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Improved Fisheries Policy Through Economics

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Fisheries management exists as a result of humans interfering with the lives of fish -- by using their home as a place of recreation, by using their water for human consumption and industry, and by using the fish themselves as a source of food and other products. The successful management of fisheries, therefore, requires not only the expertise of biologists to manage the fish but the expertise of economists and social scientists to manage people.

This publication illustrates economic models and policies that can be applied to the effective economic management of fisheries, using concepts such as taxation and subsidies, property rights, gross and net willingness-to-pay, consumer surplus, use value, existence value, option value, travel cost, contingent valuation, and hedonic prices. It also refers to Garrett Hardin's 1968 essay, "Tragedy of the Commons," to illustrate the need to understand and incorporate human behavior in natural resource management when the environments and needs of humans and other animals overlap.

For successful fisheries management, biologists have a comparative advantage in addressing the biology of fish, but economists and social scientists know more about how people respond to characteristics of fishery resources, how people are likely to use fisheries with various characteristics, and the resulting values people place on these fisheries. Economists and social scientists can help biologists understand why people respond in unexpected ways to command and control management strategies and how to modify policies to obtain the desired fishing effort levels.

Considering how the interests of fish and people overlap, this author argues that economists and social scientists need to be involved in developing and implementing fishery policies. Improved recreational policy requires surveys of anglers and boaters, which will translate, into numbers, the value these people place on fisheries. These data can help managers determine when, for example, a particular fishery risks becoming overfished by people.

It is with this understanding -- that the interests of fish and people overlap considerably -- that the author of this publication claims that the proper management of fisheries requires the active participation of economists and social scientists and the input of more hard data, not only about fish but also about people.

Economic Information in U.S. Fisheries Policy: Gaps Between Theory, Information, and Capability[1]

The successful management of fisheries actually calls for the management of two different animals -- fish and the people who catch them. Management agencies employ biologists to understand and manage the one; it is this author's contention that agencies must employ sociologists and economists to understand and manage the other.

Without human interference, fish populations would manage themselves. But humans do interfere with fish populations and intrude themselves to such a degree that, for their own preservation, fisheries must be managed. The *economic* management of fisheries relies on two essential pieces of information. First, we need to know the value people place on various fisheries for recreational and commercial purposes. To estimate commercial value, standard market tools will suffice (with adequate data and in the absence of major market externalities). Determining the value of recreational fisheries, however, requires a good database of the people who use them, and their attitudes and behavior. Second, we need to know how a fishery *changes* in its value to commercial and recreational anglers with a change in the fishery. This also necessitates a database of people's attitudes and behaviors.

Unfortunately, there is a bias in U.S. funding of research toward the development of new theoretical and quantitative tools without obtaining the sort of empirical data mentioned above, on which management decisions need to be based. Granted, the new theoretical approaches have been highly productive, but, for management policies to be adequate, some sort of balance needs to be struck between the theoretical and empirical.

Economic Valuation Of Recreational Fisheries

There has been rapid improvement in theoretical and quantitative models for estimation of the net economic value or welfare of fisheries resources (consumer surplus, producers surplus, etc.). The travel cost approach has been improved significantly since it was first suggested by Hotelling (1949), both in terms of theoretical specification and empirical estimation (see Table 1 for definitions of terms). In addition, the more recent contingent valuation (CV) provides the potential to estimate existence and option values of recreational resources as well as user values. And, although economic policy tools such as taxes, subsidies, and transferable quotas are still largely textbook models with few specific applications to particular problems or settings, the experimental use and study of Individual Transferable Quotas (ITQs) is a notable exception.

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[1] This manuscript was presented at the World Fisheries Congress, Athens, Greece, 3-8 May 1992 and will be published in the Proceedings of the Congress and later made available by Ohio Sea Grant as a reprint.

The major national source of data for recreational fishing behavior in the U.S. is the National Survey of Fishing, Hunting, and Wildlife Associated Recreation, published every five years by the U.S. Fish and Wildlife Service. Most recreational studies, however, are based on special data surveys for the particular fishery being studied.

Dwyer et al. (1977) review early development of Hotelling's travel cost method that involved estimation of the equation

Trips/visits = f (trip cost, population of zone, proximity of substitute sites, site quality) (1)

These early models were estimated using zonal or area data on number of visits from and characteristics of predefined zones. As researchers began to collect data on individual recreational behavior, they began estimating travel cost models using this individual-based data. Most of these estimates were biased in one or more ways, through use of continuous estimation methods on truncated data sets, use of data that did not sample the complete population of potential users of a site, and omission of the value of travel time. Sorg and Loomis (1984), Walsh et al. (1988), and Smith et al. (1989) have developed procedures to adjust these biased estimates. Comparison with more recent studies using unbiased procedures, however, suggests that these adjustments are not adequate.

Table 2 provides the estimates of economic value per day from the American Fisheries Society (AFS) (1992). Nearly all of the travel cost method (TCM) estimates were made using ordinary least squares regression and adjusted using Sorg and Loomis. Two exceptions are the Ohio estimates for walleye and yellow perch, which were estimated using a truncated least squares or conditional maximum likelihood estimator. The comparable estimates from ordinary least squares regression were about $25 each day, or five times greater (Hushak et al. 1988). The Sorg and Loomis correction is about 20 percent.

Perhaps the most important development was the derivation and standardization of censored and truncated econometric procedures (Maddala 1983). These procedures permitted joint accounting for changes in participation rates and for changes in the frequency of participation as trip costs changed. There were important theoretical developments as well.

Bockstael et al. (no date) and Bockstael et al. (1987) developed models that distinguish between those who can substitute work and leisure time and those who cannot. Kealy and Bishop (1986) specified their model in terms of recreation days rather than trips or visits in order to account for trips of varying duration. McConnell and Strand (1981) and Smith et al. (1983) provide techniques for estimating the value placed on human time during recreation trips. Pollak and Wales (1980, 1981) provided models for the incorporation of demographic characteristics of recreators into demand models. The repackaging model of Wilman (1987) specifies a procedure whereby trips of differing characteristics can be grouped into subsets of trips, and then demand functions for each type of trip with substitution between types of trips are estimated.

Probably the most useful approach uses a two-step hedonic model originally proposed by Rosen (1974), called the Hedonic Travel Cost Method (Smith and Palmquist 1989; Smith et al. 1989). In the first step, hedonic equations are estimated of the form

Price = f (quantity/quality of recreation site amenities) (2)

In step 2, called the Hedonic Travel Cost Function, the hedonic price (HP) (the regression coefficient of each amenity in equation 1) is regressed on the vector of amenities

HP = g (quantity/quality of recreation site amenities) where HP is the hedonic price (3)

A major problem with this approach is that the coefficient of each amenity in equation 2 is regressed back on the quantity of that amenity in equation 3. Brown and Mendelsohn (1984) propose market segmentation, where separate hedonic equations 2 are estimated for each market segment. The "independent" estimates of the hedonic price of each segment are then used to estimate equation 3. Kriesel (1988) attempted to use this model to estimate the marginal value of added years of expected life of shoreline property. He used the hedonic equation 2, but backed away from using step 2 because he was unable to segment his market. Smith et al. (1989) use multiple hedonic price equations 2 in generating hedonic prices for use in equation 3. Caulkins et al. (1986) address site-quality issues using a multinomial logit model, a potential alternative to the hedonic travel cost model.

Jeng (1990), in her attempts to estimate the repackaging model of Wilman (1987), developed the hedonic price equation 2 for the estimation of endogenous trip prices that include endogenous on-site monetary and human time costs:

Price = h (trip duration, recreator characteristics) (4)

Because trip duration is also endogenous, it is predicted by the equation

Trip duration = h' (distance, recreator characteristics) (5)

Since Jeng's focus (see also Hushak and Jeng 1990) was on trip duration and on respondent characteristics, her problem was to generate a trip price that incorporated on-site costs of a heterogeneous trip, which varied in duration, but excluded elements of on-site costs that reflected tastes, income, or other factors. This "predicted" price, as estimated from equation 4 as the predictable portion of reported trip price, was then used as the trip price in the recreation demand equation

Trips = k (price, recreator characteristics) (6)

Jeng successfully estimated this model using data subsamples of recreators who can and cannot substitute work and leisure time as suggested by Bockstael et al. (1987). However, her attempts to separate the sample into trips of varying duration (a major trip characteristic) to estimate Wilman's repackaging model were not successful because of high multicolinearity across the prices of trips of varying duration.

Estimates of economic value in the form of willingness-to-pay or consumer surplus from these models is a base for fisheries policy or management (see Table 1 for definitions of terms). They provide insights about how various fisheries are valued by recreators and other users and the potential benefits from various management strategies. However, the theoretical models are still rapidly changing, and the estimates are still necessarily preliminary.

One example of the need for economic value information is the development of a strategy by AFS to assist fisheries managers in assessing damages in fish-kills due to toxic substance discharges or other reasons. In 1982, AFS published a document that contained guidelines for counting dead fish in fish kills and provided the hatchery costs of replacing these fish (AFS 1982). Since 1982, several states have used these guidelines.

These procedures are adequate where killed fish can be replaced immediately with like-sized fish. However, they lack the capability of assessing damages due to lost recreational days, where the fishery is allowed to or must rehabilitate itself through natural processes, or where smaller fish are stocked and allowed to grow to the size of killed fish. In 1989, under a grant from the U.S. Fish and Wildlife Service, the Socioeconomics section of AFS undertook a project to update the hatchery cost estimates and also to compile the existing literature on economic values of lost recreational and commercial fishing days, or lost harvest, by state and by species (AFS 1992, 1993). The compilation of results of these studies for freshwater studies is shown in Table 2. Given the rapid change in theory and the large number of fisheries and fish species, however, we seldom find more than one study for any given species in a specific fishery. In addition, studies of a given species across fisheries are usually done with sufficiently different methods and data limitations that comparability across species is questionable.

Economic Tools for the Management of Fisheries

The current approach to fisheries management in the U.S. is to manage fishing seasons, with daily bag limits or quotas on individual species and for individual anglers (commercial or recreational). If anglers were to respond to these tools in the way desired by the management agency, then overexploitation would not occur and fisheries would not be destroyed.

Commercial fishermen, however, are economically rational people; they harvest fish as long as the cost of harvesting an additional fish does not exceed the price they are paid for it at the dock. If each commercial fisherman owned his/her own plot of fishery, as farmers do, they would take account of stock changes and implications for future harvests, and not over-harvest their fishery plot.

Sport anglers, likewise, want to engage in fishing as long as the satisfaction gained from fishing exceeds its monetary and time costs to them. As with commercial fishermen, sport anglers do not realize that in catching and harvesting fish, they are, jointly with other anglers, contributing to significant decreases in the total stock of fish.

Throughout history, common property resources such as fisheries, over long periods of time, have been successfully "managed" by the people using them through various community sanctions against anyone violating the trust of the "commons." These systems of management were successful during periods when technology was stable and when the demands for the goods and services provided by the commons were stable. The systems required the ability of the common users to impose sanctions on each other and to limit the use of the commons by those who were not one of the common "owners."

However, the conditions under which the requirements for successful management of the commons can be imposed are fragile. When technology changed or when new demands on the resources of the commons arose, the implicit sanctions broke down. When the common "owners" lose control of the commons, the resource(s) becomes what we call "open access," where everyone has rights to use the resource with no means of imposing sanctions, except by government. In the example of redfish, in which a seafood fad for blackened fish swept the U.S. and depleted stocks, a working situation broke down because of increased demand, resulting in incentives to increase the commercial harvest, which the then-existing policy was unable to control.

The case of redfish is an example of what Harden (1968) calls the "Tragedy of the Commons." In trying to maximize profits, fishermen do not recognize how their individual actions in aggregate serve to deplete the fishery. To restore stability to an open-access resource, one must restore a set of sanctions or incentives to convince users to reduce use to sustainable levels. An improved information base from travel cost or contingent valuation studies on how resources are valued would improve our ability to predict when an existing situation is likely to break down by being better able to predict changes in demand for the resource.

This "Tragedy of the Commons" is illustrated in Figure 1 from Tietenberg (1984, p. 196). For discussion purposes, it is assumed that fish price is constant, so that any variation in revenues is due to changes in fishing harvest resulting from changes in fishing effort. For the fishery as a whole, each unit of increased effort results in declining marginal revenue in the lower portion of Figure 1 because of reduced harvest per unit of effort. However, each angler, commercial or recreational, has such a small impact on the harvest rate that each experiences the fishery's average revenue (and harvest rate) as its marginal revenue rate. When the average revenue for the fishery (= marginal revenue for the individual angler) is equal to marginal = average cost at a level of fishing efforts which exceeds point b in the lower portion of Figure 1 (where the marginal revenue = 0, and which is also the maximum revenue point in the upper portion of Figure 1), then the fishery will be depleted. To prevent the "Tragedy of the Commons," management policy must reduce fishing effort below level b.

Management strategies such as fishing seasons, bag limits, or quotas tell anglers, commercial or recreational, to stop fishing when, in their view, it is still profitable to do so, i.e., when their "marginal" revenue from additional fishing effort at any level less than point c exceeds marginal cost. Anglers have incentives to "break" the law, and evidence suggests strongly that they do so. The record of success for these strategies is not good; some would argue that it is dismal! Therefore, there has been increasing call to try the tools of the economist that more directly impose total fishery stock effects on individual anglers, commercial or recreational (Tietenberg 1984; Howe 1979).

Where possible, the most effective policy would be to assign long-term property or harvest rights to individual commercial anglers over explicit areas of water. This policy would work where species are not highly mobile and where the citizenry, including sport anglers, accept limitations on access to the fishery waters. Such a policy would create "mini" fisheries where each angler faced the downward sloping marginal revenue curve in Figure 1. However, such policies are usually not feasible, because the species are mobile or they are in waters to which the citizenry demands access, at least in the U.S.

Where property rights assignments are not feasible, economists recommend alternative incentive policies such as taxes or subsidies, input purchases, or several forms of quotas. Taxes may be levied on units of fish harvested or on inputs such as the size of the fishing vessel, the size and type of gear, or the amount of labor. Or, subsidies may be paid to producers to idle resources, such as payments for so many days of use of a fishing vessel. In Figure 1, these taxes or subsidies have the effect of raising the marginal = average cost curve. This subsidy strategy has been used for many years in U.S. agriculture to purchase the annual services of land from landowners in order to reduce crop output. Although economists argue that such a subsidy strategy is not efficient because it affects only one input and commercial anglers would simply use other resources (vessels not idled, labor, and harvest gear) more intensively, it is much more effective than seasons, bag limits, or quotas.

Another economic-based management strategy that has potential in fisheries management is to purchase inputs from producers. In U.S. agriculture policy, there are provisions for long-term idling of sensitive lands through longer term agreements, usually of about 10 years. In Ohio, the Division of Wildlife was legislatively forced in 1982 to purchase gill nets from commercial anglers to reduce yellow perch harvest and the incidental catch of walleye. The gill net is by far the most effective and efficient harvest gear for yellow perch. Whereas even economists would have argued that this strategy was not efficient nor needed at the time it was implemented, it was effective in reducing yellow perch harvest and eliminating incidental harvest of walleye. The purchase of certain types of harvest gear, thereby eliminating them from use in a fishery, can be an effective and reasonably efficient strategy where destruction of a fish stock is occurring, or where bycatch is a serious issue.

Quotas of various types have been used by fisheries managers, but are effective and efficient management tools only under certain conditions. The first condition is that harvest can be monitored under the quota because a quota does not have a direct effect on the marginal cost of harvesting fish. If this is true, then Tietenberg (1984, p. 204) lists three conditions for efficient quotas.

1. The quotas entitle the holder to catch a specified weight of fish.
2. The total amount of fish authorized by the quotas held by all fishermen should be equal to the efficient catch for the fishery.
3. The quotas should be freely transferable among fishermen.

It is important that the quota be on quantity of fish harvested. Quotas on days of fishing, which do not consider variations in fishing effort per fishing day, provide incentives for increased vessel size or increased gear and/or labor per vessel, because anglers still have the incentive to engage in more effort than the optimal level. The second condition is necessary for optimal harvest, and also makes obvious the need for effective monitoring. Finally, efficient quotas must be transferable among anglers because of differing costs per unit of fishing effort across commercial fishing firms. Higher cost firms must be able to sell their quota to more efficient or lower cost firms in order to minimize the cost of harvest for any given fishery.

Although we are still far from effective and/or efficient management of fisheries, the individual transferable quota or ITQ is being accepted as a management tool by fisheries managers and by commercial anglers. Anderson (1989) and others in Neher et al. (1989) discuss the use of ITQs and ITQ policies in the various fisheries. The International Joint Commission (IJC) and U.S. Environmental Protection Agency (USEPA) have begun to examine how to use economic tools to reduce toxic emissions into the Great Lakes and other bodies of water. These are encouraging signs, but there is little evidence of the acceptability of other strategies in fisheries management unless forced on them from outside, as in the case of Ohio's purchase of gill net fishing rights.

Inadequate Databases

Federal statistical budgets in the U.S. declined in real terms during most of the 1980s and have only begun to recover (OMB 1992 and earlier issues). My perception of U.S. fisheries agencies (Fish and Wildlife Service, National Marine Fisheries Service) is that they are not very concerned about statistics, whether economic or biological.

Recreational valuation studies have been completed at widely differing dates, using data that are inadequate in one or more ways, and using statistical estimation methods that are biased. From these sketchy and inadequate research studies management plans for fisheries are developed and justified.

Economists and social scientists must become an integral part of fisheries policy-making to effectively employ economic policy tools. Further, they need the support and assistance of fisheries agencies in obtaining the needed financial support to carry out the research necessary to develop a proper database for resource management. At present, U.S. funding agencies are biased strongly toward frontier theory in the estimation and evaluation of economic policies, when what is needed is a strong database obtained from the people for whom the policies are being developed.

Implications for Improved Policy

Economists and other social scientist need access at the policy making level to effectively bring economic and social science policy tools to fisheries management. One should not expect biologists to develop sophisticated economic policy for management strategies, any more than the economist or social scientist could be expected to be schooled in the life cycles of fish.

Resource management agencies in the U.S. have not made rapid progress to incorporate economists and other social scientists at the policy making level for two reasons. First, resource management agency heads have not made the transition from "the management of fish" to the "management of people." Until they recognize that incorporating human behavioral responses in the policy process is critical to policy success, progress will be slow. Second, they are not aware of the contributions that economists and other social scientists make to the policy frameworks of other areas, such as agriculture. Such awareness would increase the confidence that the social sciences have much to contribute.

For the proper management of fisheries, economists and social scientists must be involved in the fisheries management policy process, requiring research in the social sciences and the resulting database.

Table 1. Definitions of Concepts and Methods

Definitions of Concepts

Gross Willingness-to-Pay: The total amount one is willing to pay for a resource or amenity rather than go without it. It is approximated by the area under the demand or average revenue curve up to the level of consumption in Figure 1.

(Net) Willingness-to-Pay: Gross willingness-to-pay minus the costs of purchasing the output. In Figure 1, it is approximated by the area under the demand or average revenue curve and above the price or average cost line.

Consumer Surplus: An approximation of willingness-to-pay as defined as the area under the demand or average revenue curve and above the price or average cost line.

Use Value: The value placed on a resource or amenity by an individual for its use in recreational activities, such as the value of a particular fishery or the value of a population of fish within the fishery.

Existence Value: The value placed on a resource or amenity by an individual because of its existence irrespective of use, such as placing a positive value on a population of fish even if one never fishes.

Option Value: The value placed on a resource or amenity by an individual to maintain the possibility of using the resource or amenity at some future time, such as placing a positive value on a population of fish because one might want to fish for them at a future time.

Definitions of Methods

Travel Cost (Recreation) Demand (TC): An approximate demand for recreation activities using proxy variables, such as number of trips for quantity demanded and the cost of travel and other recreation expenses for price. The estimated TC demand function allows estimation of consumer surplus.

Contingent Valuation (CV): The direct questioning of individuals about the valuation placed on recreational or other resources or amenities. The CV method can be used for direct estimation of willingness-to-pay, existence value, or option value.

Hedonic Function: The relationship between the price or value of a recreational or other resource or amenity and the characteristics of that amenity. The hedonic price is the contribution of a particular characteristic, such as fishing quality, to the total price of a resource or amenity.

Table 2. Average Valuation of Freshwater Recreational Fishing

State	*Valuation*	*Species*	*Economic*	*method*[a]	*value*[b]	*($/day)*
Alabama	CVM	trout		29.22 (1)		
Alaska	CVM	trout		40.91 (1)		
Arizona	TCM/CVM	trout		17.12 (3)		
	TCM/CVM	coldwater	74.65 (3)			
	TCM	warmwater	145.49 (1) per trip			
	TCM	coldwater	158.83 (1) per trip			
Arkansas	CVM	trout		21.92 (1)		
California	TCM	coldwater	21.04 (1)			
	CVM	trout		23.38 (1)		
Colorado	CVM	trout		16.80 (2)		
	CVM	coldwater	16.46 (4)			
Connecticut	CVM	Trout		11.69 (1)		
	CVM	all		10.81 (3)		
Delaware	CVM	trout		16.07 (1)		
Florida	TCM	warmwater	37.85 (1)			
	CVM	all		17.43 (1)		
	CVM	trout		13.15 (1)		
Georgia	TCM	warmwater	34.50 (1)			
	CVM	trout		14.61 (1)		
Hawaii	No Studies					
Idaho	TCM/CVM	coldwater	23.95 (6)			
	TCM/CVM	steelhead	22.34 (6)			
	TCM/CVM	warmwater	24.73 (6)			
	CVM	mixed	14.87 (1)			
	TCM	cold/mixed	32.25 (1)			
	TCM	warm/mixed	35.14 (1)			
	CVM	trout		18.89 (1)		
Illinois	CVM	trout		24.84 (1)		
Indiana	CVM	trout		13.15 (1)		
Iowa	CVM	trout		29.22 (1)		
Kansas	CVM	trout		24.84 (1)		
Kentucky	TCM	coldwater	11.74 (1)			
	CVM	trout		19.00 (1)		
Louisiana	Hedonic	warmwater	36.31 (1)			
Maine	TCM	coldwater	33.61 (1)			
	CVM	trout		13.15 (1)		
Maryland	CVM	trout		19.00 (1)		
Massachusetts	CVM	trout		13.15 (1)		
Michigan	TCM/CVM	trout		17.86 (2)		
Minnesota	TCM	coldwater	42.37 (1)			
	CVM	trout		20.46 (1)		
Mississippi	No Studies					
Missouri	TCM/CVM	trout		22.38 (2)		
Montana	TCM	coldwater lake	37.47 (1)			
	TCM	coldwater str.	55.22 (1)			
	CVM	trout		17.53 (1)		
Nebraska	CVM	trout		19.00 (1)		
Nevada	CVM	trout		16.07 (1)		
	CVM	coldwater	22.18 (1)			
New Hampshire	CVM	trout		10.23 (1)		
New Jersey	CVM	trout		14.61 (1)		

State	Valuation	Species	Economic	method[a]	value[b]	($/day)
New Mexico	TCM	warmwater	28.08 (1)			
	CVM	trout		20.46 (1)		
New York	TCM	coldwater	39.86 (3)			
	TCM	muskellunge riv.	99.16 (1)			
	TCM	muskellunge lk.	26.21 (1)			
	TCM	all		58.13 (2)		
	TCM	lake		30.07 (1)		
	TCM	stream	40.17 (1)			
North Carolina	CVM	trout		14.61 (1)		
North Dakota	CVM	trout		17.53 (1)		
Ohio	TCM	walleye	4.96 (1)			
	TCM	yellow perch	4.08 (1)			
	TCM	walleye/perch	15.32 (1)			
	CVM	trout		10.23 (1)		
Oklahoma	CVM	trout		29.22 (1)		
Oregon	TCM	coldwater	95.77 (1)			
	TCM	steelhead	71.88 (2)			
	TCM	salmon/steelhead	49.61 (1)			
	TCM	salmon river	26.35 (1)			
	TCM	steelhead river	35.93 (1)			
	TCM	coho		37.36 (1) per trip		
	TCM	steelhead	55.72 (1) per trip			
	CVM	trout		17.53 (1)		
Pennsylvania	CVM	trout		11.69 (1)		
Rhode Island	CVM	trout		13.15 (1)		
South Carolina	CVM	trout		11.69 (1)		
South Dakota	CVM	trout		17.53 (1)		
Tennessee	TCM	coldwater	43.84 (1)			
Texas	CVM	trout		35.07 (1)		
Utah	CVM	trout		16.07 (1)		
	CVM	coldwater	22.18 (1)			
Vermont	CVM	trout		10.23 (1)		
Virginia	CVM	trout		16.07 (1)		
Washington	TCM	coldwater	53.52 (1)			
	TCM	salmon river	26.35 (1)			
	TCM	steelhead river	35.93 (1)			
	CVM	trout		16.07 (1)		
	CVM	salmon	118.62 (1)			
West Virginia	CVM	trout		16.07 (1)		
Wisconsin	TCM	coldwater	4.28 (1) per trip			
	TCM	trout/salmon	16.76 (1)			
	CVM	trout		28.55 (1)		
Wyoming	CVM	trout		13.15 (1)		
	CVM	coldwater	22.18 (1)			
Regions:						
Rocky Mountains	CVM	coldwater	14.08 (1)			
Lake Mead	TCM	largemouth bass	91.21 (1)			

State	Valuation	Species	Economic	method[a]	value[b]	($/day)
U.S.	CVM	bass		43.17 (1)		
	CVM/TCM	trout		46.83 (5)		
	CVM/TCM	anadromous	129.51 (2)			
	CVM	panfish	43.17 (1)			
	CVM	catfish	34.17 (2)			
	CVM	pike/walleye	70.43 (1)			
	CVM	general	40.90 (1)			
	TCM	bass, etc.	88.61 (1)			
	TCM	other		86.34 (1)		
	TCM	coldwater	39.62 (1)			
	TCM	warmwater	35.18 (1)			
	TCM	rough fishing	26.31 (1)			

[a] Valuation Methods: CVM - Contingent Valuation Method; TCM - Travel Cost Method; Hedonic - Hedonic Method.

[b] Standardized Value: Average of studies using the same valuation technique for the same state and species. These numbers are adjusted for methodological differences and updated to 1989 values using the CPI. ( ) indicates number of studies in sample. For explanation of valuation methods and standardization process, please see AFS (1992, 1993).

Source: AFS (1992).

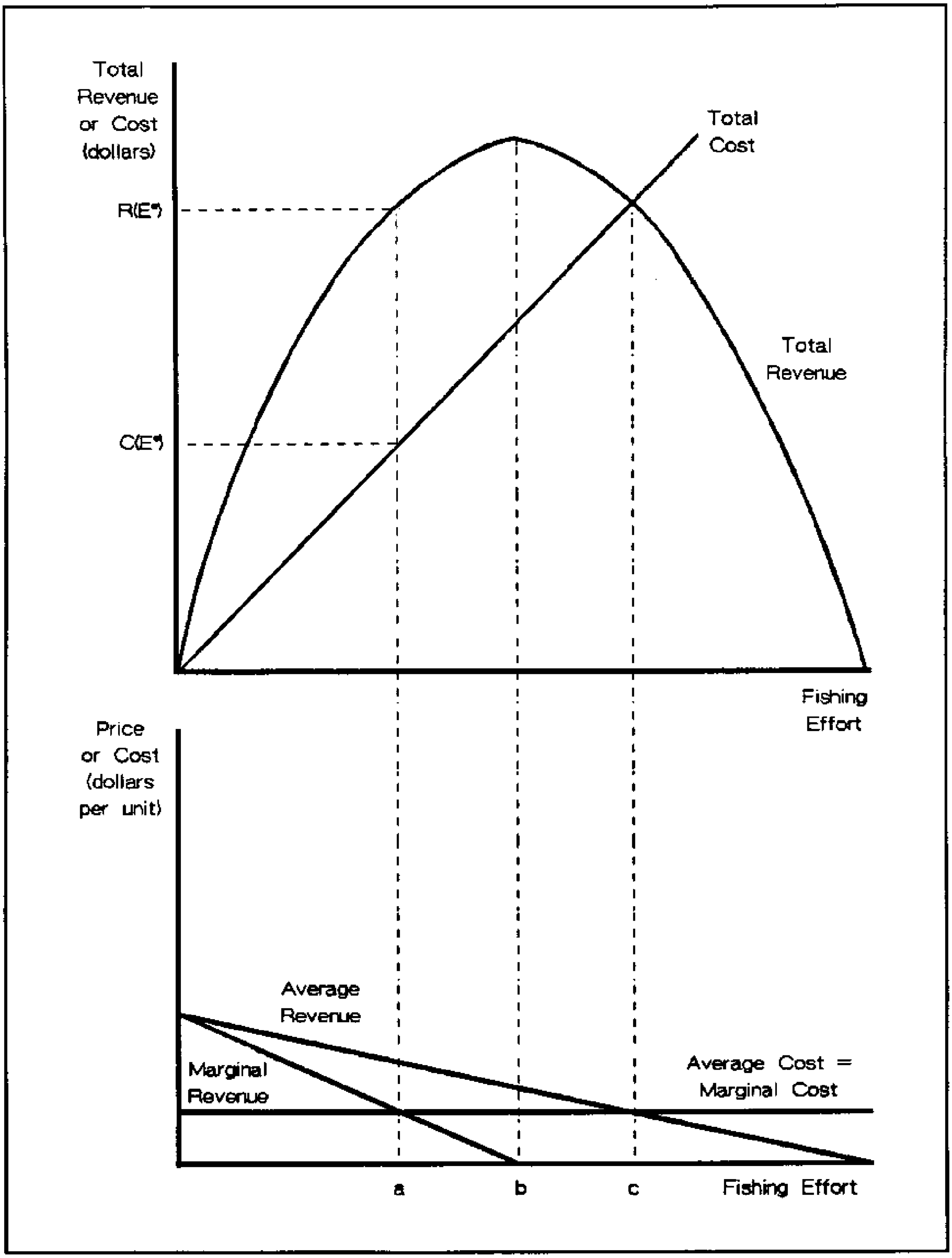

Figure 1. Market allocation in a common-property fishery, Tietenberg (1984).

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A Model Fishery and Socio-Economic Issues in the Context of Walleye Rehabilitation[2]

Walleye do not exist in a vacuum, but coexist with other species in the Great Lakes fisheries. Understanding these multi-species fisheries requires biological knowledge about how various species in the mix complement or compete with one another. *Managing* the fisheries requires knowing how angler preferences affect populations of particular species, and how those population variations affect angler preferences. Management is further complicated by the fact that the rights to fish for walleye and other species are shared by commercial and sport interests (and sometimes Native American interests). What's more, the fisheries themselves exist in the context of the Great Lakes waters that are also being used as water supplies for urban centers and industries, as disposal sites for waste products, and as transportation arteries. These water uses have their own particular perceived values. Where allocations of water use are competitive, resource managers must try to calculate which use should prevail.

The Need for Data

The need for better data is not explicitly discussed very often in lake reports, but is implicit in most discussions. In many cases, assessment of walleye stocks is based only on impressions of fisheries managers or talk by anglers about populations or harvests. Christie et al. (1987) discuss the status of Great Lakes data and the additional and new kinds of data needed in the move towards multi-species/community management.

The method most often used by economists to evaluate fisheries resources has been all-or-none willingness to pay (WTP). In this type of study, the total value of the fishery is compared to being without the fishery or to the totally depleted fishery. This derives the average value of the fishery per fish or per recreation trip or day; however, these average values cannot answer questions about small changes in the fishery.

Economists must generate *marginal* WTP estimates for marginal changes in policy/management strategies, such as a reduction in daily bag limit from six to five walleye, an increase in stocking rate of 10 percent, a change in or establishment of a fishing season, or a change in or establishment of a size limit for harvesting fish. Economists have relatively well-developed models for net all-or-none economic values to users (consumer surplus) of recreational resources and for marginal changes in the economic value of a resource due to some change. Marginal changes in management policies, however, which affect fish populations also affect behavior of anglers (which also affects fish populations). We need to quantify these

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changes through behavioral studies to choose effective management strategies.

Having data at hand beyond narrative descriptions may help fisheries managers determine precisely when a fish stock is at risk of over-exploitation, which appears to be the primary reason for the loss of walleye fisheries.

A Model Fishery

Imagine Lake Fish, a body of water that is capable of generating a harvestable surplus of three species of fish, where a species is either a single fish, such as walleye, or a fish group of similar characteristics, such as salmonids. The lake has three extreme fish community alternatives:

A) 10 m (m = million) harvestable fish of species 1, each weighing one standardized unit, which is a forage fish *and* zero of species 2 and 3;

B) 16 m harvestable fish of species 2, each weighing one-half a standardized unit, *and* 1 m of species 1, plus 0.5 m of species 3, each weighing 2 standardized units; and

C) 4 m harvestable fish of species 3 *and* 1 m of species 1 plus 2 m of species 2.

Figure 2 illustrates these extreme alternative fish communities and the interior points. Species 2 and 3 require species 1 as a forage food, resulting in a harvestable surplus of the forage fish in all cases. Species 1 can exist without species 2 and 3. Further, species 2 and 3 must both be present in order for the other to survive. Within the bounds of these three extremes, the tradeoffs in numbers of harvestable fish are one unit of species 1 for 2 units of species 2 for 0.5 units of species 3. For example, Lake Fish can support a fish community that generates a harvestable surplus of 2 m of species 1, 8 m of species 2, and 2 m of species 3. It can support any fish community that yields a maximum of 10 m standardized weight units of harvestable surplus.

Suppose further that the fisheries manager is able to change the harvestable surplus of each species. Which is the best fish community for this body of water? Ecologically, any of the alternatives are equally sound; as long as the harvestable surplus is maintained at 10 m weight units, the fishery remains in a stable condition. However, to manage the lake at its most productive, a manager needs to know the consumers' preferences for alternative fish communities. For simplicity, we limit the discussion here to how the community values the fish monetarily, although values that cannot be quantified in monetary terms are also important.

Suppose that species 1 has a value in excess of harvest costs or net value of $0.05 per standardized weight unit; species 2 a net value of $2.00 per standardized weight unit (or $1.00 per fish); and species 3 a net value of $2.50 per standardized weight unit (or $5.00 per fish). Net value has two components: consumer surplus, or the excess of satisfaction to consumers over costs, and producer surplus, or the excess of revenues over costs of production of harvest services, i.e., profits. The net values of the Lake Fish fishery at each of the boundary fish communities are shown in Table 3. In this case, boundary fish community *C* is the most highly valued. The species trade-off function is linear within the boundary communities, and the net value of each species is constant over all possible fish community structures. A change in either of the last two conditions could lead to an optimal fish community at an interior point of Figure 2.

Few fisheries are as simple as our first description of Lake Fish, so now we add two methods of harvest: commercial and sport, where the net values per standardized weight unit are shown in Table 4. For the commercial industry, the total of net value is profit accruing to commercial firms. In this case, alternative *C* is still the optimal fish community and we would maximize the value of alternative *C* by allowing the commercial industry to harvest species 1 and the sport industry to harvest species 2 and 3.

Suppose further that a viable commercial fishing industry cannot be maintained with less than $200,000 in profits (net value) *and* it is the fishery. If not harvested, it will crowd out species 2 and 3. Since the net loss in value from commercial harvest of species 2 is $1.00 per standardized weight unit ($2.00 - $1.00), but $1.25 for species 3 ($2.50 - $1.25), it is optimal to allow commercial harvest of 150,000 standardized weight units of species 2 ($150,000/$1.00), or 300,000 fish of species 2, in order to maintain a viable commercial fishing industry. However, this constraint reduces the maximum value of the fishery to $21.9 m, or by the reduced value of $1.00 per unit for 150,000 weight units of fish from $22.05 m, where there were no constraints.

Fisheries managers may also have to deal with native fishing rights, which are likely to be determined in the legal system outside of the fisheries manager's control. Maintenance of fishing rights for native populations, however, does not necessarily reduce the value of the fishery. If the net values of the species to native peoples exceed the larger of the commercial and sport industries, then the net value of the fishery is larger when native people have and use these fishing rights. If the net values of one or more of the three species to native peoples are less than the profit part of the net values to the commercial or sport industries, then native people will be better off if they generate their net fishery values through profits from providing commercial or sport fishing services. In doing so, they may also gain the net values to sport anglers (consumer surplus).

Socio-Economic Issues

This section discusses six issues to which socio-economic analysis can contribute: (1) self sustaining stocks/stocking programs, (2) overexploitation, (3) poor natural recruitment, (4) species invasion, (5) water quality, and (6) shoreland access/wetlands preservation.

Self Sustaining Stocks/Stocking Programs

Lakes Erie, St. Clair, Ontario, and western Superior have maintained self-sustaining stocks of walleye, while Lakes Huron, Michigan, and other parts of

Superior continue stocking programs to maintain walleye fisheries. The socio-economic issues for most walleye stocking programs in the Great Lakes are similar to those for self-sustaining stocks: both attempt to regenerate a self-sustaining stock from a depleted stock. Species competition appears to be minor in most rehabilitation efforts, so that loss of value from lost species is not an issue. Self-sustaining stocks do, however, involve the additional consideration of the costs of the stocking programs per unit of fish harvested, and they require control of harvest to avoid stock depletion.

In decisions of whether to stock species, or stock non-native species fisheries management should be able to answer how sport or commercial anglers will respond to changes in composition of the fish community. As the abundance of the stocked species increases, what shifts in the angling community occur? Are new anglers attracted to the fishery, or do existing anglers switch to the new species from a substitute species, e.g., from salmonids to the newly stocked walleye? What is the net value of the new species? What are the net values of the reductions in other species harvested?

In particular cases, the costs of management policies to a Department of Natural Resources are for the maintenance and/or stocking of walleye in fisheries, and the effects of these stocking programs on recreational activity. The linkages between management expenditures and recreational activity are not easily identifiable. Randall and Hoehn, in press, discuss problems in identifying the relationships between the availability of recreational activities and the quantity and cost of inputs provided by the operators of recreation facilities. The effects of management must be distinguished from other input factors affecting the fishery, as must be the contributions of inputs from the various outputs of a fishery (walleye, other species, water supply, waste disposal, etc.). The models of economists for addressing these issues are well developed. The use of these models to obtain estimates of the costs of walleye rehabilitation or similar activities is in its infancy.

Overexploitation

Overexploitation of walleye has been one reason for the collapse of naturally producing walleye populations in all of the Great Lakes. One issue affecting exploitation is satisfying the demands of both the commercial and sport industries. The relative contributions of these industries to net value can be estimated in socio-economic studies. The net values in terms of consumer surplus and producer surplus from maintaining the fishery as opposed to its loss through overexploitation are obtained by studying the values of the fishery under alternative conditions. Hushak et al. (1986) estimate the relative income impacts of sport vs. commercial harvest of yellow perch in Lake Erie.

Poor Natural Recruitment

Poor natural recruitment and limited spawning substrate are problems for Lakes Huron, Superior, and Michigan. The ability to provide artificial spawning habitat is limited, but may be economically feasible in some cases. Socio-economic analysis can assess the net values of increased fish populations through stocking, compared to the costs of acquiring those populations through improved recruitment to assist fisheries managers in determining where creating artificial spawning habitat is reasonable. This issue is also related to the use of lakeshore frontage and the role of wetlands in species maintenance, one aspect of which is recruitment. The effects of wetlands on recruitment need substantial socio-economic analysis.

Species Invasions

Species invasions have affected all of the Great Lakes. In some cases invading species have enhanced the net economic values of fisheries. In most cases a method of control is unknown. While socio-economic analysis can evaluate these changes, it probably has little to contribute to this issue until techniques for control can be developed. Control techniques for one species may have detrimental effects on other species. For example, electric sea lamprey control barriers may have contributed to reduced walleye populations. Socio-economic analysis can provide estimates of the costs and benefits of species invasion control technologies with respect to changes in walleye and other species populations.

Water Quality

Water for human consumption is usually complementary with fishery uses since both require "clean" water. Industrial uses, on the other hand, may be competitive with fishery stocks by displacing them through increases in water temperature or discharge of toxic substances. Water bodies are also often used as disposal sites for waste products. Their ability to dissipate and biodegrade waste products is a resource of value. Socio-economists try to answer questions such as how will the introduction of toxic substances affect the value of harvested fish to the commercial industry? to the sport fishery? What is the value of the water body in a waste recycling capacity? How do these issues weigh in decisions about the management of fish communities? How are these issues to be weighed in political decisions affecting alternative uses of Lake Fish?

Great Lakes nearshore water quality includes wetlands, recreational access, and housing. With few exceptions, such as PCB and mercury contamination of large walleye in Lake Superior and the mercury contamination of walleye in Lake Erie, offshore water quality changes of significance have not been seen in walleye populations. However, relatively small changes in levels of toxic substances may have profound effects on the economic value of a fishery. Toxic substances accumulated by fish over time may eventually eliminate them as a product for commercial markets. These accumulations may also make the fishery less attractive to the angler who likes to eat his catch, as is true of the walleye anglers in Lake Erie. A toxic substance fish advisory on a recreational species that is typically eaten will likely reduce recreational fishing significantly.

Increased industrial activity on the Great Lakes increases the importance of examining the economic impacts of the discharge of waste products into the

Great Lakes and of accidental spills of toxic substances. Toxic sediments from past discharges, likely to be disturbed with increased dredging due to currently (1989) lowered water levels in the Great Lakes, can also cause severe toxic substance problems in fish. Toxic substance discharges that kill or contaminate walleye stock require calculation of the change in value of the stock through willingness-to-pay studies.

Shoreline Access and Wetlands Preservation

Shoreline access and wetlands preservation are mentioned as issues only in a Canadian report on Lake Huron. However, it is an important issue to the maintenance of the walleye population in Lake Erie and may be an important issue for other of the Great Lakes. Little is known about the contribution of nearshore wetlands to the recruitment of walleye. In the concentrated recreational areas of walleye fisheries, which also happen to be near spawning grounds in most cases, the willingness to pay for recreational uses of wetlands is high. Destruction of these wetlands may reduce substantially the value of the access for these recreational uses if the fish populations on which these values are based are reduced. Here is an area where much better biological information is needed for improved socio-economic analysis.

In addition, there are these issues: What are the comparative demands of commercial vs sport fishing for shoreline access? What are the shoreline facilities needed to support the walleye sport fishery? What happens to the socio-economic demand for shoreline facilities when the recreational base develops beyond, or becomes independent of, the fishery, walleye or otherwise? This has happened in parts of the Chesapeake Bay and appears to be happening in the Western Basin of Ohio's portion of Lake Erie.

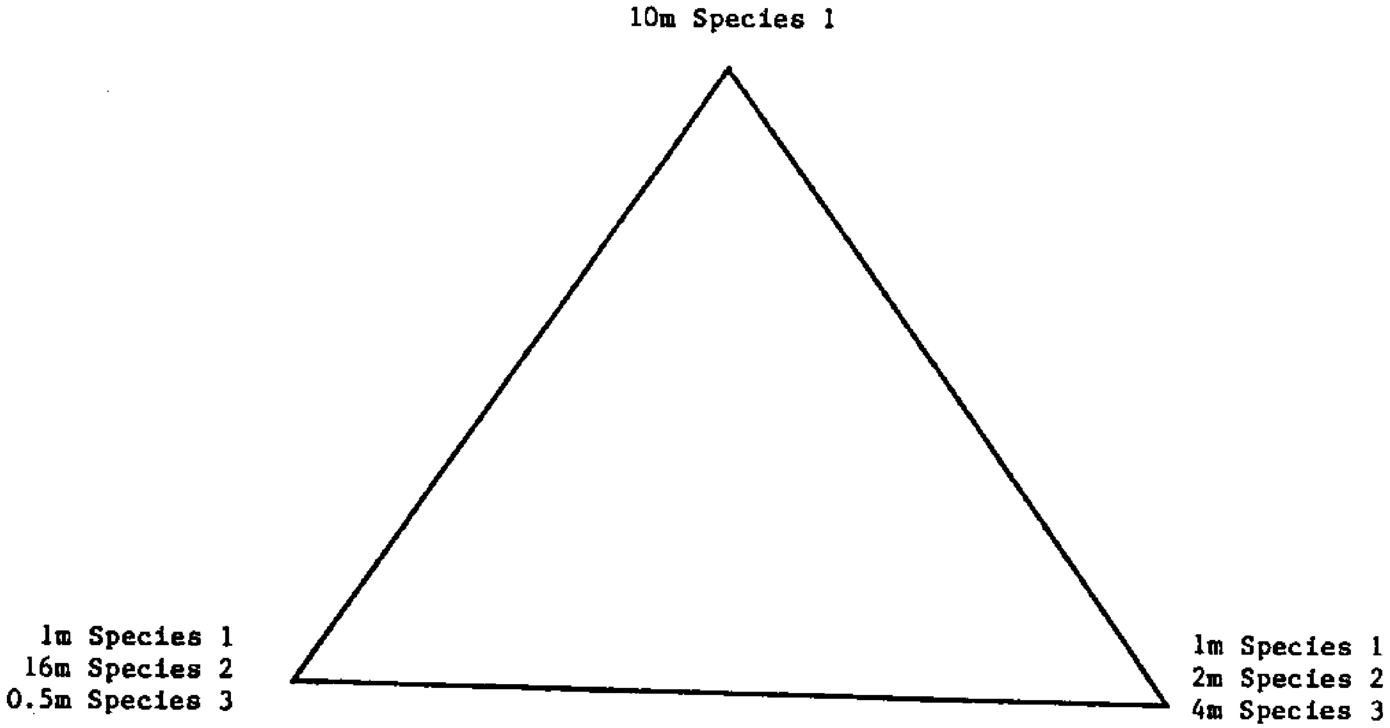
Table 3. Optimal Fish Community for Lake Fish, Single Use Option

Species	*Value per unit weight ($)*	*Value of extreme alternatives ($m)* *A*	 *B*	 *C*
1	0.05	0.50	0.05	0.05
2	2.00		16.00	2.00
3	2.50		2.50	20.00
Total Value		0.50	18.55	22.05

Table 4. Commercial and Sport Net Values for Lake Fish Under Dual Use Conditions

Species	*Value per unit weight ($)* *Commercial*	 *Sport*
1	0.05	0.00
2	1.00	2.00
3	1.25	2.50

Figure 2. Illustration of alternative set of feasible fish communities with boundary condition of 10 m standardized weight units, where m equals million, species 1 equals 1, species 2 equals 0.5, and species 3 equals 2 standardized weight units, respectively.



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