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On Estimating Compensation for Injury to Publicly Owned Marine Resources

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Abstract *It is well established that the public has the right to use certain marine resources, including fish stocks, beaches, and marine waters, for certain purposes, including recreational fishing. Rights in public resources are held "in trust" by federal and state governments for the public, both now and in the future. Given public rights, we not only argue that minimum willingness-to-accept-compensation (WTA) is the theoretically correct measure of economic damages when a publicly owned marine resource is injured, but that it is, in fact, feasible to measure WTA, and therefore, WTA should be used to estimate compensation. Two utility-theoretic approaches for welfare analysis, which use Hausman's (1981) method and the contingent valuation method, are outlined.*

Keywords willingness-to-accept-compensation, natural resource damages, marine pollution, recreational fishing, contingent valuation method, public trust doctrine

Introduction

It is well established that the public has the right to use and otherwise enjoy certain marine resources, including fish stocks, beaches, and marine waters, for certain purposes, including recreational fishing. These public rights are distinct from private rights in marine resources in that they are held collectively by the public and protected and managed by federal and state governmental "trustees" for the benefit of the public, both now and in the future. As a result of these public rights, it is increasingly argued by legal scholars and others that the public is entitled to compensation in the form of economic damages when publicly owned marine resources are injured (e.g., Dower and Scodari 1987).

Although economists concede that, in principle, the minimum that one is willing to accept in compensation (WTA) is the appropriate measure of economic damages when publicly owned natural resources are injured, maximum willingness-to-pay (WTP) or changes in Marshallian surplus (S) generally are used when actually estimating economic damages (Dwyer et al., 1977; Yang et al. 1984). Recently, Assaf et al. (1986), in their outline of nonmarket valuation of accidental oil spills, defended this void between theory and practice by arguing that WTA is too difficult, if not impossible, to measure. Furthermore, they invoke Willig's (1976) benchmark discourse on "consumer surplus without apology" when remarking that changes in Marshallian surplus, compensating variation, and equivalent variation are all statistically similar anyway. In contrast to these arguments, however, recall Bockstael's and McConnell's (1980) findings that, for losses of natural resource commodities that have few if any close substitutes, WTA could be considerably greater than WTP and S. Furthermore, Hausman (1981) and others explain how to measure WTA with no more information than required to estimate a Marshallian demand model. In our article, we argue for using WTA when estimating compensation for injury to publicly owned marine resources.

Whether WTA can be measured and is greater than WTP and S is much more than an intellectual curiosity as can be seen in Mishan's discourse (e.g., 1974) on common law property doctrines and "amenity rights." Furthermore, the focus on WTA is sharpened by the continued spread of marine pollution and habitat losses and by legal and philosophical principles that both bolster the public's rights to marine resources and, accordingly, maintain that damages to publicly owned natural resources must be redressed in a manner consistent with public ownership. That is, when applicable, the public's right to marine (and other natural) resources could have a significant effect on damage estimates, especially when the resources lack close substitutes or when they actually are differentiated commodities that support a variety of personal use and nonuse, or existence values such as preservation of wildlife and bequests of ample resources to future generations.[1] Although legislatures, regulatory agencies, and courts ultimately constrain economic assessments and decide what constitutes "costs" and "fair" damages, economists should promote damage measures that are both compatible with legal and philosophical principles and are also consistent with utility theory.

In order to avoid confusion, we stress that our focus is on the measurement of economic damages that are not revealed in markets for single goods with close substitutes—we do not address economic efficiency per se. Whether the restoration, mitigation, or replacement of an injured marine resource is potentially Pareto optimal is a separate (but obviously related) matter. Accordingly, we restrict our attention to the proper measure of economic damages arising from injuries to marine resources, where by injury we refer to physical, chemical, thermal, and other destructive changes to publicly owned marine resources caused by private parties. We also distinguish between measures of economic damages and the methodologies used to make such measurements. Specifically, we address the necessity and feasibility of estimating WTA, but refrain from providing yet another review of nonmarket valuation methodologies.[2] Finally, our discussion focuses on use and existence values derived from publicly owned marine resources. Private damages are excluded from this paper.[3]

In the next section, we outline the legal basis for the public's use and enjoyment of certain marine resources, and we highlight recent trends in the expansion of such public rights. From these legal (and philosophical) principles, the third section argues for estimating WTA whenever measuring economic damages to publicly owned marine resources. Section four illustrates how easily WTA can be estimated by applying Hausman's "exact" procedure to a Marshallian demand model for marine recreational fishing, and it discusses how WTA can be derived from WTP models in contingent valuation studies. The finally section summarizes and concludes the article.

Public Rights in Marine Resources

As Sax (1970) so eloquently stated, "Certain interests are so particularly the gifts of nature's bounty that they ought to be reserved for the whole of the populace." Although many property rights have been transferred into private ownership, some have been retained by the public for the use and enjoyment of current as well as succeeding generations. The collective ownership of these public rights is overseen by state and federal governments acting in the capacity of "trustee" for the protection and management of such rights.

One area in which the property rights of the public has been well documented is in the case of marine resources. Specifically, the public holds rights that are distinct from privately held rights in certain marine resources such as fish stocks, marine waters, and beaches for certain purposes, including recreational fishing. The legal underpinnings of these public rights stem from several sources, including common law property doctrines, state constitutions, case law, and state and federal statutes such as the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). These sources are briefly highlighted in what follows.

Of the several common law property doctrines that concern the rights of the public in marine resources, the most well known is the public trust doctrine. Developing out of the public's need for access to navigable waters and shorelands for the purposes of navigation and fishing, the doctrine focuses on the rights of the public in tideland areas (i.e., submerged lands and the water above), the foreshore (i.e., the land between the ordinary high watermark and the low watermark), and other navigable waters for these public uses (Rodgers 1977; Stevens 1980).

Under the public trust doctrine, the state, as "trustee" of the public's rights, has an affirmative duty to manage trust resources consistent with such public purposes and to avoid the impairment of such public uses. In addition, the state must protect public values in trust resources, including use as well as nonuse values. Thus as Huffman (1986) has summarized, "[t]he doctrine's central idea is that the state is limited in its disposition and management of particular resources; that the state holds those resources in trust for the public and must dispose of or manage those resources consistent with that trust."

The rights of the public in marine resources are also established by state constitutions. For example, the constitutions of the states of Alaska, California, and Washington declare that the "waters of the state" (a term that includes marine waters) belong to the public.[4] The public's rights in marine resources, however, are most well developed on a state-by-state basis by case law. Several recent cases that illustrate these rights are highlighted below.

In the late 1970s, a controversy arose in Oregon concerning the extension of an airport runway that would involve the filling of a tideland area. The importance of maintaining the state's tidelands and other navigable waters for its people in a natural unaltered condition was described by the Oregon Supreme Court:[5]

> The severe restriction of the power of the State as trustee to modify water resources is predicated not only upon the importance of the public uses of such waters and lands but upon the exhaustible and irreplaceable nature of the resource and its fundamental importance to our society and to our environment. These resources, after all, can only be spent once. Therefore, the law has historically and consistently recognized that rivers and estuaries

once destroyed or diminished may never be restored to the public, and, accordingly, has required the highest degree of protection from the public trustee.

Also in the late 1970s, it was ruled by the Massachusetts Supreme Judicial Court that the tideland areas could not be permanently conveyed into private ownership. Although the court found that *title* to tideland property could in fact be conveyed to a private owner, the title nonetheless was burdened by an "implied condition subsequent" that the property be used for the public purpose for which the land was originally granted, namely for access to marine waters for navigation, fishing, and other uses.[6]

A similar decision was reached by the Supreme Court of Alaska in *CWC Fisheries, Inc., v. Bunker* [755 P.2d 1115 (Ak. 1988)], involving an action for trespass brought by a private coastal land owner against a commercial fisherman. The court found that tidelands conveyed to private owners were conveyed subject to the public's rights to utilize such lands for the purposes of navigation, commerce, and fishing (the court called such property rights "public easements"). Thus the court held "[w]hile [private owners] are free to make such use of their property as will not reasonably not interfere with these continuing public easements, they are prohibited from any general attempt to exclude the public from the property by virtue of their title" [755 P.2d 1121 (AK. 1988)].

Two recent cases in Washington also illustrate the nature of public rights in marine resources. In *Caminiti v. Boyle* [732 P.2d 989 (Wa. 1987)], the Washington Supreme Court found that although the state has the power to dispose of its ownership of tidelands and shorelands, this is subject to the paramount right of the public in navigation, fishing, and recreation in such areas. The court thus categorized two separate property interests—a private property interest, which can be bought and sold, and a public authority, which is inalienable.

In *Orion Corp. v. State* [747 P.2d 1062 (Wa. 1988)], the Washington Supreme Court held that the public's interest in tideland areas resembles a covenant running with the land for the benefit of the public, which cannot be negated by the state. Therefore, the court found that such tidelands may not be used or developed in a manner in which the public's right of navigation, fishing, and other incidental uses is substantially impaired.

State statutes codify the rights of the public in marine resources. For example, in Massachusetts the public trust doctrine has been codified to require all projects in state tidelands to "serve a proper public purpose and that said purpose shall provide a greater benefit than public detriment to the rights of the public in said lands."[7] In addition, the statute requires the state to maintain a fiduciary responsibility to the public regarding the management of such lands (Lahey 1985).

In Oregon a statute was enacted that in essence codified the 1969 decision of the Oregon Supreme Court in *State ex rel. Thorton v. Hay* [462 P.2d 671 (1969)] concerning the rights of the public in shoreline areas.[8] Specifically, the court found (and the statute provides) that the public has an easement for recreational purposes in the shoreland area between the mean high tide line and the visible line of vegetation based upon the common law doctrine of customs.

Several federal statutes also document the rights of the public in marine resources. Notably, in the natural resource damage provisions of CERCLA, federal and state governments are designated as trustees for public natural resources and are charged with the affirmative responsibility of seeking damages for injuries to such natural resources (Carlson 1988; Dower and Scodari 1987; Yang et al. 1984).

Thus it is well established that the public holds property rights in marine resources for several purposes, including recreational fishing, navigation, and other uses. As the result of these property rights, it is widely accepted that the public is entitled to adequate compensation when such resources are injured.

On Estimating Willingness-to-Accept Compensation

In our view, legal principles that stem from, for example, the public trust doctrine and statutes such as CERCLA clearly recognize, and are intended to protect, public ownership of marine resources. Damages caused by pollution (e.g., oil spills and waste disposal) and habitat degradation contravene public rights and, thereby, lower the personal welfare of recreationists and those who have existence values. It follows, then, that measures of economic damage that are compatible with public ownership and trusteeship must be contingent upon the level of personal utility that precedes an injury. Accordingly, "[a]s long as the government resources are viewed as publicly owned, the value is the minimum compensation required by those who use the present facilities [e.g., resources]" (Dwyer et al. 1977).

To set the stage for the remainder of this article, consider Figure 1 and how an injury to fish stocks or water quality might increase travel costs for, say, marine recreational fishing. Prior to injury, travel costs to the usual fishing site are C^0 and the number of fishing trips is R^0 (Fig. 1b). In our exercise, however, injury to the marine environment at the original site causes the user to travel to a farther site where resource quality is equal to preinjury conditions at the previously preferred site. In our exercise, travel costs increase to C^1, trips decrease to R^1, and utility decreases from U^0 to U^1. The demand curves corresponding to these travel costs are the Marshallian demand curve (D) and the Hicksian demand curves associated with the original level of utility (H^0) and the postinjury, lower level of utility (H^1). Also, M is income and Y is expenditure on all other commodities.

Figure 1 can be used to define WTA for two situations. First, WTA is the increase in income that the person requires to condone an increase in travel costs but, at the same time, remain on the original utility frontier, U^0.[9] With an increase in travel costs from C^0 to C^1, WTA is defined according to the indirect utility functions, $U^0[C^0,M] = U^0[C^1,M + WTA]$, and is shown by area C^1bcC^0 behind demand curve H^0 in Figure 1b. This area, which is the compensating variation of welfare change, clearly is greater than the corresponding change in Marshallian surplus (i.e., area C^1acC^0). It follows, therefore, that WTA is also greater than the equivalent variation (i.e., area C^1adC^0), or the maximum that the person is willing to pay to prevent the increase in travel costs to C^1. In this context, WTP is defined according to $U^1[C^1,M] = U^1[C^0,M - WTP]$. Note, however, that utility is held constant at the postinjury, lower level (i.e., at U^1), thereby implicitly ignoring the person's right to the publicly owned marine resource. Yet, analyses such as Assaf et al.'s (1986) recent discussion of economic damages caused by accidental oil spills and, curiously, CERCLA's natural resource damages program implicitly adopt this postinjury, lower level of utility when recommending the use of WTP and S to measure economic damages.

In the second situation, we ask what is the minimum increase in income that the person is willing to accept to continue to endure the increased cost of marine recreational fishing already caused by the injury? WTA is still defined according to the relationship, $U^0[C^0,M] = U^0[C^1,M + WTA]$, but in this case it is the equivalent variation of welfare change. (Notice that in this case U^0 is the new—not the original—level of utility.) Simi-

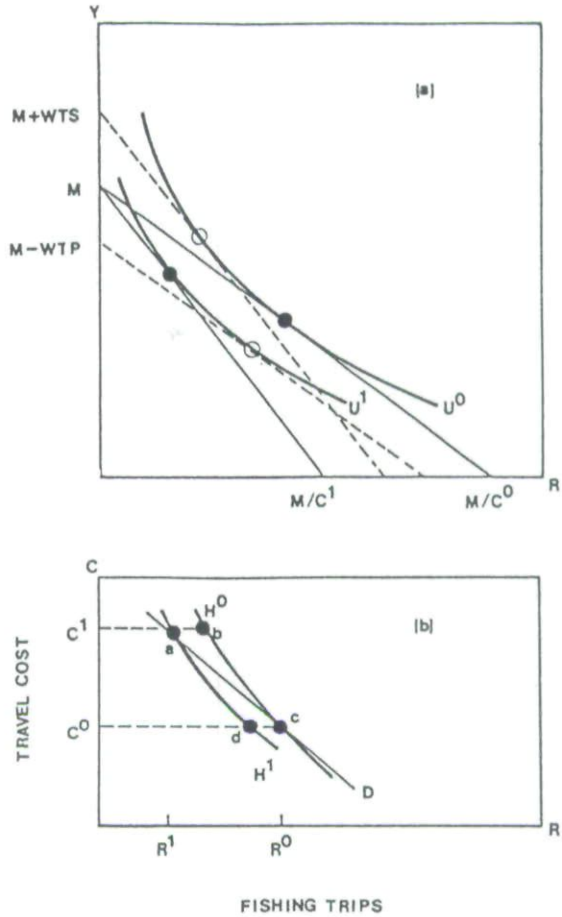

Figure 1 Stylized preferences for recreational fishing. (*a*) Utility. (*b*) Demand.

larly, the persons's WTP to return to the original travel costs, C^0, is still defined by $U^1[C^1,M] = U^1[C^0,M - WTP]$, but WTP is the compensating variation in this case.[10] Furthermore, the utility level for WTP is still the postinjury level even though travel costs are again C^0.

Whether WTA is the compensating variation or equivalent variation (or compensating surplus or equivalent surplus, where applicable) may not be important, but it is clear from Figure 1 that WTA is greater than S and even greater than WTP. Consequently, using WTP collected from, say, a contingent valuation study to establish economic damages is even more biased than using S. Nevertheless, Willig's argument that the three empirical measures of welfare change will be statistically similar often is used to rationalize the use of S and WTP instead of WTA. We argue, however, that there are at least four reasons to reject this pragmatic retreat from estimating WTA. First and foremost, even when Willig's rules of thumb are satisfied, WTA is still greater than WTP and S, and it is the correct measure of compensation for injury to publicly owned natural resources.[11]

Second, the alleged statistical similarity between S and WTA (and WTP) is suspect when applied to injured natural resources, particularly when there are no close substitutes. Willig's analysis best fits price changes in markets for single goods or services that have close substitutes. However, when natural resources contribute substantially to a persons's welfare (e.g., the ratio of S to income is large), there can be significant differences between WTA, S, and WTP depending on the size of the reduction in recreational trips and the availability of close substitutes (Bockstael and McConnell 1980; Hanemann, 1980; Mishan 1974). In addition, marine resources often are *commodities*, vis-a-vis single goods or services. That is, marine resources often support a variety of personal use and existence values that are simultaneously compromised by injuries.[12]

A third reason—one that actually corroborates the above argument—is that contingent valuation studies consistently report WTA to be substantially greater than WTP. For example, ratios of WTA to WTP summarized by Cummings et al. (1986) range from 3:1 to 10:1. Perhaps most important, though, is Bishop et al.'s (1983) study in which WTA collected from *actual* cash transactions in a simulated market was three times greater than WTP collected from a hypothetical, contingent market.[13] Furthermore, WTA surveys typically elicit considerably more "protest" bids, including "infinite" and "not-for-sale" valuations, than do WTP surveys—more than 50% of total responses compared to less than 10% in WTP surveys. Certainly, one reasonable interpretation of protest bids is that they register the public's strong perception of inalienable rights to certain natural resources (Meyer 1979).

Although subject to measurement error, the large differences between WTA and WTP—particularly those reported in recent contingent valuation studies—cannot be shrugged off hastily. We disagree with Assaf et al. (1986) and others who casually reject the credibility of the contingent valuation method. Many initial concerns about response biases, including unsubstantiated incentives for strategic behavior (but not found, for example, in Bohm's [1972] study even when encouraged), have been mollified by extensive testing and refinement of the methodology (Mitchell and Carson 1989). For example, recently, economists have improved sampling and questionnaire designs (e.g., Desvousges et al., 1983), experimented with more precise ways of eliciting (e.g., Boyle et al., 1985; Brookshire and Coursey 1987) and analyzing (e.g., Hanemann, 1984) valuation data, and established certain criteria. or "reference operating conditions," to judge specific applications of the method (Cummings et al., 1986).[14]

Finally, a fourth argument for estimating WTA is that WTA *can* be measured by one of several techniques, most of which begin with an estimate of Marshallian demand. Next, we turn our attention to measuring WTA.

An Illustration

Having argued for using WTA to measure natural resource damages, it is important to illustrate the feasibility of deriving WTA from data on income, environmental quality, and costs. There are at least four procedures available to empiricists. One procedure is adding Willig's (1976) bounds to S or WTP.[15] Alternatively, Vartia (1983) describes how income elasticity can be used to transform a Marshallian demand model into Hicksian demand.

In contrast, two utility-theoretic procedures can be used to derive "exact" formulae for WTA. Hausman's (1981) "exact" procedure also begins with a Marshallian demand model; however, WTA is derived—not approximated— from the implicit form of either the expenditure function or the indirect utility function that matches demand. Notice that the Hausman (1981) procedure presumes no more knowledge about utility functions than that already implied by a Marshallian demand model.

The second utility-theoretic procedure begins with a utility model and then derives expressions for demand and WTA. Hausman (1981) argues that his procedure has a comparative advantage over beginning with a largely unknown utility function, however, since the best-fitting functional form for demand can be selected through econometric analysis. Accordingly, the Hausman procedure can be applied most fruitfully in travel cost and hedonic demand studies. However, as proposed below, the approach that first specifies a utility function will be especially useful in contingent valuation studies from which estimates of parameters in WTP models can be used to derive WTA.[16]

We begin with an illustration of the Hausman-procedure that is based on a semilog travel cost model for shad fishing reported by McConnell and Strand (1981). This demand model was selected because of the evidence that supports a semilog specification of recreational demand models (McConnell 1985), and because it is specified with the requisite variables: the natural logarithm of fishing trips [ln(R)], travel costs (C), catch rate per trip (q), and a variable that reportedly represents income—namely, length of boat (L). Specifically,

$$\ln(R) = 0.16 - 0.01\,C + 0.221\ln(q+1) + 0.063L. \quad (1a)$$

For purposes of this exercise, assume that the relationship between L and income, M, is (M/L) = 3,000. Accordingly, the demand model becomes

$$\ln(R) = 0.16 - 0.01C + 0.221\ln(q+1) + 0.000021M. \quad (1b)$$

Following Bockstael et al.'s (1987) general case, the indirect utility function corresponding to demand (1b) is

$$U(C,q,M) = -e^{(-0.000021L)}/0.000021 + e^{(-0.01C+0.16+0.221\ \ln(q+1))}/0.01. \quad (2)$$

It follows from the general relationships, $U^0[C^0,q^0,M] = U^0[C^1,q^1,M + WTA]$ and $U^1[C^1q^1,M] = U^1[C^0q,^0,M - WTP]$, that were reported above and from the indirect utility function (2), that for an increase in travel costs from C^0 to C^1,

$$WTA(C) = -(1/0.000021)\ln((0.000021/-0.1)\cdot(R[C = C^0] - R[C=C^1]) + 1)/0.000021 \quad (3a)$$

and

$$WTP(C) = (1/0.000021)\ln((0.000021/-0.1)\cdot(R[C = C^1] - R[C = C^0]) + 1)/0.000021; \quad (3b)$$

for a reduction in catch rate from q^0 to q^1:

$$WTA(q) = -(1/0.000021)\ln((0.000021/-0.1)\cdot(R[q = q^0] - R[q = q^1]) + 1)/0.000021 \quad (4a)$$

and

$$\text{WTP}(q) = (1/0.000021)\ \ln\ ((0.000021/-0.1) \cdot (R[q = q^1] - R[q = q^0]) + 1)/0.000021; \tag{4b}$$

and, finally, for both an increase in travel costs and a reduction in catch rate:

$$\text{WTA}(C,q) = -(1/0.000021)\ \ln\ ((0.000021/-0.1) \cdot (R[C = C^0; q = q^0] - R[C = C^1; q = q^1]) + 1)/0.000021 \tag{5a}$$

and

$$\text{WTP}(C,q) = (1/0.000021)\ \ln\ ((0.000021/-0.1) \cdot (R[C = C^1; q = q^1] - R[C = C^0; q = q^0]) + 1)/0.000021. \tag{5b}$$

Equations (3a) and (3b) apply to anglers who travel farther to fish at a site with catch rates equal to the preinjury site; equations (4a) and (4b) apply to anglers who continue to fish at their original site but have a lower catch rate; and equations (5a) and (5b) are a combination of both cases.

The changes in welfare reported in Table 1 were derived from the above equations. *Keep in mind that this illustration merely underscores the feasibility of estimating WTA using the Hausman procedure; hence, the values reported in Table 1 do not suggest the likely magnitude of differences among the welfare measures in general.* Indeed, peculiar results from common functional forms indicate that more research into demand specification is needed. For example, in our exercise the change in Marshallian surplus due to a change in catch rate cannot be completely measured because the semilog demand approaches the cost axis asymptotically. Consequently, the results in Table 1 for reductions in catch rate were approximated by cutting off the intergration at $R = 1$ [i.e., $\ln(R) = 0$]. Log-linear models will have the same problem. Concerning the linear form, both WTA and WTP are equal to the product of the change in catch rate multiplied by the ratio of the own-price and income coefficients (in absolute value). Without further research, we can only speculate that variable-parameter models (e.g., Vaughn and Russell 1982) and flexible functional forms should be explored for modeling differences between WTA, S, and WTP. See Hausman (1981) for advise on how to recover indirect utility functions from well-behaved Marshallian demand models. For now, though, Table 2 summarizes the expressions required to derive WTA from linear, semilog, and nonlinear demand models.[17]

Unlike the Hausman procedure that begins with a Marshallian demand model, the alternative utility-theoretic approach derives WTA from a utility function. As mentioned above, this alternative will be especially useful in contingent valuation studies of natural resource damages. For example, the Marshallian demand model corresponding to the utility function,

$$U = \gamma \cdot \ln(R) + \beta \cdot \ln(X) = \alpha \cdot q \cdot \ln(R) + \beta \cdot \ln(X), \tag{6}$$

and the simple budget constraint, $M = X + C \cdot R$, is

$$R + [\alpha \cdot q/(\alpha \cdot q + \beta)]M \cdot C^{-1} \tag{7}$$

Table 1

Welfare Losses Caused by an Increase in Travel Costs (C) and Reduction in Catch Rate (q)
(initial conditions: $C^0 = \$15$ and $q^0 = 10$)

Case	(C^1, q^1)	Income, M	WTP[1]	Change in Marshallian surplus, S	WTA[1]
(1) Increase in	(30,10)	30,000	44.75	44.77	44.79
travel costs	(30,10)	60,000	83.99	84.06	84.13
	(60,10)	30,000	116.13	116.47	116.61
	(60,10)	60,000	218.18	218.68	219.19
(2) Reduction	(15,5)	30,000	40.11	40.12	40.14
in catch	(15,5)	60,000	75.28	75.34	75.40
rate	(15,1)	30,000	100.41	100.52	100.62
	(15,1)	60,000	188.36	188.73	189.11
(3) Increase in	(30,5)	30,000	79.24	79.31	79.37
travel costs	(30,5)	60,000	148.67	148.90	149.14
and reduction	(60,1)	30,000	180.22	180.56	180.90
in catch rate	(60,1)	60,000	337.82	339.02	340.24

[1]For these changes, WTP is the equivalent variation and WTA is the compensating variation.

Table 2

Utility-Theoretic Relationships for Common Demand Functions[1]

Relationship	Linear[2]	Semilog[3]	Log-linear[2]
Marshallian demand	$R = \alpha + \beta\cdot C + \delta\cdot q + \phi\cdot M$	$\ln(R) = \alpha + \beta\cdot C + \delta\cdot q + \phi\cdot M$	$\ln(R) = (\alpha + \delta\cdot q) + \beta\cdot\ln(C) + \phi\cdot\ln(M)$
Indirect utility, U(C,q,M)	$e^{-\phi\cdot C}\cdot(M + (1/\phi)\cdot(\beta\cdot C + \alpha + \delta\cdot q + \beta/\phi)$	$-e^{-\phi\cdot M}/\phi - e^{(\beta\cdot C + \alpha + \delta\cdot q)}/\beta$	$-e^{(\alpha + \delta\cdot q)}\cdot C^{(1+\beta)}/(1 + \beta) + M^{(1-\phi)}/(1 - \phi)$

[1]WTA and WTP can be derived from the relationships, $U^0(C^0,q^0,M) = U^1(C^1,q^1,M + WTA)$ and $U^1(C^1,q^1,M) = U^1(C^0,q^0,M - WTP)$ where $C^1 > C^0$ and $q^0 > q^1$.

[2]Source: Hausman (1981)

[3]Source: Bockstael et al. (1987)

where X is the Hicksian bundle (i.e., all other goods), α and β are parameters, and γ is a variable parameter that depends on the value of catch rate, "q." Substituting demand (7) into indirect utility function (6) yields the indirect utility function, which, as above, can be used to solve for WTA and WTP corresponding to an increase in travel costs and a reduction in catch rate:

$$\text{WTA} = e^{[\eta^0 \cdot \ln(M) - (\alpha \cdot q^0 - \alpha \cdot q^1) \cdot \ln(C) + (\phi^0 - \phi^1)]/h^1} - M \tag{8a}$$

and

$$\text{WTP} = e^{[\eta^1 \cdot \ln(M) - (\alpha \cdot q^0 - \alpha \cdot q^1) \cdot \ln(C) + (\phi^1) - \phi^0)]/h ⅔0} - M \tag{8b}$$

where

$$\eta = \alpha \cdot q + \beta$$

and

$$\phi = \alpha \cdot q \cdot \ln(\alpha \cdot q/\eta) + \beta \cdot \ln(\beta/\eta).$$

The parameters shared by functions (8a) and (8b) provide a means to derive WTA from the WTP model. In particular, estimates of the parameters in model (8b) can be used to derive the values for α, β, and, through substitution into model (7b), WTA. As can be seen, this indirect approach to measuring WTA overcomes problems with eliciting WTA directly from the public.

Summary and Conclusions

We have outlined theoretical arguments (legal, philosophical, and economic) for why WTA is the appropriate measure of economic damages when publicly owned marine resources are injured and for why the differences between WTA and WTP and S for natural resource commodities could be substantial. In addition, we emphasized how WTA can, in fact, be derived indirectly from the same data ordinarily used to estimate Marshallian and WTP demand models in travel cost, hedonic demand, and contingent valuation studies. Although much research is needed into what specifications best capture preferences for publicly owned natural resources, expressions for the common demand models are already available (Table 2). In addition, it is relatively straightforward to derive expressions for WTA from simple utility models such as model (6).

We want to emphasize that the natural resource damage assessment program established pursuant to CERCLA represents a major step toward a coherent unification of economics and law. Nevertheless, the program's present form contains several curious restrictions on economic analysis. Notably, WTA was excluded from the final rule because, as we mentioned in the introduction, it is believed to be both too difficult to measure and statistically similar to S and WTP anyway. We refuted the first reason concerning measurement and the second reason concerning the size of WTA relative to WTP is not supported by the evidence in the contingent valuation literature. Also, it is contradictory that the program espouses public rights but sanctions WTP—which also is, after all, a utility-theoretic measure of welfare—and, implicitly, the postinjury level of well-being. As we hopefully made clear, the same information used to estimate WTP and S can be used to derive WTA. Unless this logic and the methods are made understandable and accessible to courts and regulatory agencies, however, the public's welfare will continue to erode as it is less than fully compensated for injuries to its marine resources.

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Notes

1. Existence values are personal nonuse benefits derived from preserving wildlife and from providing future generations with ample natural resources, including amenities and environmental quality.

2. See Dwyer et al. (1977) and Yang et al. (1984) for reviews of nonmarket and market-related methodologies in the context of damage assessment.

3. For brevity, our scope excludes damages to commercial fisheries and to private property. Losses in producer surplus of commercial fishing firms should be independent of property rights assignments unless one allows for the possibility that fishermen also derive personal utility from fishing. In contrast, using WTA to estimate damages incurred by owners of private property is a logical extension of this paper.

4. See AK. CONST. art. VIII, ss3, $, 13, 14, 15, 16; CA. CONST. art. X, ss 2, 4, 5; and WA. CONST. art. XXI, sl.

5. *Morse v. Oregon Division of State Lands*, 581 P.2d 520, 524 (Ore. 1978), *aff'd* 590 P.2d 709 (1979).

6. *Boston Waterfront Development Corp. v. Commonwealth*, 393 N.E.2d 356 (1979).

7. MASS. GEN. LAWS ANN. ch. 91, ss14, 18.

8. OR. REV. STAT. s390.610.

9. See Just et al. (1982) for a discussion of Hicksian welfare concepts.

10. In this exercise, we concentrate on situations when injuries to marine resource increase the cost of using or providing publicly owned natural resources. We should point out, however, that there may be situations when an injury imposes quantity restrictions on the public, in which case compensating and equivalent surplus would be the relevant measure of welfare change. (see Randall and Stoll 1980).

11. Willig's (1976) three rules of thumb involve the size of S relative to the income elasticity of demand.

12. In the natural resources damages program of CERCLA, existence values and option values are labeled "speculative" and, therefore, cannot be added to certain use values. See Dower and Scodari (1987) for more details on these omissions and for reasons why the damage assessment program of CERCLA is predisposed to underestimate natural resource damages. They do not discuss the difference between WTA and WTP, however.

13. Preliminary results from another study discussed by Boyle et al. (1985). indicate that for the dichotomous choice type of valuation format, there is no significant difference between contingent valuation estimates of maximum willingness-to-pay and actual cash transactions in a simulated market for recreation. These results add to the credibility of the contingent valuation method.

14. The reference operating conditions recommend against eliciting WTA. However, as shown below, WTA can still be derived from WTP if a utility-theoretic procedure is used to derive the WTP model.

15. Bockstael and McConnell (1980) discussed the tendency for Willig's rules of thumb to be invalidated by large changes in price. In fact, Willig's bounds do not exist within certain ranges of price for the linear and log-linear model. However, Willig's bounds can be computed for the other popular, semilog demand model.

16. One of the reviewers emphasized that although economists routinely apply the Hausman (1981) and Vartia (1983) procedures to aggregate and average demand functions (e.g., average number of fishing trips), these procedures should be applied only to the behavior of individuals. Our exercises are based on behavioral models for individuals. How one would go about deriving WTA from aggregate and average demand models is—as the reviewer points out—still unclear.

17. Notice that in the log-linear model reported in Table 2, the variable for catch rate enters the indirect utility function along with the intercept.

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