into somewhat homogeneous **sectors** having similar input requirements. For example, one national input-output model combines the thousands of industries in the United States into 496 sectors. In more focused, fisheries applications, however, the number of sectors are reduced further in order to facilitate analyses of the effects of a public policy on fisheries sectors. For example, in Hushak's input-output analysis of Ohio's fisheries in Lake Erie (Hushak 1987; Hushak et al. 1984), there are only 43 sectors, including commercial fishing, charter fishing, and marina and boat sales.

Although greatly simplified, the **transactions flow table** shown in Table 1 is patterned after Hushak et al.'s (1984) input-output study. In Table 1, all industries belong to one of only three sectors: 1) the commercial fishing sector; 2) the recreational fishing sector; or 3) the considerably larger combination of all "other" industries. Whereas the commercial fishing sector is restricted to only harvesting, the recreational fishing sector includes a wide variety of products and services such as charter boat fishing, boat sales, and sales of tackle, bait, and boat rentals by marinas. Other industries with ties to commercial and recreational fishing, such as boat building, food processing, finance and insurance, lodging, retail food sales, and restaurant trade, are lumped in the "other" sector with the rest of the regional economy.

Transaction flow tables reflect that industries both receive revenues for the output that they produce and incur expenditures when they purchase inputs used to produce output. In Table 1, the "producing sectors" supply both processed, or intermediate, inputs (e.g., whole fish; fiberglass for fishing poles) and **final products** (e.g., fish dinners at a restaurant or fishing trips) to industries in the "purchasing sectors," to regional consumers, and to consumers and industries in other regions. The latter groups are referred to collectively as **final demand expenditures** (hereafter, final expenditures will be used). For example, in this exercise nothing from the recreational fishing sector is sold to the commercial sector; $2 million of output from recreational fishing is sold to industries within the same, recreational fishing sector; $1 million of output is sold to "other" industries; $4 million of output is sold directly to regional consumers; and $3 million of output is exported to industries and consumers outside the region for a total output of $10 million. (In practice, business investment and the public sector could be added to the final expenditures block, but the additional detail would unnecessarily detract from this introduction.)

Likewise, the two **primary inputs** sectors listed in Table 1 supply the region's industries and consumers with imports from other regions and with labor, capital, and privately owned natural resources such as land and caught-fish from within the region. Labor, capital, and privately owned natural resources are subsumed in the value-added sector, where the phrase "value-added" refers to the increased value of **intermediate products** after productive resources such as labor, capital, and land are applied to convert a product into a form which is closer to that finally sold to consumers. For measurement purposes, the **value-added** sector includes wages, salaries, capital depreciation, and rent (Richardson 1972). For example, in this exercise, the value-added sector supplies $7 million of labor, capital, and privately-owned natural resources to the commercial fishing sector, $3 million of inputs to the recreational fishing sector, and nearly $50 billion of inputs to the "other" industries. Similarly, the region imports the following amounts of goods and services: $1 million by the commercial fishing sector; $3 million by the recreational sector; $7 billion by the "other" sector; and $10 billion by consumers. The negative entry in the import/export cell is simply the sum of imports by regional consumers and the three purchasing sectors (an import is considered to be a "negative" export).

In contrast, the distribution of a sector's expenditures on inputs appears down its column. For example, the commercial fishing sector's purchases of labor, vessels, repairs, financing, insurance, and so on are distributed as $2 million from the "other" sector, $7 million of value-added inputs, and $1 million of imports for total expenditures of $10 million; nothing is purchased from the commercial or recreational fisheries in this exercise. In contrast, regional consumers purchase products and services amounting to $4 million from the recreational fishing sector, $38 billion from the "other" sector (including seafood from retail markets and restaurants), and $10 billion from industries outside the region.[6] Expenditures by anglers who live *outside* the region on fishing trips and retail goods and services such as lodging, souvenirs, and meals are distributed between the recreational fishing and "other" sectors under the *exports* column.

From the perspective of a public servant, a primary reason for having information organized in a transactions flow table is to learn how a fishery regulation might change revenues (i.e., production), income, and employment in the regional economy through its effects on final expenditures on seafood and recreational fishing. As in benefit-cost analysis, however, the actual execution of an input-output analysis can be quite complicated. Consequently, only selected results are reported here. *See* Appendix B for more details.

The results of an input-output analysis are determined by up to three levels of impacts, or effects: 1) direct effects; 2) indirect effects; and 3) induced effects. The initial impacts of an increase in final expenditures for a sector's output are called **direct effects** and are measured by **technical coefficients**. Technical coefficients are calculated by dividing a sector's various direct input requirements by its total output. For example, from Table 1, each dollar increase in final expenditures for goods and services produced by the recreational fishing sector requires $0.20 of inputs from its own sector (i.e., $2 million divided by $10 million), $0.20 of inputs from "other" industries, $0.30 of labor and other value-added inputs, and $0.30 of imports. Likewise, the inputs required to satisfy each dollar increase in final expenditures for output from the commercial fishing sector (only exports in this exercise) are $0.20

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[6] Notice that a sector's output (i.e., revenue) and inputs (i.e., expenditures) are equal, and that total value-added is equal to total final demand ($50.002 billion). The latter condition assures that final expenditures (i.e., gross regional product) do not exceed total regional income.

Table 2

Economic impacts and multipliers corresponding to Table 1.

	Sector		
Impact category	Commercial fishing	Recreational fishing	''Other'' industries
	Type I (direct + indirect)		
Output multiplier	1.35	1.69	1.75
Direct income effect	0.7	0.3	0.49992
Total income effect (Keynesian multiplier)	0.88	0.59	0.88
Income multiplier (ratio multiplier)	1.25	1.98	1.75
Direct employment effect	0.00003	0.00002	0.00001
Total employment effect (Keynesian multiplier)	0.000034	0.000029	0.000018
Employment multiplier (ratio multiplier)	1.12	1.47	1.75
	Type II (Type I + induced)		
Output multiplier	5.33	4.39	5.74
Direct income effect	0.7	0.3	0.49992
Total income effect (Keynesian multiplier)	2.86	1.94	2.87
Income multiplier (ratio multiplier)	4.09	6.48	5.74
Direct employment effect	0.00003	0.00002	0.00001
Total employment effect (Keynesian multiplier)	0.000073	0.000056	0.000057
Employment multiplier (ratio multiplier)	3.66	2.82	5.74

from ''other'' industries, $0.70 of labor and other value-added inputs, and $0.10 of imports.

The initial, direct effects of an increase in final expenditures on a region's output also give rise to **indirect effects** and **induced effects** as new-found revenues and income, respectively, are spent again and again on inputs and final goods and services. For example, in order to supply the recreational fishing sector with inputs so that it can satisfy the increased demand it faces for recreational goods and services, industries in the ''other'' sector must increase their own use of inputs from each sector in the region (see the ''other'' sector's column for specific input requirements). Similarly, increased use of labor, capital, and privately-owned natural resources presumably generates additional income for regional consumers which, in turn, induces additional expenditures on all final goods and services produced in the region. In these ways, the regional industries and consumers ''recycle,'' if you will, the money supply. At each step in the process, though, money ''leaks'' from the regional economy owing in large part to imports.

Once all the spending and respending are computed, the overall effects of all rounds of spending on output from the regional economy can be expressed by indices called output **multipliers**. Mathematically, the usual output multiplier is the overall, or **total effect** of a change in final expenditures on regional production divided by the initial, direct effect, where the total effect is the sum of the direct, indirect, and, sometimes, induced effects. In other words, the output multiplier is average production in the economy per dollar of direct effect. There are at least two general kinds of output multipliers. For a **type-I multiplier**, the total effect of an increase in final expenditures on regional production includes only the direct and indirect effects. In contrast, a **type-II multiplier** also includes induced effects generated by regional consumers.

Table 2 lists the output multipliers calculated from the transactions flow table reported in Table 1. For example, the type-I output multiplier for recreational fishing is 1.69, meaning that, on average, each $1 increase in final expenditures for output produced by the recreational fishing sector requires $1.69 of inputs from *all* producing sectors in the region (including recreational fishing) once indirect effects are taken into account. The type-I output multiplier of 1.35 for commercial fishing reveals that each $1 increase in final expenditures for output from the commercial fishing sector requires a total of $1.35 in output from the region.

Common Misconceptions and Pitfalls

The elements of input-output analysis were presented in order to help identify several common misconceptions and pitfalls which characterize the controversy over fishery allocations between commercial and recreational fisheries. Several problems surround the interpretation and use of multipliers.

Output multipliers are tremendously important to industries that expect to benefit or lose financially from a fishery management regulation, particularly an allocation rule. Their interests center, quite understandably, on what affects the profit and market share of their industry's revenues pie, but certainly not on the overall effect of management on net national benefits. From a broader perspective, however, if a fishery regulation results in, say, anglers spending less money on recreational fishing, the anglers will most likely spend more money on other forms of leisure. Likewise, even if a proposed regulation is expected to reduce industrial output within the region being studied, financial gains from increased exports by *other regions* will usually offset the loss. *Overall, then, when a fishery sector or a region loses money, other sectors in the region or, possibly, in other regions will usually gain money.* Thus, when marine pollution off the northeast coast of the United States caused tourism and seafood consumption to decline in 1988, consumers spent their money at other resorts. *As introduced in the Benefit-Cost Analysis section, purely financial exchanges are transfer payments, the overall effect of which is zero.*

Consequently, it is not surprising when regional economists remark that output (i.e., revenue) multipliers ''are of little economic significance'' from the public sector's perspective because they do not have a discernable relationship to net economic values (Archer 1977, p. 517). Similarly, Scott (1984, p. 253) concluded that in general ''. . . there is no particular relationship (even in algebraic sign) between changes in net societal [i.e., national] benefits. . . and changes in regional incomes.'' That is, although revenues subsume producer surplus, *it is not possible to state a priori how producer surplus changes when regional output changes. Furthermore, consumer surplus is completely disregarded in input-output analysis.*

An emphasis on expenditures, revenues, and output multipliers in input-output analysis also leads to at least two curious conclusions when the logic is extended to similar circumstances. First, it behooves owners of commercial fishing operations, or any business, for that matter, including tackle manufacturers and boat builders, to minimize financial costs and, thereby, increase profitability. Consequently, to compare the expenditures of commercial fishermen and anglers is improper. *In fact, net national benefits are actually enhanced when businesses, including commercial fishing operations, minimize use of productive inputs because the remaining inputs can be used to produce other goods and services.*

Second, it follows from the illogic surrounding the purely financial indices that injury to fish stocks caused by sewage pollution, toxic waste disposal, or disasters such as oil or chemical spills (recall the Exxon-Valdez spill) are a regional benefit because they generate regional expenditures on inputs used for clean-up and habitat restoration. Clearly, though, pollution will only diminish the value that consumers and producers derive from fish. To make matters worse, resource costs will increase because inputs which are devoted to monitoring, assessing, and mitigating damages are removed from the production of other goods and services valued by consumers. These logical extensions of popular input-output arguments should raise very serious doubts about the use of output multipliers and whether expenditures and revenues themselves reflect economic value.

In contrast to output multipliers, changes in income (i.e., payments to value-added inputs such as labor and owners of capital and land) can, in principle, be used to estimate changes in producer surplus (Harris and Norton 1978; Hushak 1987). Also, changes in employment brought about by a fishery management rule are potentially estimable from input-output analysis. Nevertheless, several misconceptions and pitfalls surrounding the use of even income and employment multipliers need to be highlighted here.

Multiplier effects on regional income and employment are determined from the direct and total income and employment effects of a change in final expenditures (Table 2; *see* Appendix B for details). The direct income effect of a change in final expenditures is the average income in a sector per dollar of the sector's output. The same is true for employment. (Hereafter, the discussion focuses on income, although the remarks apply equally well to employment.) For example, in the transactions flow table, value-added inputs employed by the recreational fishing sector earn, on average in the economy, nearly \$0.30 for each dollar of the recreational fishing sector's output (i.e., \$3 million/\$10 million). Respending of revenues by the recreational fishing industries ultimately leads to a total income effect of nearly \$0.59 of income per dollar of output by the industrial sector. Finally, the total income effect increases to \$1.94 per dollar of output when respending of additional income earned by regional consumers is taken into account. The analogous income effects on the commercial side are 0.70, 0.88, and 2.86, respectively (Table 2).

Typically, the various income effects are used to generate the more familiar, albeit increasingly abused, **ratio multiplier**. As its name might imply, a ratio multiplier for income is generated by dividing the total income effect by the initial direct income effect. (For future reference, it is important to notice that *income is divided by income.*) For example, the recreational fishing sector's type-I ratio multiplier for income is 1.98, (i.e., 0.59/0.30). That is, on average in the *present* economy, once respending by the industrial sectors is taken into account, the total income effect of an increase in final expenditures for goods and services produced by the recreational fishing sector is nearly two times greater than the initial direct effect of final expenditures on income. On the commercial side, the type-I ratio multiplier for income is less in this exercise—1.25 (i.e., 0.88/0.70)—only because the direct income effect is proportionally greater (nearly 80% of the total income effect) than in the recreational fishing sector (51% of the total income effect). The type-II multipliers for both sectors are greater than their type-I counterparts because of the additional induced effects of respending by regional consumers. (The type-I and type-II ratio multipliers for employment are calculated analogously.)

Because of the way that they are calculated, ratio multipliers actually do not provide much useful information beyond an indication *of the self-sufficiency of the economy being studied.* For example, without imports and other "leaks" from the economy such as savings, money would continually recycle within a regional economy, resulting in *infinite* total effects and, therefore, *infinite* type-II multipliers.[7] Accordingly, the larger the regional economy, the larger a multiplier tends to be when imports decrease in proportion to total regional production. Also, in a regional economy with negligible leaks, the magnitude of type-I multipliers tends toward infinity as the proportion of value-added inputs to total outputs decreases (i.e., as the direct income effect decreases). *Because of the influence of the size of an economy on the size of ratio multipliers, extreme caution is advised when comparing multipliers between regions and from different studies. Unless the context is specified, multipliers are meaningless (Archer 1984).*

Extreme caution is also advised when ratio multipliers are used to *predict* how a fishery management rule will *change* regional income. *Although seemingly appropriate, one cannot predict the total impact on regional income of a change in final expenditures by multiplying a ratio multiplier by the change.* The approach is mathematically illogical because, unlike that for output multipliers, the denominator of a ratio multiplier for income is income, not expenditures; hence, the units of the denominator do not "cancel out" when multiplied by final expenditures. Instead, the total income effect—the *numerator* of a ratio multiplier, or what Archer (1977) calls a Keynesian multiplier—should be multiplied by the expected change in final expenditures to determine changes in income. (The same rule applies to employment effects.)

The results from Table 2 help to emphasize when ratio multipliers are inappropriately used to predict economic impacts on income. In particular, notice that the total income and employment effects—the Keynesian multipliers—can be much smaller than their ratio counterparts. Consequently, total impacts of a change in final expenditures on regional income and employment tend to be exaggerated when ratio multipliers are incorrectly used as just described. Perhaps more importantly, though, improper use of ratio multipliers can lead to incorrect inferences about how allocation might affect income or employment in a region. For example, the type-I and type-II ratio multipliers for income are greater for recreational fishing than for commercial fishing in this exercise. However, the relative sizes of the total income effects—again, the Keynesian multipliers—are actually greater in the commercial fishing sector (Table 2). Consequently, in this exercise, a $1 increase in final expenditures for output from the commercial fishing sector might actually have a greater impact on regional income than an equal increase in final expenditures for recreational fishing despite the relative size of the ratio multipliers. As noted above, this reversal arises because the direct income effects in the commercial fishing sector are proportionally greater with respect to indirect and induced effects than in the recreational fishing sector.

The overall impact of a change in final expenditures on income or employment in an economy depends on both the size of the Keynesian multiplier and on the expected change in final expenditures because these components are multiplied to calculate the overall impact. In fact, information on expected changes in final expenditures actually requires an estimate of consumer demands for fish as illustrated in Figure 3. For example, even if a management rule is expected to increase catch rate among anglers, the rule will *not* necessarily increase regional income unless the higher catch-rate increases the demand for fishing trips—regardless of the size of the Keynesian multiplier.

Difficult problems remain, however, even when Keynesian multipliers are used to project changes in income and employment. Only two problems are mentioned here. First, overlooking likely adjustments in input use in other sectors of the economy could deceive fishery managers and policy makers. For example, projections based on a region's *current* industrial structure and employment of value-added inputs tacitly assume that there is sufficient productive capacity and inputs to satisfy an increase in final expenditures by increasing output. When employment of labor, capital, and natural resources is high or when unemployed resources lack the necessary skills and characteristics to meet the increased demand, an increase in production in one sector could easily be at the expense of another sector's production (Haveman and Krutilla 1968).[8] Also, imports from other regions are viewed negatively by the region enclosed by a study (sometimes narrowly defined as a community); yet regions which supply the imports certainly consider their exports to be beneficial. *Taken together, it is not clear, a priori, whether regional income—including producer surplus—or employment will increase or decrease even when Keynesian multipliers are used, unless the levels of these activities with management are compared to levels without management.*[9]

Summary

Input-output analysis was originally developed to describe the links among industries (in terms of expenditures and revenues), final expenditures (e.g., consumer expenditures

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[7] The infinite multiplier arises because of constant returns to scale and fixed input ratios.

[8] Impacts are generally based upon the average relationships for the existing economy, although marginal changes are much preferred.

[9] Gross National (Regional) Product and Gross National (Regional) Income should not be confused with total impacts determined from an input-output analysis. In general, only total final "demand" measures Gross National (Regional) Product, and only income for value-added inputs measures Gross National (Regional) Income (Miller and Blair 1985). In this exercise, gross regional production and gross regional income are both $50,002. Total regional output—$100,020—is considerably greater because it "double-counts" what labor and other value-added inputs contribute to the final product. Consequently, regional transaction tables and associated indirect, induced, and total effects must be interpreted carefully when determining contributions to the economy.

and exports to markets outside the region), and primary inputs, such as labor, in a regional economy. The methodology is important in projecting how a change in expenditures by the final demand sector affects the *distribution* of income, employment, and revenues among a region's industrial sectors. The ability to project financial effects on industries is important to constituencies and communities which would benefit or be harmed by a fishery allocation. Nevertheless, public officials may favor looking at the overall effects of a fishery policy on all constituencies, even when the officials' purview is restricted to a region. Accordingly, the following remarks should be kept in mind whenever input-output analysis is incorrectly casted as benefit-cost analysis:

- Output, or revenue effects—including output multipliers—generated in an input-output analysis are irrelevant when discussing net economic value.
- Ratio multipliers are deceptive and should be ignored when one wants to project how an allocation rule will affect income and employment. Instead, Keynesian multipliers, or total income and employment effects, should be used in conjunction with expected changes in final expenditures to determine overall economic impacts.
- In isolation, even Keynesian multipliers cannot reveal how a fishery management regulation will affect income and employment. Notwithstanding legitimate concerns about compensatory adjustments in other sectors and regions, both Keynesian multipliers and the expected changed in consumer expenditures and purchases in export markets are required to estimate the overall, net impact of a regulation on regional income and employment.
- Input-output analyses of fishery management policies tend to be restricted to the regional level and, therefore, ignore compensatory changes in income and employment in other regions. This limitation could lead to disagreements between regional and national perspectives on fishery management depending on the size of the region. Often, however, the impacts of an allocation rule are concentrated within the management agency's regional purview.
- Because of the link between producer surplus and income earned by labor and owners of capital and natural resources, input-output analysis could, conceivably, be used to estimate changes in producer surplus in sectors indirectly related to fisheries; however, this extension of input-output analysis is in a developmental stage. Furthermore, even a satisfactory extension of input-output analysis would still ignore consumer surplus. For this, and the many other reasons described in section IV, input-output analysis (and other forms of economic impact analysis) cannot be a surrogate for benefit-cost analysis.

Comparison of Benefit-Cost Analysis (BCA) and Input-Output Analysis (IOA)

In this section, benefit-cost analysis and input-output analysis are briefly contrasted, side-by-side, using Table 3

Table 3

Comparison of input-output analysis and benefit-cost analysis.

Category	Economic impact analysis	Benefit-cost analysis
A. Focus	economic activity (revenues, expenditures, taxes, income, employment)	economic value (consumer and producer surpluses) and resource costs
B. Boundary	all industries in a regional economy; consumers are disregarded except for their expenditures	generally, consumers and only industries which make fish available to consumers
C. Determines changes in net economic value?		
1) consumer surplus?	no	yes
2) producer surplus?	potentially	yes
3) efficiency?	no	yes
D. Emphasis on net effects of regulation?	yes, but usually not analyses developed by constituencies	yes
E. Weight given to indirect and induced effects	generally very important despite compensations in other regions	considered negligible owing to adjustments elsewhere in economy
F. Weight given to distribution of revenues and expenditures	a principle application by constituencies	none
G. Distribution of effects over time?	no	yes

as a guide. *The comparison concerns how the methods are generally understood and applied (as opposed to a theoretical ideal).* Most differences involve what is being measured and what industries are being included.

Recall from the Input-Output Analysis section that input-output analysis describes the distribution of production and input requirements for *all industries within a regional economy*, although the industries are aggregated into a manageable number of somewhat homogeneous sectors based upon similarities among input requirements. The scope of benefit-cost analysis tends to be regional, but the analysis is generally *restricted to only those industries which harvest, distribute, process, and retail the resource being regulated—yield from a fish stock*. Possible effects in related markets for inputs used to harvest and make fish available to consumers generally are assumed to be negligible or short-lived in benefit-cost analysis owing to input substitution in other markets. That is, after initial impacts of a regulation, primary inputs such as labor, capital, and natural resources (e.g., iron and aluminum used to make engines and fishing gear) are assumed to be hired or bought by other industries at equivalent prices.

Also recall from above that benefit-cost analysis and input-output analysis focus on different types of information. Benefit-cost analysis focuses on economic value and resource costs and on whether a regulation will increase economic efficiency from use of publicly owned fish stocks. *The strong emphasis placed on measuring changes in net national benefits—consumer surplus and producer surplus—is a hallmark of benefit-cost analysis and a significant difference between it and input-output analysis which inherently ignores changes in consumer surplus and does not appear to be developed sufficiently to measure regional changes in producer surplus.* In contrast, the garden variety of input-output analyses which are promoted by constituencies tend to focus on the *distribution* of financial gains and losses for their respective sectors instead of on estimating net changes in income or employment.

What constitutes direct, indirect, and induced effects needs to be reviewed, too, because of differences in meanings and because of implications for what is and is not measured. In input-output analysis, the "direct" effects of a regulation which influences final demand expenditures are spread across primary and intermediate *inputs from the entire economy*, including labor, capital, and privately owned natural resources such as land and caught-fish. Also, often when recreational fishing is being evaluated, consumption of goods and services which are unrelated to fishing trips, such as meals and souvenirs, are "direct" effects even when recreational fishing comprises only part of a vacation or trip.

"Indirect" and "induced" effects in input-output analysis arise only after increased revenues and income are respent in the economy. Note that depending on how the transaction flow table is configured, wholesale and retail trade of fish products could arise only from "indirect" and "induced" effects. Finally, consumer surplus enjoyed by seafood consumers and anglers, either from inside or outside the region, is disregarded in input-output analysis. In input-output analysis, consumers are important only for their expenditures.

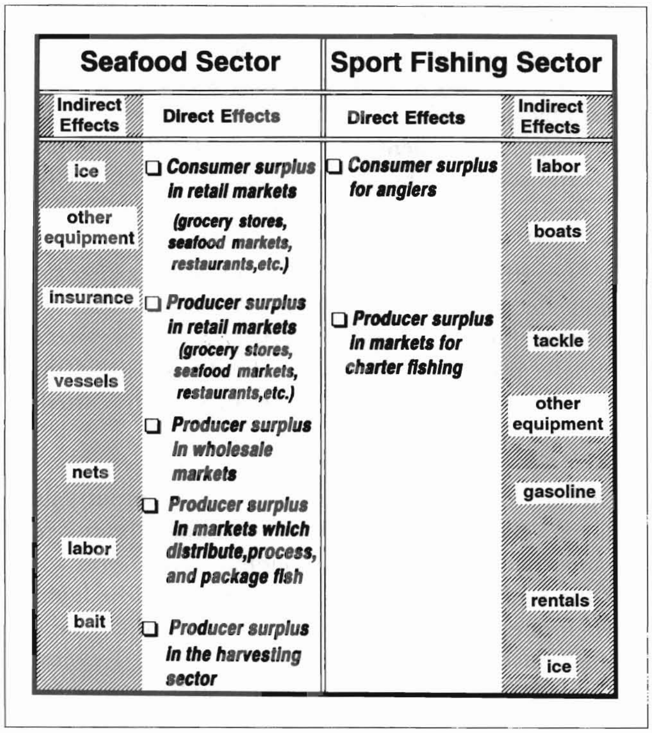

Figure 7

Benefit-cost analysis concentrates on changes in net national benefits (i.e., net economic value) associated with consumers and with industries which make fish available to consumers.

In contrast, *"direct" effects in benefit-cost analysis generally are confined to changes in net economic value in markets which trade the regulated fish resource* (Fig. 7). In the seafood sector, direct effects include both consumer surplus and producer surplus for commercial fishing companies and for other industries which distribute, process, and retail fish. On the recreation side, the analogous vertical integration of industries which catch and handle fish is condensed because the angler is, in effect, a sole "producer" except when charter services are hired to gain access to fish stocks. Otherwise, anglers combine bait, tackle, fishing poles, ice, and, in some cases, private or rental boats to catch, process, and consume fish.[10]

Also in benefit-cost analysis, "indirect" effects concern markets for all inputs other than fish which are employed by the fishing sectors. The long list includes labor, boats,

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[10] This inclusive description abstracts from the variety of anglers, some of whom catch but do not land and consume fish. Overall, however, it fits into a general type of household production framework. *See* McConnell and Sutinen (1982) for an application to fisheries.

engines, fishing gear, tackle, gasoline, bait, and ice (most of which are part of "direct" effects in input-output analysis), but, unlike input-output analysis, strictly excludes "induced" effects from the sale of products unrelated to fish or fishing such as souvenirs, visits to tourist attractions, and meals eaten on the fishing trip. However, two basic and sensible assumptions of benefit-cost analysis are that: 1) losses attributable to obsolete inventories of processed products such as fishing gear will be short-lived (and possibly negligible if the regulations are phased in); and 2) all primary inputs other than fish (many of which are part of "direct" impacts in input-output analysis) will be employed in other industries producing similarly valued commodities if not engaged in fish-dependent trades. Consequently, the possible "indirect" and "induced" components of changes in net national benefits are generally assumed to be zero unless prices in these related markets are expected to change.[11]

A final issue concerns the temporal distribution of effects. Input-output analysis abstracts from time, giving no indication of when or for how long impacts might take place. In contrast, the net economic value and resource costs of a proposed fishery regulation are intimately connected with time in a benefit-cost analysis, usually through the dynamics of the fish population and consideration of income flows to those affected.

Efficient Allocation

An appropriately standardized benefit-cost analysis of allocation between commercial and recreational fisheries would determine whether any of a set of proposed management measures would increase net national benefits from the use of fish for food and sport. As emphasized in the Comparison of BCA and IOA section, the comparison would include all relevant users from harvesters to consumers but exclude purely financial considerations (Fig. 7). Taken one step further, the analysis would identify which combination of shares would *maximize* net national benefits from use of a total allowable catch. Depending on the costs of management, the search for the most efficient allocation system could be tantamount to finding the one which maximizes the sum of consumer and producer surpluses in *both* uses. This section draws on the foundation of previous sections in order to illustrate several important—and possibly surprising—properties of such a maximization. In order to simplify the exercise, research, enforcement, and administration costs are assumed to be equal across allocations. These costs could be accounted for, however, in an actual application. *See* Rothschild et al. (1977) and Sutinen (1980) for related presentations.

The guide also culminates here by underscoring two mistaken arguments which characterize the commercial-recreational controversy. As emphasized previously, the improper use of input-output analysis to determine the relative economic value of commercial and recreational fisheries is promoted by sport fishing constituencies when revenues from the sale of fishing supplies and other goods and services to anglers (even goods and services which are unrelated to recreational fishing) are greater than dockside revenue and, sometimes, retail sales of seafood to consumers. The fishing industry has also indulged in this reasoning. This revenues-argument was discussed in the Benefit-Cost Analysis section and the Input-Output Analysis section. Also, exclusive use of a fish resource cannot be allocated even on the basis of which use derives the greatest *total* net economic value, let alone on the basis of total revenues (or expenditures). Contrary to this "total value argument," *tradeoffs in net national benefits from changes in shares of a catch quota must be used to identify an efficient allocation of a fish stock between commercial and recreational fisheries.*

An Illustration

In Figure 8, let the entire seafood sector be represented by a single demand curve that combines final demand by consumers with "derived" demands for intermediate fish products by all suppliers which distribute, process, and market fish in the seafood sector (Fig. 8, A and B). That is, the entire seafood sector's demand curve portrayed in Figure 8 actually includes producer surplus (as well as consumer surplus) in all markets which eventually make seafood available to consumers. Accordingly, the demand curve for the seafood sector subsumes consumer surplus and producer surpluses for each industry *except* the commercial fishing industry itself.[12]

The anglers' demand curve for *sport-caught fish* is portrayed in Fig. 8, C and D. Attributing all consumer surplus of *sport fishing* to the sport-caught fish would overestimate the value of sport-caught fish to anglers because other factors, including being outdoors and camaraderie, are also part of the fishing experience (Dawson and Wilkins 1981; Fedler 1984). Accordingly, only the demand for sport-caught fish is illustrated in Figure 8.

For simplicity, let producer surplus be zero for owners of commercial fishing vessels, although this assumption is false for "highliners" in a fishery. Also, the sport fishery could be diversified by adding producer surplus for the charter boat industry. However, expanding this exercise

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[11] This assumption is weakened by deviations from full employment and from pure competition in input markets and by anything short of instantaneous adjustment in input markets and costless relocation of inputs.

[12] Just et al. (1982) developed the general theory of "equilibrium" sector demand models. Unlike dockside demand, equilibrium demand for landings allows prices in other related markets to adjust endogenously.

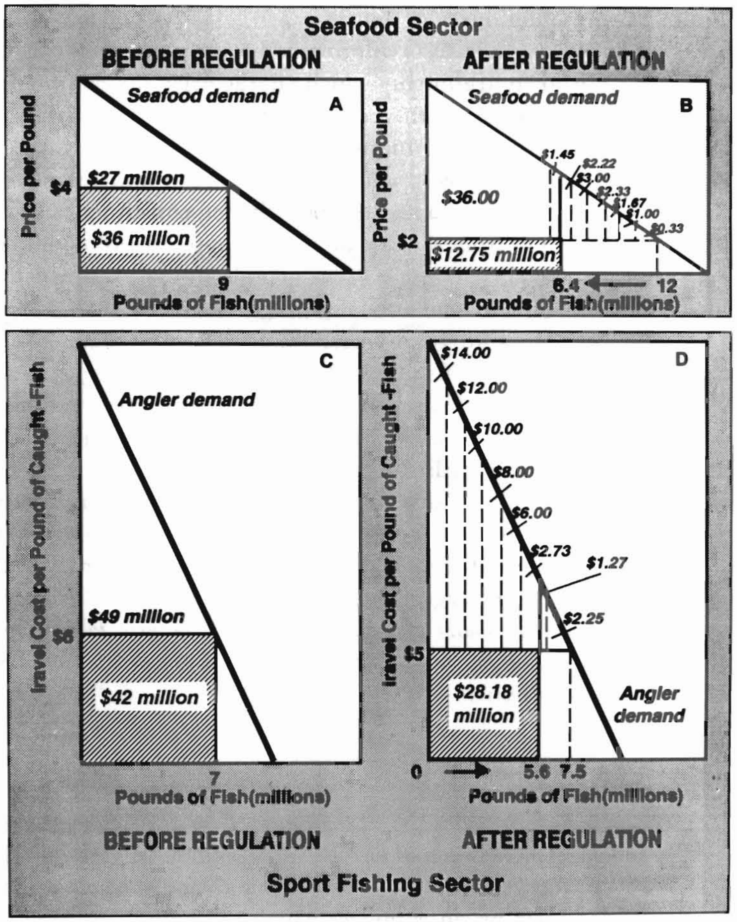

Figure 8

Effects of allocation on net national benefits (i.e., net economic value) in the seafood and sport fishing sectors.

to include these industries would only complicate the task without adding new insights.

As is usually the case, assume that resource costs can be accurately measured by the prices of fishing gear and other goods and services used to catch fish. Accordingly, let the initial resource costs of landing fish in the seafood sector be equal to the exvessel price of $4 per pound of fish. Also, at the current stock size let the resource costs of bait and other factors used to gain access to and to catch sport fish be constant at $6 per pound. That is, the anglers' costs of catching fish translates to $6 per pound.

Assume also that the hypothetical, open access fishery currently suffers from recruitment overfishing and that current landings of the 16 million pounds are not sustainable, but that a maximum sustainable yield of 12 million pounds of fish a year is considered by management to be "optimal" for increasing and stabilizing the stock.[13] At the larger stock size, let resource costs decline to $2 and $5 per pound in the seafood and sport fishing sectors, respectively, because the larger stock will increase productivity of both commercial fishermen and anglers (Fig. 8, B and D). If all resource costs associated with fishery management are independent of the management strategy (admittedly a naive assumption), how should the total allowable catch of 12 million pounds be allocated in order to maximize total net economic value? Other potentially important aspects of this allocation question, such as competition for space or local concentrations of fish and how fish size affects commercial and recreational value, could be factored in, but this complexity would also unnecessarily complicate the analysis.

If management followed the total value argument, or even, in this exercise, the revenues-argument, the species would be designated a game fish because both net economic

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[13] This simplified exercise abstracts from a formal economic assessment which simultaneously solves for the most efficient total allowable catch and shares. Also, I ignored stock externalities and the associated intertemporal social costs which give rise to the open access problem. *See* Bishop and Samples (1980) and McConnell and Sutinen (1979) for bioeconomic models of commercial and recreational harvesting in an optimal control framework. However, the exercise conforms to standard management practice of first using biological criteria to determine total allowable catch from a stock or management unit, and then allocating total allowable catch to user-groups.

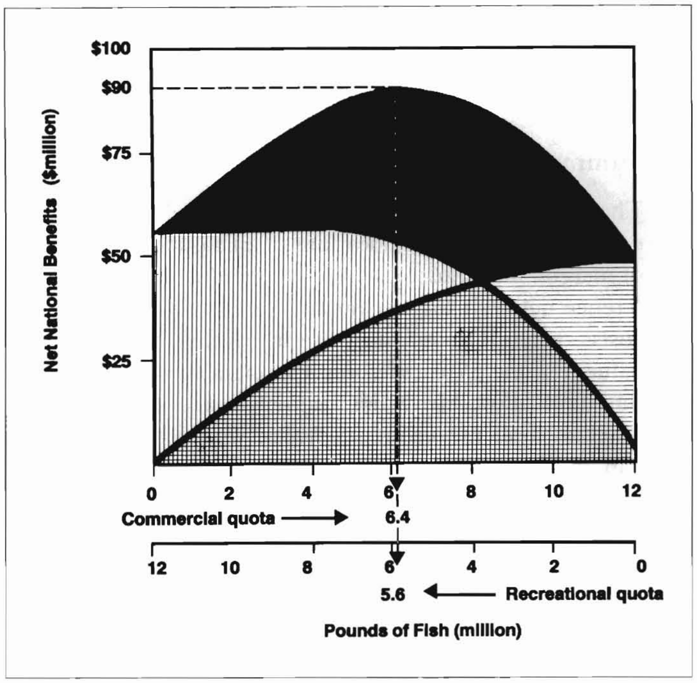

Figure 9
Total net national benefits (i.e., net economic value) from allocation of the 12 million pound total allowable catch quota.

value and total expenditures in the sport fishery ($49 and $42 million, respectively) are greater than their commercial counterparts ($27 and $36 million, respectively; Fig. 8, A and C). In fact, though, the allocation that maximizes total net economic value in the *combined* sectors actually slightly favors the seafood sector in this exercise!

To understand this possibly surprising result, first assign the entire total allowable catch of 12 million pounds of fish to commercial fishermen as begun in Figure 8B (the final shares are independent of the starting point). Next ask whether total net economic value would increase if the commercial fishing quota is reduced by, say, one million to 11 million pounds and the anglers' quota is simultaneously increased from zero to one million pounds. The partitions of the respective net value "triangles" in Figure 8, B and D show that the approximate $0.33 million loss in net economic value in the seafood sector is considerably less than the $14.00 million gain in consumer surplus by anglers, therefore, the new allocation results in an overall net gain of about $13.67 million in total net economic value.

Next ask whether total net economic value would increase further if the commercial fishing sector's share of the catch quota is reduced by a second million pounds of fish and the recreational quota is increased by one million to two million pounds? Total net economic value increases by $11.00 million (i.e., $12.00 million minus $1.00 million) from this second adjustment. The allocation of a third one million pounds increases total net economic value too, but, again, by a lesser amount ($10.00 million minus $1.67 million, or $8.33 million). The process continues until, finally, total net economic value is maximized when about 5.6 million pounds of fish are allocated to anglers, and about 6.4 million pounds of fish are allocated to the seafood sector.

Any adjustment in this maximally efficient allocation in favor of standard notions of equity or fairness would reduce total net economic value from use of the fish stock. For example, making the allocation equal by further reducing the commercial quota by about 0.4 million to 6 million pounds would increase consumer surplus for anglers by $1.27 million, but at the same time reduce net economic value in the seafood sector by more—by $1.45 million. In contrast, a share system which maintains the historical proportions of landings—56% for the commercial fishery (9/16), or 6.8 million pounds, and 44% for the sport fishery (7/16), or 5.2 million pounds—would diminish total net economic value too. Relative to the maximally efficient allocation, net economic value in the seafood sector increases by $1.35 million with an increased share of 0.4 million pounds, but net economic value in the sport fishing sector decreases by $1.55 million. (This tradeoff is not obvious from Figure 8.)

The efficient allocation of the 12 million pound total allowable catch may be easier to envision in Figure 9. Here, the vertical axis records net economic value from Figure 8, B and D, for the seafood sector, the sport fishing sector, and the two sectors combined. The horizontal axis records total allowable catch. The possible commercial and sport fishing shares run in opposite directions, such that at any point along the horizontal axis, the sum of the two shares is 12 million pounds.

The curve that increases steadily *from left to right* traces the *cumulative* amount of consumer and producer surpluses in the seafood sector as the commercial fishery's share increases from zero to 12 million pounds. For example, when exvessel price is held constant at $2 per pound as in Figure 8B (this is still assumed to measure resource costs), net economic value in the seafood sector increases from $0 to $7.7 million and then to $14.7 million when the commercial fishery's share increases from zero to one million and then to two million pounds. Similarly, the curve that increases *from right to left* accumulates the anglers' consumer surplus as their share of total allowable catch increases from zero to 12 million pounds. For example, when the resource costs of sport-caught fish are $5 per pound (Fig. 8D), consumer surplus increases from $0 to $14 million and then to $26 million as the anglers' share increases from zero to one and then to two million pounds. Total consumer surplus for anglers levels off at about 7.5 million pounds because, in this exercise, the anglers are not willing to pay $5 to catch additional fish (*see* the anglers' demand in Fig. 8D).

The "hill" in Figure 9 traces total net economic value in the combined sectors for each possible share system. Graphically, this hill is the vertical summation of net economic value in each sector. It is clear from this top curve that total net economic value is maximized at the apex, or at about $90 million where, as above, the anglers' share is about 5.6 million pounds of fish and the commercial fishermen's share is 6.4 million pounds. Any deviation from these shares would reduce total net economic value, including, as we saw above, "fair" allocations such as an equal apportionment or a system that is proportional to historical or current use.

Although not obvious from Figure 9, the net economic value of the 5.6 million*th* fish in the sport fishery and the 6.4 million*th* fish in the seafood sector are equal at nearly $3.75.[14] This latter property of the maximally efficient allocation illustrates the economic principle that in order to maximize the total net economic value from using fish for food and sport, an allocation must equate **marginal** net economic values from each conflicting use of the fish stock.[15]

Summary

The exercise in this section emphasized the importance of determining efficient allocations of a fish stock on the basis of incremental tradeoffs in net economic values—the difference between total economic value and total resource costs—when different uses are in conflict. Had the total value-argument (or revenues-argument) been applied and the total allowable catch been awarded completely to anglers, total net economic value would be only about $56.25 million (i.e., the entire area under the anglers' demand curve in Figure 8D and above the $5 cost line) instead of the $90 million achieved by the efficient allocation that includes the seafood sector. Indeed, in this exercise the stock would be underutilized if the entire total allowable catch of 12 million pounds was awarded to anglers because sport fishing costs amounting to $5 per pound of sport-caught fish result in a harvest of only about 7.5 million pounds by anglers (Fig. 8D).

Also notice that total net economic value in the regulated fishery (i.e., $90) is greater than under open access conditions (i.e., $76 million—*see* Fig. 8, A and C). Therefore, the regulation would pass the benefit-cost criterion to increase net economic value (provided that the increase in the total resource costs of management—including administrative, scientific assessments, and enforcement costs—is less than the increase in consumer and producer surpluses over time).

Finally, in this exercise the efficient allocation happens to increase surplus benefits in each sector (compare surplus values in Fig. 8A with Fig. 8B and in Fig. 8C with Fig. 8D). This improvement in each sector's net economic value occurs despite the *reductions* in total expenditures in *each* sector that result from how a larger stock size is expected to increase the productivity of anglers and commercial fishermen!

Of course, the maximally efficient solution to an actual fish allocation problem will be influenced strongly by the position and shape of the respective seafood and angler demand curves, as well as by the fish stock's population dynamics and the sensitivity of resource costs to stock size.

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[14] This and other results of this exercise can be shown mathematically. The demand models used to generate Figures 8 and 9.

$$\begin{array}{lrcl} \text{Seafood sector:} & q_f & = & 15 - 1.5c_f \\ \text{Sport fishing sector:} & q_s & = & 10 - 0.5c_s, \end{array}$$

where q_f and q_s are quantities demanded in the seafood and sport fishing sectors, respectively, and c_f and c_s are the corresponding costs of fish. Holding costs constant at $2 per pound in the seafood sector and $5 per pound in the sport fishing sector, the expressions for net value (v) in the respective sectors are

$$\begin{array}{lrcl} \text{Seafood sector:} & v_f & = & 10q_f - 0.335q_f^2 - 2q_f \\ \text{Sport fishing sector:} & v_s & = & 20q_s - 1.000q_s^2 - 5q_s. \end{array}$$

Next, maximize the sum of v_f and v_s with respect to the shares, q_f and q_s; subject to the constraint imposed by the total allowable catch quota:

$$\text{Maximize}_{q_f,\,q_s} \qquad V = (v_f + v_s) + \eta(12 - q_f - q_s),$$

where η is the Lagrangian multiplier. In this application, η is the net economic value of the marginal, or "final," fish allocated to both uses. The solutions to this system are $q_f = 6.375$, $q_s = 5.625$, and $\eta = \$3.73$. Finally, substituting the shares into their respective net benefit equations and adding the results yields $90.12 million in net economic value ($37.39 million in the seafood sector and $52.73 million in the sport fishing sector).

[15] This principle holds whenever the economic value of competing uses is compared, including conflicts between fishing and waste disposal, oil production, habitat destruction, and aquaculture.

In fact, it is conceivable that based on economic efficiency alone, the elimination of either a commercial or sport fishery would be necessary to maximize net national benefits. This would occur, for example, when the marginal net economic value of one use was *everywhere* greater than for the other use within the bounds of total allowable catch.

Summary and Conclusions

As stated in the Introduction, this guide was written both to expose specious economic-sounding arguments often heard when fish allocations are debated by commercial and recreational constituencies, and to provide fishery managers, policy makers, and other interested parties with a foundation in benefit-cost analysis as it applies to the allocation of a fish stock among competitive uses. Accordingly, the Economic Value section defined economic value; the Benefit-Cost Analysis section presented the elements of benefit-cost analysis; the Input-Output Analysis section outlined the elements of input-output analysis in order to explain why this methodology cannot be used as a surrogate for benefit-cost analysis; the Comparison of BCA and IOA section contrasted benefit-cost analysis and input-output analysis in greater detail; and the Efficient Allocation section illustrated the properties of an efficient allocation of total allowable catch between the seafood producing and the recreational fishing sectors.

Economic assessments of fishery allocations emphasize the following conclusions:

- In benefit-cost analyses of fishery management, economic value is the maximum amount that consumers are willing to pay for fish for food and for recreational fishing, and economic costs are the economic value of foregone production when resources such as labor, capital, and fish stocks are used to produce seafood or sport-caught fish instead of other goods or services which are valued by consumers and which would contribute to the nation's GNP. Neither expenditures nor revenues are notions of economic value. Net national benefits are, by definition, the difference between gross, or total, economic value and resource costs. Put another way, net national benefits are the sum of consumer and producer surpluses for seafood consumers, anglers, and all industries that catch, land, distribute, process, or otherwise make fish available to seafood consumers and anglers.
- Input-output analysis was originally developed to describe a region's industrial network and interdependencies in terms of expenditures and revenues. Multipliers are very useful indices of a region's self-sufficiency in input and output requirements and of the *distribution* of financial assets within a region. However, output multipliers and financial impacts have no relationship to benefit-cost analysis. Input-output analysis is not a surrogate for benefit-cost analysis.
- A fishery regulation which increases net national benefits promotes the efficient use of publicly owned fish stocks and, thereby, improves the overall economic well-being of the nation, although, generally, net *national* benefits will actually be concentrated regionally. An economically efficient allocation cannot be determined, however, from historical catch or equal shares, consumer expenditures, industry revenues, output and other input-output multipliers, or even a simple comparison of which sector leads to the higher total level of consumer and producer surpluses. Instead, net national benefits are enhanced when the *combination* of consumer and producer surpluses in *both* the seafood and sport fishing sectors are increased. Changes in economic surpluses in related input and retail markets (e.g., labor, gasoline, ice, fishing nets, tackle, meals, lodging) should be counted as negligible or zero unless there is significant unemployment of labor, capital, and/or natural resources.

If this guide clarifies concepts and methods applicable to benefit-cost analyses of fishery allocation, then it also underscores considerable incompatibilities among social goals and the influence of vested interests. That is, an inefficient regulation may support more jobs or may somehow appear "fair" if both the value-based and purely financial benefits and costs are shared more equally. Indeed, the most efficient regulation of a fishery will not necessarily promote a "fair" distribution of, say, consumer surplus and industry profits.

Clearly, given concerns about "fairness" and other social goals, conflicts surrounding fish allocations will be resolved politically whereas this guide focuses only on economic efficiency and the appropriate application of benefit-cost analysis. Nevertheless, deviations from the most efficient use of publicly owned fish stocks must be quantified and compared to net gains in employment and the distribution of financial assets which are expected from alternative management measures if informed decisions are to be made. This is the only way to gauge whether gains in areas other than efficiency actually justify losses in net national benefits.

Acknowledgments

This report is, in effect, a collaborative effort, although I am solely responsible for any errors or omissions. Phil Logan, Chief of the Economics Investigation at the Northeast Fisheries Center, NMFS, suggested that I write the report and devoted untold hours to thorough reviews. Dan Huppert, Wally Milon, and Jon Sutinen also commented extensively on an early draft. Others providing constructive comment were Jack Doll, William Emerson, John Gates, Jon Platt, Barbara Pollard, Dave Rockland, Michael Scott, Tim Tyrrell, John Walden, and the editor's two reviewers, including Terry Smith. Brenda Figuerido, the Center's graphics artist, provided able graphics assistance.

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Appendix A: Glossary and Index

See Greenwald et al.'s (1983) dictionary of economics for additional concepts. Page numbers follow each definition.

aggregate demand—the sum of each person's demand. (p. 5.)

benefit—in benefit-cost analysis, "benefit" is synonymous with value, or the *maximum* willingness-to-pay for a good or service, including environmental resources and services. It derives its monetary units from the willingness of consumers and producers to exchange income and revenue for goods, services, and inputs, but "benefits" could, in principle, be measured in terms of any constraint on choices, including leisure time. Total benefits include expenditures. See consumer surplus, producer surplus, and net national benefits. (p. 6.)

benefit-cost analysis—a methodology that compares economic value and the opportunity costs of using productive resources (i.e., resource costs). A project or regulation is efficient if its total value exceeds its resource costs (i.e., if the change in net national benefits measured in terms of changes in consumer surplus and producer surplus is positive). (p. 6.)

common property—classically, a resource such as a fish stock in the Extended Economic Zone, but also resources such as groundwater and open space, which are publicly owned and can be used in a physical sense. Because of the absence of private property rights and because users cannot be excluded from the resource, common property is generally "overexploited" in the sense that one person's use affects the productivity of others or the value that others derive from the resource. (p. 1.)

consumer surplus—the net economic value from consumption or use of a good or service. It is the difference between the maximum that a person is willing to pay for the good or service rather than do without it and what he/she actually spends. The adjective, "consumer" is misleading because this category of value also applies to nonconsumptive uses (e.g., observing salmon runs) and to nonuse benefits (e.g., protecting marine mammals from exploitation). (p. 4.)

contingent valuation method—a survey methodology in economics that is often used to elicit the value of natural resources and environmental services which are not adequately traded in markets. (p. 6.)

cost—*see* expenditures, opportunity costs, and resource costs. (p. 6.)

demand—in economics, the usually 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. (p. 4.)

direct effects—in input-output analysis, the amount of inputs required to produce the output necessary to satisfy final demand. (p. 11.)

economic impact analysis—*see* input-output analysis, the principle method. (p. 10.)

economics—in this primer, the study of how individuals and groups allocate scarce stocks such as income, time, and fish among competitive uses, and the responses to limitations on their choices, including fishery regulations. (p. 1.)

efficiency—in economics, an objective evaluation of the net national benefits of a public project or government regulation. Efficiency increases in proportion to increases in consumer surplus and producer surplus. (p. 8.)

expenditures—financial costs. Contrast with opportunity costs and resource costs. (p. 6.)

final demand expenditures—in input-output analysis, expenditures by consumers, investment by industry, government expenditures, and exports from the regional economy. (p. 11.)

final products—output sold to consumers. Contrast with intermediate product. (p. 11.)

financial analysis—cost accounting based on market prices as opposed to opportunity costs. Financial analysis is an important application of economic impact analysis. (p. 7.)

income—payments received by labor and other primary inputs including owners of capital and natural resources. (p. 10.)

indirect effects—in input-output analysis, the amount of inputs required to satisfy derived demands by industrial sectors after the first round of direct effects (p. 12.)

induced effects—in input-output analysis, the amount of inputs required to satisfy further increases in final demand which are induced by payments to primary inputs in response to direct and indirect effects. (p. 12.)

inputs—both a productive resource, such as labor, capital, land, water, and fish, which is used to produce an output for use by other industries or by consumers (also called factor of production) and intermediate products. In input-output analysis, inputs are expressed as expenditures. (p. 10.)

input-output analysis—a systematic method that both describes the financial linkages and the network of input supplies and production which connect industries in a regional economy (however defined), and predicts changes in regional output, income, and employment. Input-output analysis generally focuses on economic activity and the self-sufficiency of an economy, unlike benefit-cost analysis which focuses on changes in net national benefits from use of productive resources. *See* benefit-cost analysis and multipliers. (p. 10.)

intermediate product—a processed product from one industry which becomes an input in another industry. Contrast with primary input and final product. (p. 11.)

Keynesian multiplier—*see* **multiplier**.

marginal—a mathematical concept that in economics refers to very small, incremental changes in value and resource costs which add to or detract from the total amount. It gives rise to concepts such as marginal cost, marginal revenue, and marginal willingness-to-pay. (p. 20.)

multiplier—as generally used in input-output analysis, the ratio of total impacts on output, income, or employment in a regional economy divided by the respective direct impact initially generated by investment or consumer expenditures. The size of a **ratio multiplier** is indicative of the self-sufficiency of a regional economy's industrial complex, but ratio multipliers should be interpreted with extreme caution when comparing the potential impact of alternative public investments and government regulations. Unlike ratio multipliers, **Keynesian multiplier** is the total impacts on output, income, or employment per dollar of initial investment or consumer expenditures. **Type-I multiplier** (either ratio or Keynesian) includes direct and indirect effects of investment and consumer expenditures. **Type-II multiplier** also includes induced effects. (p. 12.)

net economic value—the net result after subtracting resource costs from consumer surplus and producer surplus. (p. 7.)

net national benefits—consumer surplus (total maximum willingness-to-pay minus expenditures) plus producer surplus. See value and resource costs. (p. 7.)

opportunity costs—generally intended to refer to foregone economic value when a productive resource, such as labor, capital, land, or fish, is used to produce one good or service instead of something else. *See* resource costs. (p. 7.)

output—a good or service created by a production process. In input-output analysis, output is sales or revenue. Contrast with intermediate product. (p. 10.)

primary input—in input-output analysis, labor, capital, entrepreneurial skills, taxes, rent payments, and imports used to produce goods and services. *See* income and value-added, and contrast with intermediate product. (p. 11.)

producer surplus—total revenue minus all opportunity costs of production, including the opportunity costs of the entrepreneurs' skills, labor, capital, and ownership of natural resources. (p. 8.)

profit—total revenue minus all financial costs for inputs, but not the opportunity costs attributable to entrepreneurs. Contrast with producer surplus. (p. 5.)

quantity-demanded—the amount of fish, fishing trips, or any other good or service purchased by a consumer at a given price or cost. In every day language, this is referred to as "demand." (p. 5.)

ratio multiplier—*See* **multiplier**.

resources—the productive inputs, labor, capital, fish, land, and other natural resources. (p. 7.)

resource costs—the value of forgone production when productive resources are used to produce one good or service instead of something else. This phrase is less ambiguous than opportunity costs because the latter could actually be applied to financial costs. (p. 6.)

revenues—gross financial benefit to producers. *See* profit. (p. 7.)

sectors—a group of industries which share a common characteristic. In input-output analysis, the industries in a sector have similar input requirements. In benefit-cost analysis, a sector tends to be a chain of vertically-integrated industries which increasingly transform a raw material into a form sold to consumers (harvest → wholesale → retail). (p. 10.)

supply—schedule of the quantities of goods and services that a business is willing to sell at various output prices. Other factors that affect supply include input prices. (p. 7.)

technical coefficients—in input-output analysis, the average amount of a sector's input which is required to produce $1 of output. (p. 11.)

total effect—In input-output analysis, the amount of output, income, or employment generated by a dollar of final expenditures, including the influence of respending. Total effects are also called Keynesian multipliers. *See* multipliers. (p. 12.)

transactions flow table—in input-output analysis, a matrix which organizes input requirements of a regional economy and the distribution of output among industrial sectors and final demand. (p. 11.)

transfer payments—transfers or exchanges of money (e.g., taxes, unemployment compensation, subsidies). Transfer payments redistribute income but not the total value of production. Hence, net national benefits are not affected by transfer payments. (p. 7.)

travel cost method—a methodology which uses travel-related costs to measure willingness-to-pay for natural resources and services, such as fishing trips and catch rates, and to estimate demand models. (p. 6.)

type I multiplier—*see* **multiplier**.

type II multiplier—*see* **multiplier**.

value—*see* maximum willingness-to-pay. Net value from consumption is consumer surplus and net value from production is producer surplus. In economics, value should be distinguished from financial benefits. It is misleading, therefore, that in benefit-cost analysis a "benefit" is a gain in consumer and producer surpluses and a "cost" is a loss in economic value (i.e., a resource, or opportunity cost). (p. 3.)

value-added—the difference between the price of a business's output and the opportunity costs of intermediate products used to produce the output. In input-output analysis, it is the increased value contributed by primary inputs, excluding imports. (p. 11.)

willingness-to-pay—in economics, what consumers are willing and able to pay for goods and services (including environmental goods and services) or what producers are willing and able to pay for inputs. (p. 4.)

Appendix B: Elements of Input-Output Analysis

This appendix presents technical aspects of input-output modeling. It begins with the transactions flow table presented in Section IV that is based loosely on Hushak's (1987) study of Ohio's Lake Erie commercial and recreational fisheries. See Archer (1977), Isard (1975), Miernyk (1966), Miller and Blair (1985), Propst and Gavrilis (1987), and Richardson (1972) for more details on modeling procedures.

Nearly all information required for standard input-output analysis is contained in a transactions flow table such as Table 4. The analysis is facilitated if we recognize that much of this table can be expressed in matrix form as a system of equations. Accordingly, the output of a producing sector is

$$\underset{\substack{\text{intermediate}\\ \text{demand}}}{\sum_{j=1}^{m} X_{ij}} + \underset{\substack{\text{final}\\ \text{demand}}}{\sum_{i=m+1}^{n} F_i} = \underset{\substack{\text{total}\\ \text{output}}}{X_i}, \qquad (1)$$

where "*i*" and "*j*" designate rows and columns, respectively. For example, the row for recreational fishing can be written

$$0 + 2 + 1 + 4 + 3 = 10. \qquad (2)$$

Similarly, inputs required by a purchasing sector are

$$\underset{\substack{\text{intermediate}\\ \text{demand}}}{\sum_{i=1}^{m} X_{ij}} + \underset{\substack{\text{value-added}\\ \text{demand}}}{V_j} + \underset{\substack{\text{import}\\ \text{demand}}}{I_j} = \underset{\substack{\text{total}\\ \text{inputs}}}{X_i}. \qquad (3)$$

For example, the input requirements for the recreational fishing sector can be expressed as

$$0 + 2 + 2 + 3 + 3 = 10. \qquad (4)$$

Notice that routine input-output analysis requires a sector's inputs and outputs to be equal (i.e., $X_i = X_j$). Accordingly,

$$\sum_{i=1}^{m} X_i = \sum_{j=1}^{m} X_j, \text{ and} \qquad (5)$$

$$\sum_{i=m+1}^{n} F_i = \sum_{j=m+1}^{s} (V_j + I_j). \qquad (6)$$

Also, regional income must equal final demand expenditures, adjusted for imports.

Together, Equations (1–6) are used to "reconcile," or balance the transactions flow table for a regional economy. Data plugged into the table can be primary data collected from regional surveys, or they can be secondary data generated from technical coefficients from another input-output model and from average output, input, and income relationships reported by the Bureau of the Census (e.g., Hushak et al. 1984). Often, regional economists use the "semi-survey" approach which combines surveys of sectors that are important to the analysis (e.g., commercial fishing and charter boat fishing) with secondary data.

What follows from here depends upon which primary input sectors and final demand sectors are included in the analysis. We begin with an analysis of type-I effects for which only sectors producing intermediate products are endogenous. Notice that Equations (1 and 2) for a single producing sector can be rearranged such that

Table 4

Transactions flow table ($ millions).

	Purchasing sectors (i.e., intermediate demand)			Final demand expenditures		
	Commercial fishing	Recreational fishing	All other industries	Households	Exports	Output
Producing sectors						
Commercial fishing	0	0	7	0	3	10
Recreational fishing	0	2	1	4	3	10
All other industries	2	2	43000	38000	18996	100000
Primary inputs						
Value-added	7	3	49992	0	—	
Imports	1	3	7000	10000	- 17004	—
Total inputs	10	10	100000	48004	1998	100020

$$X_i - X_{i1} - X_{i2} - X_{i3} = F_i. \tag{7}$$

Furthermore, if the amount of sector i's output purchased by each of the purchasing sectors is a linear function of the latter's output, we can express Equation 7 as

$$X_i - a_{i1}X_1 - a_{i2}X_2 - a_{i3}X_3 = F_i, \tag{8}$$

where the a_{ij} are the *technical input coefficients*,

$$a_{ij} = X_{ij}/X_i, \tag{9}$$

or the direct input requirements per dollar of output.

Equation (8) can be further generalized and used to derive *interdependence coefficients*. The system of three equations with form (8) can be written in matrix form,

$$X - AX = (I - A)X = F, \tag{10}$$

where, in this exercise, A is a (3×3) matrix of technical coefficients and I is a (3×3) identity matrix with "1"s along the diagonal and "0"s elsewhere. In our example,

$$A = \begin{bmatrix} 0.0 & 0.0 & 0.00007 \\ 0.0 & 0.2 & 0.00001 \\ 0.2 & 0.2 & 0.43000 \end{bmatrix}. \tag{11}$$

Finally, it follows that

$$X = (I - A)^{-1}F = BF, \tag{12}$$

where B is a matrix of interdependence coefficients. In our example, the B matrix of direct and indirect effects is,

$$B = \begin{bmatrix} 1.00002 & 0.00003 & 0.00012 \\ 0.00000 & 1.25000 & 0.00002 \\ 0.35089 & 0.43862 & 1.75444 \end{bmatrix}, \tag{13}$$

where b_{ij} is the total inputs required from sector i per dollar of final demand for sector j's output. For example, a $1 million increase in final demand for the recreational sector's output requires approximately $0.44 million in inputs ($j = 2$) from industries in the "other" sector ($i = 3$). Recall from the Input-Output Analysis section that these type-I impacts are the sum of direct and indirect effects.

Output multipliers associated with a change in final demand for each sector's output are simply the sums of the respective sectors' interdependence coefficients. Thus, the output multipliers for the commercial fishing, recreational fishing, and "other" sectors are 1.35091, 1.68865, and 1.75458, respectively. A sector's output multiplier expresses the total input requirements from *all* sectors required to produce $1 of its output.

Total impacts and ratio multipliers for income and employment are derived from their direct requirements and Equation (12). In our example, the direct requirements for value-added inputs (i.e., income to labor, capital, and land) are

$$C = \begin{bmatrix} \frac{7}{10} & \frac{3}{10} & \frac{49{,}992}{100{,}000} \end{bmatrix} = \begin{bmatrix} 0.7 & 0.3 & 0.49992 \end{bmatrix}. \tag{14}$$

Also, we are using the following direct employment requirements:

$$D = \begin{bmatrix} 0.00003 & 0.00002 & 0.00001 \end{bmatrix}. \tag{15}$$

For example, a dollar of output from the commercial fishing sector requires 0.00003 employees (i.e., each $100,000 of output requires three employees). In turn, the total income effects for each sector are

$$\text{Total income effects} = CB \tag{16}$$

where $CB = \begin{bmatrix} 0.87543 & 0.59429 & 0.87717 \end{bmatrix}$. For example, $1 million of final demand for commercial fisheries generates about $0.88 million in income for primary inputs. Similarly, the total employment effects for each sector are

$$\text{Total employment effects} = DB, \tag{17}$$

where $DB = \begin{bmatrix} 0.0000335 & 0.0000294 & 0.0000175 \end{bmatrix}$. For example, in this exercise, $1 million of final demand for recreational fisheries generates about 29 jobs. Finally, the ratio multipliers for income and employment effects are simply total effects divided by direct effects. See Table 2 in the Input-Output Analysis section for a summary of the various type-I impacts and multipliers.

Recall that type-II effects include induced effects. This expansion of input-output analysis requires the technical coefficients matrix to be augmented by one row for value-added inputs and by one column for final household demand:

$$A = \begin{bmatrix} 0.0 & 0.0 & 0.00007 & 0.000000 \\ 0.0 & 0.2 & 0.00001 & 0.000083 \\ 0.2 & 0.2 & 0.43000 & 0.791600 \\ 0.7 & 0.3 & 0.49992 & 0.000000 \end{bmatrix}. \tag{18}$$

Notice that the fourth column corresponds to household expenditures and is calculated by dividing entries in the transactions flow table by total household expenditures (i.e., by $48,004).

Calculation of total type-II effects and ratio multipliers is analogous to the type-I calculations with the addition of a fourth column for direct income and employment effects in matrices C and D, respectively. In our example, these columns have zero entries. Type-II results are also reported in Table 2 in the Input-Output Analysis section.

Appendix C: General Equilibrium Demand in an Exvessel Market

Just et al. (1982) present theory and practical advice for estimating multimarket changes in net economic value behind a single derived demand curve when a resource market supplies a necessary input to related markets.[1] Their contribution is important in the context of fishery management because the data required to estimate separate welfare changes in exvessel, wholesale, and retail markets for fish generally are not available. This appendix (which augments the discussions in the Benefit-Cost Analysis section, the Comparison of BCA and IOA section, and the Efficient Allocation sections of net benefit estimation in seafood markets) is adapted from Chapter Nine in Just et al. (1982). Rigorous, mathematical proofs supporting the heuristic presentation here can be found in their Appendix D, "Welfare Measures for Multimarket Equilibrium." For empirical applications to commercial fisheries see Edwards (1981) and Ready and Bishop (1988).

This presentation derives from the demand and supply relationships depicted in Figure 10. Figure 10A contains the wholesale industry's input demand curves in an exvessel market for marine fish: $D_e(p_w{}^0,\delta)$ and $D_e(p_w{}^1,\delta)$. Although not shown explicitly, resource supply is assumed to be perfectly inelastic. For now, ignore $D^*(\delta,\theta,\bar{p}_r)$. In Figure 10B, $S_w(p_e{}^0,\delta)$ and $S_w(p_e{}^1,\delta)$ are wholesale supply curves and $D_r(\bar{p}_r,\theta)$ is the derived demand of retailers. (For simplicity, the various possible wholesale markets—distributors and processors—are aggregated.) In Figure 10C, we assume for the moment that consumer demand in the retail market is perfectly elastic and, therefore, represented by $\bar{p}_r$. $S_r(p_w{}^0,\theta)$ and $S_r(p_w{}^1,\theta)$ are retail supply curves. The other prices, p_e and p_w, are exvessel and wholesale prices, q_e, q_w, and q_r are exvessel, wholesale, and retail quantities, and δ and θ are exogenous determinants of wholesale and retail supply, respectively. The superscripts, ^{0} and ^{1}, denote initial and final prices and quantities, respectively.

The starting point for our comparison of welfare "triangles" in the three markets depicted in Figure 10 is the understanding that producer surplus measured behind a retail supply curve is completely captured behind the demand curve for an essential input.[2] Accordingly, area $x + y$ behind wholesale supply curve, $S_w(p_e{}^0,\delta)$ is equal to area $a + c$ behind exvessel demand, $D_e(p_w{}^0,\delta)$. Similarly, area $x + u$ behind $S_w(p_e{}^1,\delta)$ is equal to area $a + b$ behind $D_e(p_w{}^1,\delta)$.

Next consider a fishery regulation which effectively increases the stock of fish available to anglers but reduces commercial catch from $q_e{}^0$ to $q_e{}^1$ and increases exvessel price from $p_e{}^0$ to $p_e{}^1$—possibly a ban on a commercial fishing in state waters. This regulation sets off a series of adjustments in the seafood sector, beginning with a shift in the wholesale supply curve from $S_w(p_e{}^0,\delta)$ to $S_w(p_e{}^1,\delta)$. Consequently, wholesale price increases from $p_w{}^0$ to $p_w{}^1$,

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[1] Just et al. (1982) define a necessary input (also called essential input) as one for which a firm will exit the industry if the input is either not available or priced above the firm's willingness-to-pay.

[2] This statement derives from duality theory and the envelope theorem. (*See*, for example, Just et al. [1982].)

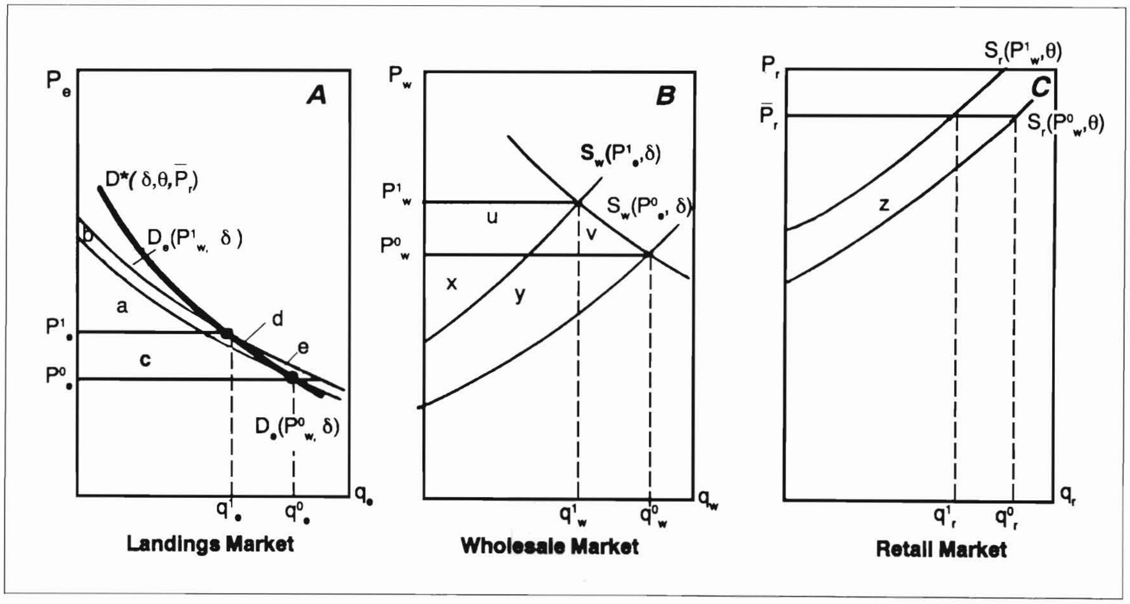

Figure 10
Net national benefits (i.e., net economic value) behind a vertically integrated exvessel demand curve.

causing derived demand in the exvessel market to increase to $D_e(p_r^1)$. Notice that $D^*(\delta,\theta,\bar{p}_r)$ (which is described later as sectoral demand) connects the initial and final equilibrium positions in the exvessel market. (Notice also that retail price remains constant by assumption, and, therefore, derived demand in the wholesale market does not shift.)

What are the complete welfare implications of this regulation and how can the change in net total economic value be measured? As begun above with reference to duality theory, the change in the wholesale industry's surplus can be measured in either the wholesale or ex-vessel markets. In the wholesale market the change is area $x + y$ minus area $x + u$, or area $y - u$. Equivalently, the change measured in the ex-vessel market is area $a + c$ minus area $a + b$, or area $c - b$. Hence, area $y - u$ is equal to area $c - b$.

This assessment is incomplete, however, until we include the welfare changes for retailers and commercial fishermen (and, later, consumers) imposed by reduced landings. In Figure 10B, the change in the retail industry's surplus is area $u + v$ (or area z in Fig. 10C). As a result, the total change in producer surplus in the wholesale market is area $u + v$ plus area $y - u$, or area $v + y$. Finally, although the information is not shown on Figure 10A, the change in the commercial fishing industry's producer surplus can be calculated as the change in total revenue due to reduced catch minus the change in total costs due to increased travel distance. Unfortunately, information required to estimate a system of demand and supply curves (e.g., retail prices) generally is lacking. Thus, from an applied perspective we have not yet answered how to measure the total change in net economic value caused by the fishery regulation. The answer lies behind curve $D^*(\delta,\theta,\bar{p}_r)$ in the exvessel market in a manner of speaking. That is, the derived demand curve for a hypothetical integration of wholesalers and retailers is $D^*(\delta,\theta,\bar{p}_r)$ where wholesale price, p_w, adjusts *endogenously*. This follows under competitive market conditions because profit maximization by the hypothetical integrated industry is equivalent to profit maximization by the individual industries. Thus, $D^*(\delta,\theta,\bar{p}_r)$ takes account of equilibrium adjustments in prices and output in related markets. (Again, the reader is referred to Appendix D in Just et al. [1982] for a rigorous proof.) Accordingly, area $c + d$ is equal to area $y + v$ in the wholesale market (i.e., the net change in the wholesale and retail industries' producer surplus).[3]

Approaching these results from another direction will shed some light on the theory. Let the wholesale industry's "ordinary" exvessel demand curve be

$$q_e = \alpha_0 + \alpha_1 p_e + \alpha_3 p_w + \alpha_2 \delta. \qquad (19)$$

Also, let the price linkage between markets be

$$p_w = \beta_0 + \beta_1 p_e + \beta_2 \delta + \beta_3 \theta + \beta_4 \bar{p}_r. \qquad (20)$$

Finally, substitution of linkage (20) into demand model (19) yields what Just et al. (1982) label the "equilibrium" demand curve,

$$q_e = (\alpha_0 + \alpha_3\beta_0) + (\alpha_1 + \alpha_3\beta_1)p_e + (\alpha_2 + \alpha_3\beta_2)\delta + \alpha_3\beta_3\theta + \alpha_3\beta_4 \bar{p}_r. \qquad (21)$$

At least two properties of equilibrium demand curve (21) are important. As illustrated in Figure 10A, the inverted equilibrium demand model has a steeper slope than the market demand model. In addition, wholesale price, p_w, varies endogenously in an equilibrium exvessel demand model unlike in an market demand model where the wholesale price variable (or an instrumental variable from, say, the first stage of two stage least squares) is specified. This feature allows researchers to estimate changes in net benefits in wholesale and retail markets behind an appropriately specified ex-vessel demand model such as model (21). Note, however, that dropping related market prices such as p_w from the exvessel demand curve due to severe multicollinearity does not accidentally result in a general equilibrium demand model unless it is accompanied by specification of the exogenous determinants of wholesale and retail supply.[4]

We can now introduce the effects of a downward sloping consumer demand model. Although not demonstrated graphically, the equilibrium exvessel demand model becomes $D^*(\delta,\theta,\varepsilon)$ where ε is a vector of exogenous variables affecting consumer demand (e.g., income). In principle, then, changes in the area behind an equilibrium derived demand curve at the exvessel level can be used to measure changes in consumer surplus as well as changes in producer surplus in wholesale and retail markets given data on exvessel price and the exogenous determinants of wholesale supply, retail supply, and consumer demand. Model (21) now becomes

$$q_e = (\alpha_0 + \alpha_3\beta_0) + (\alpha_1 + \alpha_3\beta_1)p_e + (\alpha_2 + \alpha_3\beta_2)\delta + \alpha_3\beta_3\theta + \alpha_3\beta_4\varepsilon, \qquad (22)$$

where ε substitutes for $\bar{p}_r$. Accordingly, the total change in net national benefits (i.e., net economic value) due to a fishery regulation is

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[3] The change in the retail industry's surplus also can be isolated from these results. In particular, since the total change in producer surplus (excluding, for the moment, effects on the fishing industry) is $c + d = y + v$ and the change in wholesalers' surplus is $c - b = y - u$, the change in the retail industry's surplus is $d + b$ by subtraction.

[4] Similarly, simultaneous equations estimators do not produce general equilibrium demand (or supply) models because the original structural identities of the ordinary market models remain unchanged.

$$\Delta NNB = \Delta R_0 + \Delta S_0 = \Delta R_0 + \sum_{i=1}^{N} \Delta R_i + \Delta CS_N, \quad (23)$$

where ΔR_0 is the change in the *fishing industry's* producer surplus, ΔS_0 is the total change in producer surplus and consumer surplus in wholesale and retail markets, and N is the retail market. ΔS_0 is comprised of ΔR_i, the change in producer surplus for each wholesale and retail industry, and of ΔCS_N, the change in consumer surplus.

Although we concentrated on a competitive vertical market structure, Just et al. (1982) extend their theory to market distortions, a horizontal market structure, and, naturally, a combination of both structures. Indeed, whether a researcher captures general equilibrium changes in welfare depends on whether the theoretical model's assumptions concerning necessary-inputs and pure competition are reasonably satisfied, and on whether the appropriate set of related markets are included in the "mini-economy." Determinants of a "mini-economy" include prices in excluded markets (perhaps a price index), policy instruments such as taxes, and relevant natural, social, and political variables which shift ordinary demand and supply. Of course, applied economists must balance theoretical requirements of the method against the availability of data and decide whether an adequate assessment is possible. In specific applications, researchers should carefully consider whether horizontally-related markets for other inputs such as labor and for consumer substitutes should be internalized.

The multi-market framework which allows one to measure welfare changes completely in a single market seems ideally suited for fishery problems given the competition assumptions and the necessary-input requirement. Typically, fish, shellfish, and crustaceans are processed through vertically structured markets. Also, to a large extent, the industry is competitively structured because of the large number of firms in each market and because of the availability of market information. Furthermore, given the fishing sector's small size in relation to the national economy, price and quantity changes probably have small (if not negligible) effects on the rest of the economy. Also, the supply of other inputs to the fish processing sector may be nearly perfectly inelastic, although this would not be the case for labor in isolated communities. Furthermore, the multi-market framework may be the most tractable alternative for measuring combined changes in producer surplus and consumer surplus in the wholesale and retail sectors. Inadequate data and severe multicollinearity among exvessel, wholesale, and retail prices probably preclude measuring welfare changes behind ordinary demand and supply curves; therefore, the distribution of welfare changes could not be measured. The multimarket framework also offers an attractive alternative to the difficult expansion of input-output analysis for the measurement of changes in producer surplus (*see* Hushak 1987) whenever prices in other input markets change in response to a fishery regulation.