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# **Environmental Regulations and Consumers: Case of the Recreationist**

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### **Abstract**

Imposition of regulations on use of the environment is resulting increasingly due to public pressures. With recreation on public lands and waterways, regulations may influence expectations of quality, destination choice and welfare. This paper examines the effects of regulations in the case of recreational fisheries. The empirical application develops a joint model of expected catch and expected harvest in conjunction with a random utility model of regulated site choice. Findings for Maine fisheries indicate that regulations have sizable effects on catch and harvest, probability of site choice and consumer surplus.

## **I. Introduction**

Imposition of regulations on the use of natural resources and environmental goods is resulting increasingly due to public pressures. A prevalent example with international significance is the regulation of commercial and recreational fisheries. Regulations such as quotas and gear restrictions are adopted by state and federal agencies in order to correct or deter excessive harvests and derive largely from biological—rather than economic—objectives. Regardless of the objectives guiding regulators and of whether commercial or recreational fisheries are the interest, variation in the stringency of regulations over species and geographic areas may influence fishery choice and expectations of the quantity and variety of species to catch and harvest. Further, changes in the mixture of regulations may impact the profits and utility derived, respectively, from commercial and recreational fisheries.

Fisheries regulations affect resource stocks by altering the quantities caught and harvested. While the regulation of commercial fisheries has received considerable attention, the economic consequences of regulations imposed on recreational fisheries remain under-investigated despite the allocation of substantial resources to agencies to manage marine and freshwater stocks. Regulations being readily observed site attributes—by recreationists and researchers—leads naturally to their inclusion in models of recreation demand. Considering the attention given to non-market demand and benefits estimation and on-going debates on the use and management of public lands and waterways, the scant appearance of regulations in the recreation demand literature is surprising. Therefore, as light is only beginning to be cast upon the implications of environmental regulations for consumers, in general,

and recreationists, in particular, we tackle the issue in the context of regulated recreational fisheries.

The paper is structured as follows. In the next section, we develop a model of a utility maximizing consumer confronting a choice set comprised of regulated and un-regulated alternatives. Regulations enter the utility function directly as attributes of the alternatives and indirectly through individual expectations of quality, such as anticipated numbers of fish caught and harvested. It follows that regulatory changes affect welfare through multiple channels. A random utility model (RUM) of regulated fishery choice is developed in section three in the case of Maine freshwater anglers. The approach is unique for reasons attributed to the design of many systems of regulations used to manage resource-based recreation. First, because regulations often vary across species and heterogeneity in angler preferences may prevail in the population, expectations of catch and harvest are modeled for a variety of species. Second, because certain regulations target catch and others target harvest and considering the dependence of harvest upon catch, angler expectations of catch and harvest are jointly modeled. The approach also permits the effects of catch and harvest determinants to vary over species and catch and harvest expectations to enter RUMs in a variety of fashions. Welfare estimates from simulated changes in the regulations portfolio and the policy implications of the results are discussed in the fourth section. Section five concludes.

Findings indicate that regulations often have sizable effects on quality expectations, consumer choice, and the benefits derived from recreational opportunities. Further, regulations may be perceived as desirable attributes by some consumers and obstacles to avoid by others. Therefore, since changes in the natural environment may result in or from changes in regulatory systems, we suggest that the definitions of many non-market goods may need to be amended appropriately in future demand and

welfare analyses.

## II. Regulating Recreationists

Perhaps the earliest instrument to be extensively used to regulate recreation on public lands and waterways was restricting hunting and fishing privileges to license holders.<sup>1</sup> Licensing provides managing agencies with a simple means for monitoring public pressures on the natural environment. For many recreational activities, including fishing and hunting, river-rafting, hiking, site-seeing and camping, unlimited numbers of licenses are available. In addition to permitting access, licenses commonly define the activities in which the public may engage.<sup>2</sup>

Although the objectives and constraints facing regulators may differ between jurisdictions, similarities exist in the types of regulations that agencies adopt. We categorize regulations into three groups and pose them in a recreational fisheries context. General regulations do not target angler catch or harvest but instead restrict the activities of all recreationists; examples include restrictions on boat use and vehicle access. Alternatively, catch and harvest regulations target anglers. Catch regulations are designed to influence the likelihood of catching fish in order to reduce the occurrence of “hooking mortality” and other forms of pre-mature death, yet they do not target particular species; examples include restrictions on the types of gear and bait that may be used and the number of lines that one may

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<sup>1</sup> The granting of a license is generally conditional upon the individual or party meeting select requirements, such as exceeding a minimum age, and the payment of a fee.

<sup>2</sup> Regulations may also limit the number of recreationists allowed to access sites. Lotteries, queues, or auctions are then used to ration licenses.

have simultaneously in the water. In a production context, catch regulations dictate the use of relatively inefficient inputs since a given quantity of regulated inputs (e.g., capital and time) yields less outputs (i.e., catch and harvest) than a comparable amount of unregulated inputs (see Karpoff, 1987 and Wilen, 2000 for discussion of inefficient catch regulations in the case of commercial fisheries). Unlike general regulations and catch regulations, harvest regulations target particular species. Bag limits (quotas) and length limits are harvest regulations commonly used to restrict, respectively, the numbers and sizes of fish that may be kept.<sup>3</sup>

When coupled with monitoring and sufficiently stringent penalties, regulations constrain individual behavior. And to the extent that regulations influence resource stocks, they may also be a signal of quality. Considering the regulations taxonomy discussed above, in a recreation demand framework regulations affect utility directly by acting as constraints on individuals and indirectly through perceptions of quality, such as expectations of catch and harvest.

### The Behavioral Model

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<sup>3</sup> It is important to note that, unlike with recreational fishing, the distinction between catch and harvest is often ambiguous with recreational hunting as a catch generally implies a harvest. Because stock regeneration often occurs at a slower rate with terrestrial species relative to aquatic species (e.g., moose and salmon, respectively), managing agencies may restrict catch, and thus harvest, to a single unit over a season or even a lifetime. An implication is that harvest will enter the recreationists utility function as a probability rather than non-negative integer.

Begin by assuming that  $J$  destinations may be accessed by utility maximizing license holders.

On a given choice occasion individual  $i$  visits the site yielding the greatest level of utility. The individual derives utility from visiting the  $j$ th site given by the indirect utility function:

$$(1) \quad V_{i,j} = V(Y_i - P_{i,j}, I_i, R_j, Q_{i,j}) \quad \forall j \in J$$

The term  $Y_i - P_{i,j}$  is income ( $Y_i$ ) net the costs ( $P_{i,j}$ ) incurred from visiting the site, and  $I_i$  denotes characteristics of the individual. Regulations constraining activities at the site are denoted by the vector  $R_j$ , and this we partition into sub-vectors of exogenously determined general, catch and harvest regulations:

$$(2) \quad R_j = R(R_{g,j} / R_{c,j} / R_{h,j})$$

where the subscripts  $g$ ,  $c$ , and  $h$  refer to general, catch and harvest, respectively. The final term in the indirect utility function,  $Q_{i,j}$ , denotes an individual-specific vector of quality attributes associated with site  $j$  that consists of three components: physical characteristics of the fishery, expectations of catch and expectations of harvest:

$$(3) \quad Q_{i,j} = Q(A_j; E(C_{i,j,1}), E(C_{i,j,2}), \dots, E(C_{i,j,S}); E(H_{i,j,1}), E(H_{i,j,2}), \dots, E(H_{i,j,S}))$$

The term  $A_j$  is a vector of site attributes. The second set of terms contains  $S$  species-specific expectations of catch at the site. Following Anderson (1993), we also assume that utility is derived from harvested (or landed) fish, and the third set of terms in (3) reflects individual  $i$ 's expectations of harvest conditional, in part, upon the respective expectation of catch.

Catch expectations appear in the recreation demand literature as functions of angler characteristics and physical attributes of the fishery. However, since regulations target catch, they may also influence angler expectations of the quantity and variety of fish to catch. Thus, we broaden the

definition of expected catch by introducing catch regulations. Individual  $i$ 's expected catch of species  $s$  at site  $j$  is expressed:

$$(4) \quad E(C_{i,j,s}) = C(R_{j,c}, A_{j,c}, I_{i,c}) \quad \forall j \in J, s \in S$$

The catch regulations,  $R_{j,c}$ , are not species-specific, and their effects may differ between species. Expected catch is also a function of site characteristics,  $A_{j,c}$ , and individual characteristics,  $I_{i,c}$  (the subscript  $c$  denotes catch). Expectations of harvest are bound from above by expectations of catch and constrained by regulations. Individual  $i$ 's expected harvest of species  $s$  is defined:

$$(5) \quad E(H_{i,j,s}) = H(R_{s,h}, E(C_{i,j,s}), I_{i,h}) \quad \forall j \in J, s \in S$$

where  $R_{s,h}$  is a vector of species  $s$  harvest regulations at fishery  $j$ ,  $E(C_{i,j,s})$  is (4), and  $I_{i,h}$  denotes angler characteristics (subscript  $h$  denotes harvest).

In addition to including regulations in the objective function directly as attributes and indirectly through the catch and harvest expectations, two key distinctions between the model and those posed in other empirical studies should be noted. The most notable departure is that an individual derives utility from catch *and* harvest. Since anglers often keep some or all of their catch, utility is presumably derived from harvested fish. Second, because numerous types of fish often reside at a given fishery, the quality vector ( $Q_{i,j}$ ) contains a variety of species yet in a disaggregated fashion. Rather exclusively, expected catch has been defined for a single species or as a species aggregate, implying zero marginal utility for the remaining  $S - 1$  species with the former and identical marginal utilities with the latter.

### Welfare Effects of Recreational Regulations

Policy changes affecting recreational activities on public lands and waterways commonly result

in changes in the portfolio of regulations managed by state and federal agencies. The appearance of regulations directly in the utility function as site attributes and indirectly through the quality expectations implies public welfare is susceptible to policy through multiple channels. We consider in turn the welfare effects of changes in general, catch and harvest regulations.

Amendments to general regulations impact all recreationists. For example, the imposition of regulations on boat use constrains the boater population, which is comprised of anglers and non-anglers. Changes in the behavior of boaters may also affect the recreational experience of non-boaters (e.g., through reduced levels of noise and safety risk). Dropping the subscripts for simplicity, the compensating surplus (*CS*) from the change in a general regulation is represented:

$$(6) \quad V(Y - P, I, R, Q) = V(Y - P - CS, I, R^*, Q)$$

The superscript \* distinguishes the amended portfolio of regulations from the status quo. The compensating surplus (*CS*) is the incremental income that maintains the individual at the original utility level. If the regulatory change increases (reduces) utility, then all else constant, *CS* is positive (negative).

Regulatory changes that target catch or the harvest of particular species affect utility directly through the regulations vector (2) and indirectly through the catch or harvest expectations. The compensating surplus for changes in catch and harvest regulations is given by:

$$(7) \quad V(Y - P, I, R, Q) = V(Y - P - CS, I, R^*, Q^*)$$

If the policy change is associated with lower (greater) levels of catch or harvest expectations and is also perceived as an undesirable (desirable) fishery characteristic, *CS* is negative (positive). Alternatively, the *CS* may be ambiguous if the direction of the effects on utility differ.

Because consumer preferences and expectations of recreational site quality may vary within the population, the effects of environmental regulations on demand and welfare are empirical issues. The following sections explore the demand and welfare effects of regulations with a rich survey dataset consisting of Maine freshwater angler fishery choices, regulations, and catch and harvest of a variety of species. While angler preferences for regulations are the primary interest, for completeness we elaborate on the joint model for generating the catch and harvest expectations.

### **III. Econometric Modeling of Regulated Destination Choice**

Random utility models (RUMs) have emerged as the preferred statistical tool for recreation demand and benefits estimation, and recreational fishing is no exception. Notable attention has recently been given to estimating RUMs that incorporate individual-specific quality measures, such as expected catch (McConnell, Strand and Blake-Hedges, 1995; Hausman, Leonard and McFadden, 1995; Morey and Waldman, 1998; Morey and Waldman, 2000; Train, McFadden and Johnson, 2000). The quantity and variety of fish to catch are natural indicators of fishery quality. Expectations of catch are introduced through sequential or joint estimation of an expected catch model and a RUM of destination choice.

Individual expectations of catch typically enter recreation demand models in one of two fashions: as a single species of fish (e.g., Atlantic Salmon) or as an aggregate of multiple species. Aggregate models of expected catch have likely been used due to data limitations or for convenience. Instead modeling expected catch of individual species avoids aggregation biases and allows species-

specific marginal effects to be estimated.<sup>4</sup> However, species-level analyses rather exclusively consider only a single type of fish despite the presence of a variety of species commonly residing in public waters. In this case, relevant explanatory variables may be omitted from the model, leading to the introduction of other types of biases.

Although aggregate models may suffer from aggregation biases, they involve multiple species. But while species-level models may overcome the limitations of aggregate models, omitted variables bias may contaminate RUMs of fishery choice if catch expectations are limited to a single species. The solution to the dilemma is to include catch expectations for multiple species in a disaggregated fashion, while accounting for the role of fishery regulations and the discrete, *count* nature of catch and harvest. A similar argument may be made for the inclusion of harvest expectations for individual species. And, as a final caveat, the dependence of harvest upon catch necessitates that angler expectations of catch and harvest be jointly modeled.

### The Data

A rich dataset obtained from an initial and follow-up mail survey of Maine freshwater anglers during the 1994 Maine openwater fishing season is explored (see McDonald, Boyle and Fenderson,

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<sup>4</sup> Biases may still result despite species-level modeling. For example, the survey instrument may elicit catch at a site over a season rather per trip, yielding aggregates by species. Alternatively, catch data obtained on a per-trip basis are often limited to only part of a season, leading to possible biases when aggregating to seasonal or annual levels.

1995, for survey details). The surveys elicited angler preferences for various regulations-related inputs to catching fish, the sites visited, catch and harvest of ten species of fish and angler targeting of the species, and socio-economic characteristics. The sample of anglers consists of X Maine residents who took Y single-day trips to Z lakes or ponds. For our examination, choice sets are generated by the random draws approach (Parsons and Kealy, 1992).

Four species of fish are included in the analysis that comprise the bulk of reported catch and harvest. These include the coldwater species landlocked salmon and brook trout and the warmwater species bass and white perch. Summary statistics and frequency distributions of the catch and harvest data are reported in Appendix A. General, catch and harvest regulations were obtained from the handbook of fisheries regulations provided to license holders. Regulations enter the expected catch and harvest models as dummy variables and the RUM through interactions with regulations-related angler characteristics elicited from the follow-up survey. Heterogeneity in individual preferences for environmental regulations may be tested for through the inclusion of individual characteristics in the RUM.<sup>5</sup>

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<sup>5</sup> Heterogeneous preferences may be accommodated through two general methods. The “classic” heterogeneity approach used here results from interacting individual or group socio-economic characteristics with site attributes (see Swallow, Weaver, Opaluch and Michelman, 1994). Alternatively, random parameters models (e.g., Train, 1998) account for unobserved individual or group heterogeneity. Classic heterogeneity and random parameters models may also be combined (see Morey and Greer-Rossmann, 1999). While the random parameters approach is flexible, it requires the researcher to impose restrictions upon the distribution of unobserved heterogeneity in the population.

The regulations binding upon the Maine fisheries had a long-standing tradition at the time the surveys were conducted.<sup>6</sup> The catch regulations include restrictions on bait use (No Live Bait) and tackle use (Fly Fishing Only), and these enter the expected catch equations for all species (Table 1). In the RUM the catch regulations enter as interactions with angler characteristics associated with catch regulations. The regulation No Live Bait is interacted with the Likert-scale variables Lures, Worms, Dead Bait, and Live Bait, which measure the frequency of angler use of bait and tackle of the same name. The catch regulation Fly Fishing Only is interacted with the Likert-scale variable Fly Fish, which measures angler frequency of fly fishing. The gear and bait-use variables were obtained from responses to questions of the general form “How often do you use [bait type] when fishing?” contained in the follow-up survey. In all cases the response scale ranged from 0 (never) to 10 (always).

The harvest regulations examined include salmon and trout quotas and length limits. These enter the expected harvest models as dummy variables and the RUM through interactions with two angler characteristics related to harvest. The first is Targeted, a dummy variable taking a value of one if the angler reported targeting the species and a value of zero otherwise. The second angler characteristic, Recreation, takes a value of one if the individual reported fishing solely for recreation and a value of zero otherwise.

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Consistency of the parameter estimates also becomes a concern with approach as the number of random parameters increases.

<sup>6</sup> Consultation with fisheries managers indicated that the vast majority of regulations were in place for at least two years prior to the survey period. However, in the subsequent season the system was substantially revised by the Maine Department of Inland Fisheries and Wildlife.

The general regulations include two restrictions on boat use (No Boats and No Motorboats). As general regulations do not target angler catch or harvest, they are excluded from the expected catch and harvest model. General regulations enter the RUM through interactions with angler characteristics in a fashion similar to that of the catch and harvest regulations. As the follow-up survey did not elicit information directly related to the general regulations, we chose the characteristics Age and Male for the interactions.

### The Modeling Approach

Because a full information maximum likelihood approach for simultaneously estimating RUMs of site choice and multivariate models of expected catch and expected harvest is empirically intractable, the sequential approach is used here. The estimation algorithm involves the following steps. First, given the dependence of harvest upon catch, a joint model of angler expected catch and harvest is estimated. As catch and harvest are discrete, non-negative integers a count data modeling approach is used (Mullahy, 1997). The estimated model is then used to generate catch and harvest expectations at each fishery contained in angler choice sets. At the second stage, the RUM is estimated conditional, in part, upon the estimated first stage model. Angler decision making is thus assumed to first involve generating catch and harvest expectations and then choosing to visit the utility maximizing fishery. Individual and joint hypotheses may be tested from the estimated RUM regarding preferences for regulations and the welfare effects obtained for changes in regulatory policy.

Several uni-variate count data models of were examined initially (see Cameron and Trivedi 1998 for background on count data regression models). The models included the Poisson and

Negative Binomial (Type-II) models and zero-inflated versions of the Poisson and Negative Binomial models (ZIP and ZINB, respectively). The zero-inflation models accommodate frequencies of zeros exceeding those attributable to the base models by modeling the probabilities of zero and positive catch. The ZIP model was selected as it outperformed the Poisson and NB model and because the ZINB model failed to converge in several cases.

With the ZIP model (Lambert, 1992) the probability that individual  $i$ 's catch (or harvest) of species  $s$ , denoted  $Y_{i,s}$  is zero or non-zero is given, respectively, by:

$$(8) \quad \begin{aligned} \text{prob}[Y_{i,s} = 0] &= \mathbf{q}_i + (1 - \mathbf{q})e^{-\mu_i} \\ \text{prob}[Y_{i,s} = a] &= (1 - \mathbf{q}) \frac{e^{-\mu_i} \mu_i^a}{a!} \quad a = 1, 2, 3, \dots \end{aligned}$$

The term  $\delta_i$  denotes the proportion of zeros and is treated as a latent random variable;  $\mu_i$  is the mean and standard deviation of the Poisson distribution. The terms  $\delta_i$  and  $\mu_i$  are conditioned upon vectors of explanatory variables and parameters to be estimated. Non-negativity of  $\delta_i$  and  $\mu_i$  is ensured by specifying the former as a logistic transformation of  $z_i \hat{a}$  and the latter as an exponential function of  $x_i \hat{a}$ , where  $z_i$  and  $x_i$  are regressors and  $\hat{a}$  and  $\hat{a}$  are parameters.<sup>7</sup> The natural logarithm of the resulting likelihood function of the ZIP model is given by:

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<sup>7</sup> However, any valid cumulative density function may replace the logistic transformation (e.g., the standard normal cumulative density leads to the probit model).

$$\begin{aligned}
 \text{Ln}(L) &= \sum_{i=1}^n 1(y_i = 0) \ln(\exp(z_i' \mathbf{a}) + \exp(-\exp(x_i' \mathbf{b}))) \\
 (9) \quad &+ \sum_{i=1}^n (1 - 1(y_i = 0)) (\exp(x_i' \mathbf{b}) - \exp(-\exp(x_i' \mathbf{b}))) - \sum_{i=1}^n \ln(1 + \exp(z_i' \mathbf{a}))
 \end{aligned}$$

where the term  $1(y_i = 0)$  is a binary variable taking a value of one if  $Y_i$  is positive and a value of zero otherwise. The ZIP is estimated at both the catch and harvest stages of the model. Because expectations of harvest are conditional upon the catch expectations, predicted values of expected catch obtained at the first stage are substituted for expected catch in the harvest equation estimated at the second stage. Instrumental variables methods with count data regression models are presented formally in Mullahy (1997). Parameter estimates obtained at both stages are used to generate the individual-specific expectations of catch and harvest for use in the RUM.

On a given choice occasion an angler is assumed to select the fishery from the set of  $J$  alternatives that maximizes utility. Following from (1), the utility derived by individual  $i$  from visiting fishery  $j$  is given by:

$$(10) \quad V_{ij} = v(Y_i - P_{ij}, I_i, R_j, Q_{ij}) + \hat{a}_{ij} \quad \forall j \in J$$

The deterministic component of utility,  $v(\cdot)$ , consists of income net the costs of traveling to the site ( $Y_i - P_{ij}$ ), binding regulations at the site ( $R_j$ ), angler characteristics ( $I_i$ ), and fishery attributes ( $Q_{ij}$ ) including catch and harvest expectations. The term  $\hat{a}_{ij}$  denotes the unobserved, random component of utility.

The probability that angler  $i$  selects fishery  $j$  is given by:

$$\begin{aligned}
 (11) \quad \text{prob}[choose j] &= \text{prob}[v(Y_i - P_{ij}, I_i, R_j, Q_{ij}) + \hat{a}_{ij} > \\
 &v(Y_i - P_{if}, I_i, R_f, Q_{if}) + \hat{a}_{if}] \quad \forall j, f \in J, f \neq j
 \end{aligned}$$

Distributional assumptions about the errors lead to alternative RUMs (e.g., conditional logit and multinomial probit). We define the  $\alpha$ 's as independent and identically distributed type-I extreme value random variables, leading to McFadden's conditional logit model with closed-form expressions of the site choice probabilities given by:

$$(12) \quad \text{prob}(\text{choose site } j) = \frac{e^{v_{i,j}}}{\sum_{j=1}^J e^{v_{i,j}}} \quad \forall i \in I, j \in J$$

The deterministic portion of utility,  $v(\cdot)$ , is expressed as a linear function of regressors. The resulting log-likelihood function is given by:

$$(13) \quad \ln(L) = \sum_{i=1}^I \sum_{j=1}^J y_{j,i} (x'_{j,i} \hat{\mathbf{a}}) - \ln \sum_{j=1}^J \exp(x'_{j,i} \mathbf{b})$$

where the indicator variable  $y_{j,i}$  takes a value of 1 if angler  $i$  chose alternative  $j$  and 0 otherwise. The likelihood function is maximized with respect to the parameter vector  $\hat{\mathbf{a}}$ , and the solution of the resulting system of first order conditions yields the maximum likelihood estimates.

Three specifications of the indirect utility function are examined. The first (Model 1) includes the species-specific expectations of catch and site-specific constants to control for unobserved fishery attributes. This base model is most comparable to others appearing in the literature; however, the distinctions are that i) expected catch enters at the species level for a collection of species, and ii) regulations are determinants of expected catch. The second specification (Model 2) is obtained by adding to Model 1 the harvest expectations, conditional upon the catch expectations. The final specification (Model 3) extends Model 2 by adding general, catch, and harvest regulations through

interactions with individual characteristics.

### Estimation Results

We focus initially upon the first stage estimation of the joint model of angler expected catch and expected harvest. For brevity, we report only the coefficient estimates associated with the regulations variables (Table 2). The full set of estimation results is reported in Appendices B and C. Overall, six of the twelve catch and harvest regulations have statistically significant effects. For all species at least one of the two catch regulations is statistically significant ( $\alpha = 0.01$ ). However, relative to unregulated sites the directions of the effects are mixed, suggesting that relatively lower levels of catch need not be associated regulated fisheries. Considering the expected harvest models, the estimated coefficients indicate in all cases that lower levels of harvest are associated with regulated fisheries; however, only in the case of the trout bag limit is the coefficient statistically significant.

Having estimated the first stage model of catch and harvest expectations, we proceed to the second stage RUM of fishery choice. Comparing the three specifications of the indirect utility function (Table 3), the most sizable improvement in fit results from the addition of harvest expectations. Harvest expectations are included as proportions of expected catch because some of the parameters are sensitive to the specification in levels (perhaps due to sufficient correlation between some of the catch and harvest variables). Comparing models, likelihood ratio tests reject the restrictions implicit in Model 1 and Model 2 relative to the unrestricted, heterogenous preference specification (Model 3) at the  $\alpha = 0.01$  level. Results from Model 3 indicate that angler preferences for regulations may vary sizably within the population as the coefficient estimates on many of the interaction terms are highly significant.

In several cases the estimated coefficients are positive, suggesting that relatively greater choice probabilities are associated with regulated waters for some members of the angler population. An alternative explanation is that although regulations deter particular activities at a site, they may not discourage individuals from visiting the site. Hence, in some cases agency objectives underlying the adoption or amending of regulations may be achieved without sizable changes in participation.

To summarize, the three key findings are i) in many cases regulations are significantly related to catch, harvest and the probability of fishery choice; ii) regulations may be perceived as a desirable attribute by some members of the population and as obstacles to avoid by others; and iii) like with expected catch, site choice probabilities are increasing in expected harvest for all species (as a proportion of expected catch). Because non-market values are associated with recreational opportunities, such as fishing and hunting, a natural question follows regarding the welfare effects of policy changes appearing through amendments to the portfolio of regulations. We turn to this issue in the following section.

#### **IV. Regulations and Recreationist Welfare**

In the process of mitigating pressures on resource stocks and environmental quality, amending or removing existing regulations or adopting new regulations may influence the benefits derived from recreational uses of public lands and waterways. With recreational fisheries, the joint model of expected catch and harvest coupled with the RUM may be used to estimate the welfare changes resulting from changes in the portfolio of regulations. Since regulations enter the utility function directly as fishery characteristics and indirectly through expectations of catch and harvest, policy may impact

public welfare in a variety of dimensions.

In exploring the welfare effects of changes in the regulations portfolio, the interests are twofold. The first objective is to assess the robustness of the welfare estimates to the alternative RUM specifications. Exclusion of regulations, harvest expectations, and angler characteristics from the utility function may yield biased welfare estimates from changes in policy variables. Compensating surplus estimates are obtained for changes in expected catch and expected harvest for coldwater and warmwater species groups. The second objective is to examine the welfare effects from changes in general, catch and harvest regulations. The extent of public pressures relative to management efforts may lead to the removal of regulations or instead to the closure of regulated fisheries. Using Model 3 with heterogenous preferences for regulations, compensating surplus is estimated for two scenarios: removal of individual regulations and site closures. The compensating surplus for a regulatory change at fishery  $j$  is calculated as:

$$(14) \quad CS = -\frac{1}{\hat{b}_{TC}} \left[ \ln \sum_{i=1}^J e^{v_{i,j}} - \ln \sum_{i=1}^J e^{v_{i,j}^*} \right]$$

where  $v_{i,j}$  and  $v_{i,j}^*$  denote the indirect utility before and after the change, respectively,  $\hat{b}_{TC}$  is the parameter on the travel cost variable, and  $J$  denotes the full set of alternatives. In the case of site closures,  $J$  is reduced appropriately.

Consider first the estimated changes in welfare resulting from increases in expected catch and expected proportion harvested. Although Model 3 outperforms the homogenous preference models for estimating site choice probabilities, the welfare estimates are robust to the specifications of the indirect utility function. The results also indicate that increases in catch of coldwater species are more highly

valued by anglers than increases in warmwater species (columns 1 and 3). Relative to expected catch, increases in expected proportion harvested are highly valued (columns 2 and 4).

The welfare effects of amended regulations are obtained from the estimated heterogeneous preferences model (Model 3). Comparing the results within the three categories of regulations, removal of regulations can lead to improvements or reductions in welfare. Results indicate sizable differences in welfare estimates may result when relationships between regulations and expectations of catch and harvest are not given explicit consideration in the modeling (Table 5). On average, the estimated per-day welfare effects are relatively small in many cases. However, the sizes of the standard deviations relative to the means indicates that the welfare. Aggregating to seasonal levels that regulatory changes may lead to large impacts on individual welfare.

Two conclusions follow. First, while welfare losses might at first glance be associated with constraints imposed on recreational uses of natural resources and environmental goods, prudent management of these resources through systems of regulations may lead to improvements in welfare, at least for some groups of recreationists. Second, failure to include regulations in the definitions of many non-market goods or to recognize that preferences for regulations may vary within the population not only limits the scope of study and but may also lead to incomplete—and potentially misleading—information for policy analysis.

## **V. Conclusions**

Systems of regulations provide agencies with a variety of tools for managing recreation on public lands and waterways. With recreational opportunities on public lands and waterways,

regulations derive largely from non-economic objectives of state and federal planners. The impacts of regulations on natural resource stocks and environmental quality may be directly attributed to regulations' effects on individual incentives, quality expectations and destination choices. In this paper, we find that fisheries regulations often have large and significant effects on expectations of catch and harvest and destination choice. As consumer preferences for regulations may vary within the population, a legitimate question is whether their preferences for regulations are likely to be important empirically. The results of this study indicate that the inclusion of individual characteristics has a greater impact on estimates of choice probabilities than of welfare.

As a concluding note, ongoing debates on the use and management of public resources reveals that an array of constituents may be impacted by changes in regulatory policy. Further, heterogeneity in the population's preferences may result in regulations being perceived as desirable attributes by some and obstacles to avoid by others. Therefore, since changes in the natural environment may result in—or from—changes in regulatory systems, we argue that the definitions of many non-market goods should be amended appropriately in future demand and welfare analyses.

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**Table 1**  
**Sample Proportions of Regulations Variables**

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<u>Expected Catch Data</u>	<u>Expected Harvest Data</u>	<u>RUM Data</u>
----------------------------	------------------------------	-----------------

Variables	Trout	Salmon	Bass	Perch	Trout	Salmon	Bass	Perch
<b>Catch Regulations</b>								
No live bait	0.13	0.13	0.13	0.13	---	---	---	---
Fly fishing only	0.06	0.06	0.06	0.06	---	---	---	---
<b>Harvest Regulations</b>								
Length limit	---	---	---	---	0.05	0.01	---	---
Bag limit	---	---	---	---	0.10	0.03	---	---
<b>General Regulations</b>								
No boats	---	---	---	---	---	---	---	---
Boat restriction	---	---	---	---	---	---	---	---
N	692	681	691	686	459	453	460	444

**Table 2**  
**Zero Inflated Poisson Estimates of Angler Expected Catch and Expected Harvest**

	<u>Coldwater Species</u>		<u>Warmwater Species</u>	
	Trout	Salmon	Perch	Bass
<b>Expected Catch</b>				
No live bait	-0.23*** (-3.13)	0.53** (2.39)	-1.10*** (-4.34)	-0.18 (-0.92)
Fly fishing only	-0.38*** (-4.02)	0.74 (1.23)	-0.56 (-1.10)	0.94*** (2.68)
N	692	681	686	691
Ln(L)	-1,420.08	-496.04	1,057.08	-2,084.99

LR Index	0.50	0.44	0.61	0.44
Expected Harvest				
Length limit	-0.23 (1.09)	-0.65 (-0.61)	---	---
Bag limit	-0.46** (-2.01)	-1.07 (-0.99)	---	---
N	459	453	444	460
Ln(L)	-296.87	-180.51	-178.11	-116.54
LR Index	0.43	0.28	0.67	0.39

Note: The full set of estimation results are reported in Appendices C and D. \*\*\*, \*\*, and \* denote significance at the 0.01, 0.05, and 0.10 level, respectively. Numbers in parentheses are z-scores.

**Table 3**  
**Conditional Logit Estimates of Fishery Choice**

Variable	Model 1		Model 2		Model 3	
	$\hat{b}$	z-score	$\hat{b}$	z-score	$\hat{b}$	z-score
Fishery Characteristics						
Travel cost	-0.17***	-34.89	-0.17***	-33.09	-0.18***	-31.69
Acres	0.08***	2.99	0.06	1.49	0.09**	2.20
Elevation	0.34***	5.10	0.32***	4.83	0.07	1.11

Depth	0.20	1.49	-0.02	-0.12	-0.28*	-1.74
Lake type 2	-2.74***	-3.15	-3.98***	-4.47	-5.57***	-4.78
Landing	-4.38***	-3.14	-3.98***	-2.83	-3.55***	-3.02
Nmw land	5.65***	4.03	4.73***	3.35	5.65***	3.28
2W access	-4.97***	-4.94	-4.19***	-4.10	0.46	0.40
4W access	-1.05	-0.79	-0.77	-0.55	-5.15***	-3.55
Expected Catch						
Salmon	0.97***	4.04	0.43*	1.72	0.74***	2.80
Trout	1.23***	12.08	1.29***	11.65	1.36***	11.48
Bass	0.28***	5.11	0.24***	4.24	0.37***	5.88
Perch	0.19**	2.22	0.37***	4.07	0.37***	3.86
Expected Portion Harvested						
Salmon	---	---	5.32***	17.01	5.88***	17.35
Trout	---	---	3.45***	11.96	3.19***	10.81
Bass	---	---	1.33	1.52	2.38**	2.43
Perch	---	---	1.57***	4.32	1.32***	3.33
General Regulations						
No boats	---	---	---	---	-1.65	-0.96
Motors restriction	---	---	---	---	3.42***	4.46
Catch Regulations						
No live bait	---	---	---	---	---	---
Fly fishing only	---	---	---	---	---	---
Harvest Regulations						
Salmon bag limit	---	---	---	---	---	---
Trout bag limit	---	---	---	---	---	---
Salmon length limit	---	---	---	---	---	---

**Table 3 continued**

Trout length limit	---	---	---	---	---	---
<b>Angler-Regulation Interactions</b>						
No live bait * Dead bait	---	---	---	---	-0.11*	-1.95
No live bait * Lures	---	---	---	---	-0.10*	-1.88
No live bait * Worms	---	---	---	---	0.03	0.44
No live bait * Live bait	---	---	---	---	-0.12*	-1.83
Fly fishing only * Flies	---	---	---	---	1.01***	6.95
Salmon bag limit * Targeted	---	---	---	---	-4.20***	-6.89
Salmon length limit * Targeted	---	---	---	---	4.39***	4.79
Trout bag limit * Targeted	---	---	---	---	0.73	1.34
Trout length limit * Targeted	---	---	---	---	0.10	0.16
Salmon bag limit * Recreation	---	---	---	---	-1.68***	-3.18
Salmon length limit * Recreation	---	---	---	---	4.91***	5.59
Trout bag limit * Recreation	---	---	---	---	0.21	0.47
Trout length limit * Recreation	---	---	---	---	-0.54	-0.99
Ln(L)	-2,162.79		-1,884.69		-1,770.80	
Pseudo R <sup>2</sup>	0.63		0.68		0.70	

Note: \*\*\*, \*\*, and \* denote significance at the 0.01, 0.05, and 0.10 level, respectively.

**Table 4**  
**Estimated Compensating Surplus per Trip for Increases in**  
**Angler Expected Catch and Angler Expected Portion Harvested**

<u>Coldwater Species</u>		<u>Warmwater Species</u>	
25% Increase in Catch	25% Increase in Catch and Portion Harvested	25% Increase in Catch	25% Increase in Catch and Portion Harvested

Model 1	\$1.02 (1.80)	---	\$0.53 (0.69)	---
Model 2	0.92 (1.90)	\$3.67 (2.43)	0.62 (0.78)	\$1.14 (0.79)
Model 3	0.98 (1.91)	3.65 (2.42)	0.75 (1.00)	1.28 (0.99)

Note: Standard deviations are reported in parentheses.

**Table 5**  
**Estimated Compensating Surplus per Trip from Changes in Regulations**

Policy Change	With Changes in Catch or Harvest	Without Changes in Catch or Harvest
<u>Catch Regulations</u>		

Removal of <i>No Live Bait</i> Regulation	-\$0.83 (2.17)	-\$0.53 (1.63)
Removal of <i>Fly Fishing Only</i> Regulation	0.22 (1.81)	0.28 (2.50)
<u>Harvest Regulations</u>		
Removal of <i>Bag Limit</i> Regulations	-1.45 (4.40)	-0.86 (3.66)
Removal of <i>Length Limit</i> Regulations	0.10 (0.70)	0.08 (0.70)
Closure of <i>Bag Limit</i> Fisheries	0.88 (5.09)	---
Closure of <i>Length Limit</i> Fisheries	0.44 (2.47)	---
<u>General Regulations</u>		
Removal of <i>No Boats</i> Regulation	-0.06 (0.60)	---
Removal of <i>Motors Restriction</i> Regulation	0.35 (1.53)	---

Notes: Estimates obtained from Model 3.

**Appendix A**  
**Summary Statistics and Frequencies of Angler Reported Catch and Harvest**

Species	N	Mean	Frequencies	0	1	2	3	4	5	6-10
<b>Salmon</b>										
Catch	681	0.60	Observed	552	41	35	13	11	11	15
		(1.70)	Cumulative	0.81	0.87	0.92	0.94	0.96	0.97	0.99
Harvest	453	0.17	Observed	412	24	10	1	2	2	2
		(0.73)	Cumulative	0.91	0.96	0.98	0.99	0.99	0.99	1.00
<b>Trout</b>										
Catch	692	1.91	Observed	544	30	28	13	13	14	25
		(9.43)	Cumulative	0.79	0.83	0.87	0.89	0.91	0.93	0.96
Harvest	459	0.44	Observed	406	16	13	4	7	4	7
		(1.77)	Cumulative	0.88	0.92	0.95	0.96	0.97	0.98	0.99
<b>Bass</b>										
Catch	691	3.52	Observed	466	46	34	20	15	12	35
		(10.97)	Cumulative	0.67	0.74	0.79	0.82	0.84	0.86	0.91
Harvest	460	0.12	Observed	437	10	6	4	0	2	1
		(0.65)	Cumulative	0.95	0.97	0.98	0.99	0.99	1.00	1.00
<b>Perch</b>										
Catch	686	2.16	Observed	566	13	13	6	8	16	22
		(7.15)	Cumulative	0.83	0.84	0.86	0.87	0.88	0.91	0.94
Harvest	444	0.41	Observed	427	2	3	1	3	6	5
		(2.08)	Cumulative	0.93	0.94	0.95	0.95	0.95	0.97	0.98

Note: Numbers in parentheses are standard deviations.

**Appendix B**  
**Summary Statistics of Independent Variables in Angler Catch and Harvest Models**

Variable	Expected Catch				Expected Harvest			
	Salmon	Trout	Bass	Perch	Salmon	Trout	Bass	Perch
	Std Mean Dev.	Std Mean Dev.	Std Mean Dev.	Std Mean Dev.	Std Mean Dev.	Std Mean Dev.	Std Mean Dev.	Std Mean Dev.

Age	43.59	13.06	43.64	13.01	43.64	13.02	43.63	12.93	42.53	11.88	42.48	11.73	42.59	11.85	42.73	11.77
Male	0.85	0.36	0.84	0.36	0.84	0.36	0.84	0.36	0.86	0.35	0.85	0.35	0.85	0.35	0.85	0.36
Targeted	0.30	0.46	0.37	0.48	0.34	0.47	0.11	0.31	---	---	---	---	---	---	---	---
Expert	0.13	0.33	0.13	0.33	0.13	0.33	0.13	0.33	---	---	---	---	---	---	---	---
Beginner	0.03	0.17	0.03	0.17	0.03	0.17	0.03	0.17	---	---	---	---	---	---	---	---
Flies	4.04	3.44	4.03	3.45	4.04	3.45	4.04	3.44	---	---	---	---	---	---	---	---
Lures	4.86	3.24	4.87	3.25	4.86	3.25	4.88	3.25	---	---	---	---	---	---	---	---
Dead bait	1.10	1.96	1.09	1.95	1.09	1.95	1.09	1.95	---	---	---	---	---	---	---	---
Worms	3.36	3.08	3.33	3.08	3.33	3.08	3.33	3.08	---	---	---	---	---	---	---	---
Live bait	1.75	2.34	1.76	2.36	1.77	2.36	1.75	2.34	---	---	---	---	---	---	---	---
Acres	5.14	11.90	5.32	12.20	5.31	12.21	5.36	12.24	---	---	---	---	---	---	---	---
Depth	2.80	2.50	2.83	2.54	2.84	2.54	2.85	2.54	---	---	---	---	---	---	---	---
Elevation	5.34	4.46	5.33	4.44	5.33	4.44	5.32	4.42	---	---	---	---	---	---	---	---
Lake type 2	0.32	0.47	0.32	0.47	0.32	0.47	0.32	0.47	---	---	---	---	---	---	---	---
Landing	0.79	0.41	0.79	0.41	0.79	0.41	0.79	0.41	---	---	---	---	---	---	---	---
Species not present	0.49	0.50	0.23	0.42	0.55	0.50	0.38	0.49	---	---	---	---	---	---	---	---
Species not abundant	0.10	0.31	0.37	0.48	0.02	0.13	0.17	0.38	---	---	---	---	---	---	---	---
No live bait	0.13	0.34	0.13	0.34	0.13	0.34	0.13	0.34	---	---	---	---	---	---	---	---
Fly fishing only	0.06	0.24	0.06	0.23	0.06	0.23	0.06	0.23	---	---	---	---	---	---	---	---
Nmw land	0.03	0.17	0.03	0.17	0.03	0.17	---	---	---	---	---	---	---	---	---	---
Bag limit	---	---	---	---	---	---	---	---	0.03	0.17	0.10	0.29	---	---	---	---
Length limit	---	---	---	---	---	---	---	---	0.01	0.11	0.05	0.21	---	---	---	---
Recreation	---	---	---	---	---	---	---	---	0.48	0.50	0.48	0.50	0.48	0.50	0.48	0.50
Catch & Release	---	---	---	---	---	---	---	---	7.40	2.33	7.39	2.33	7.38	2.33	7.37	2.33
Predicted Catch	---	---	---	---	---	---	---	---	0.60	0.85	1.50	2.28	4.03	4.96	2.17	2.41
N	681	692	691	686	453	459	460	444								

**Appendix C**  
**Zero-Inflated Poisson Estimates of Angler Expected Catch**

	Salmon		Trout		Bass		Perch	
	Estimate	z-score	Estimate	z-score	Estimate	z-score	Estimate	z-score
Age	0.005	0.97	0.005**	2.01	-0.02***	-11.99	0.004**	2.09

Male	-0.52***	-2.71	0.24**	1.91	0.78***	6.47	0.21**	2.11
Expert	-0.04	-0.28	0.78***	11.01	0.67***	12.36	0.52***	5.15
Beginner	-1.67**	-2.55	-0.67*	-1.73	0.41***	2.69	-0.14	-0.73
Flies	-0.01	-0.51	-0.03**	-2.37	-0.05***	-5.01	-0.06***	-5.02
Lures	-0.02	-0.72	-0.07***	-4.84	-0.01	-1.35	-0.06***	-5.29
Dead bait	0.01	0.51	-0.03	-1.54	-0.03*	-1.76	0.03	1.47
Worms	0.01	0.02	0.01	0.82	-0.10***	-8.88	-0.01	-0.47
Live bait	-0.02	-0.95	-0.05**	-2.31	0.03**	2.12	-0.04**	-2.42
Acres	0.01*	1.92	-0.03***	-2.95	0.01	0.87	0.03***	5.74
Depth	0.06***	2.72	-0.23***	-7.04	-0.13***	-6.09	-0.14***	-6.90
Elevation	-0.04*	-1.82	0.01	1.07	0.001	0.06	0.03**	2.25
Lake type 2	0.02	0.09	-0.38***	-5.46	-0.28***	-6.25	-0.02	-0.27
Landing	-0.31	-1.64	-0.24***	-3.62	0.66***	8.50	0.62***	5.62
Nmw land	-0.32	-0.59	-0.53***	-3.74	-1.16*	-1.71	---	---
No live bait	0.53**	2.39	-0.23***	-3.13	-0.18	-0.92	-1.10***	-4.34
Fly fishing only	0.74	1.23	-0.38***	-4.02	0.94***	2.68	-0.56	-1.10
Constant	1.49***	3.66	2.78***	12.94	2.78***	14.43	2.22***	11.44
Targeted	-2.25***	-7.69	-1.86***	-7.21	-2.70***	-12.44	-1.62***	-5.80
Not present	1.70***	4.48	1.61***	4.09	1.13***	5.15	2.27***	6.17
Not abundant	0.53***	1.26	1.66***	5.52	1.35*	1.70	1.41***	3.91
Constant	1.89***	6.98	1.53***	6.36	1.28***	6.85	1.10***	7.49
N	681		692		691		686	
Ln(L)	-496.04		-1,420.08		-2,084.99		-1,057.08	

Note: \*\*\*, \*\*, and \* denote significance at the 0.01, 0.05, and 0.10 level, respectively.

**Appendix D**  
**Zero Inflated Poisson Estimates of Angler Expected Harvest**

	Salmon		Trout		Bass		Perch	
	Estimate	z-score	Estimate	z-score	Estimate	z-score	Estimate	z-score
E(Catch)	0.40**	1.99	0.05**	1.75	0.13***	2.59	0.07**	2.30
Age	0.03*	1.74	0.01	0.97	0.01	0.57	0.002	0.42
Male	1.28**	2.20	0.37	1.00	0.81	1.26	-0.22	-1.02
Release frequency	-0.18***	-2.90	-0.15***	-3.61	0.12	1.67	-0.01	-0.41
Length limit	-0.65	-0.61	0.23	1.09	---	---	---	---
Bag limit	-1.07	-0.99	-0.46**	-2.01	---	---	---	---
Constant	-1.82*	-1.85	1.23**	2.01	-2.04***	-1.97	1.74***	4.61
Always C&R	0.98***	2.24	0.99***	2.94	2.65***	3.49	1.38***	2.71
Constant	1.02***	3.43	1.49***	7.94	1.83***	6.01	2.35***	10.02
N	453		459		460		444	
Ln(L)	-180.51		-296.87		-116.54		-178.11	

Note: \*\*\*, \*\*, and \* denote significance at the 0.01, 0.05, and 0.10 level, respectively.