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The Effect of Modeling Substitute Activities on Recreational Benefit Estimates

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Abstract *We use a nested-logit model of recreational fishing to examine how varying the range of fishing activities included in the choice set affects welfare measures. The basic analytical results are quite intuitive: welfare calculations with a site-choice travel cost model that omits relevant substitute activities will tend to understate gains and to overstate losses for a fixed sample and a fixed set of model parameters. The magnitude of bias in any particular case will be directly related to the degree of substitution between the omitted activities and the activities included in the model. In our empirical application, we examine changes in the quality of trout and salmon fishing on the Great Lakes and on anadromous runs. For most of the scenarios examined, we find that models that only include Great Lakes and anadromous fishing activities, to the exclusion of inland fishing activities, yield welfare results that are relatively similar to those of models that include the full range of activities, provided care is taken to extrapolate the results to a common population. The results are due to the relatively low predicted rates of substitution between inland and Great Lakes fishing activities. We derive implications for benefits transfer procedures.*

Key words Choice set, Great Lakes, Michigan, nested-logit, substitutes, travel cost method.

Introduction

The random utility travel cost model is now well-established as a preferred methodology for modeling recreational choices among a wide array of substitutes and valuing changes in quality of the recreational opportunities (Bockstael, Hanemann, and Kling 1987; Bockstael, McConnell, and Strand 1991; Parsons and Kealy 1992; and Morey, Rowe, and Watson 1993). Nonetheless, various modeling and research design issues remain under discussion. One of these issues is the question of how researchers should specify the choice set. In this paper, we consider the robustness of welfare calculations when the available data on individual choices are limited to a subset of the range of recreational alternatives. We do so by examining welfare measures for models that restrict the range of alternative activities included in the choice

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sets. We focus on the context of recreational fishing in the State of Michigan, where the full range of alternatives includes fishing on the Great Lakes, on anadromous runs, and on inland freshwater lakes and rivers/streams. In coastal areas, the full range of alternatives would include marine sites rather than Great Lakes sites.

Because data collection is resource intensive and tends to be limited by the mission of the funding agency, any given recreational fishing survey typically will collect data for only a subset of these alternatives. For example, the two major funding sources for surveys on recreational fishing participation are fishing management and water quality management agencies (or research programs). The major fishing participation surveys are funded by NOAA's National Marine Fishing Service (NMFS), by the Fish and Wildlife Service of the US DOI, or by state fishing management agencies. In addition, one-time surveys are often conducted to address specific research questions (*e.g.*, the NAPAP research program on acid rain). Of this set, only the state fishery management agencies have an all-encompassing responsibility for fishery management, and generally they are the only ones collecting data from anglers fishing across the full range of fishing opportunities within their states.[1] On the other hand, the NMFS survey is limited to participation in marine fisheries nationwide (NMFS' jurisdiction), and NAPAP surveys have been limited to a small selection of inland lake fisheries potentially most affected by acid rain. In addition, states also sponsor surveys focusing on fisheries of particular management concern. While the USFWS survey covers a full range of fishing activities, it does not collect information that is detailed enough for modern travel cost methods.

Limitations in the major data sets on recreational fishing, as well as in specialized surveys for other resources of special management concern, impose restrictions on the scope of the models that can be estimated. In many cases, the models are intended for use in evaluating policy scenarios that have limited scope or that may affect only one activity. The question we explore in this paper is, what is the impact on welfare analysis of using models with choice sets that limit the range of related substitute activities? This line of inquiry exploring choices pertaining to the extent of the market across fishing *activities* complements recent research exploring the implications of alternative assumptions about what sites to include in anglers choice sets (Peters, Adamowicz, and Boxall 1995; Haab and Hicks 1997; and Parsons and Hauber 1998). An important distinction is that we address the question of how broad a range of activities to consider in a model, rather than how many sites to include *within any activity*. As more types of opportunities are included in the modeling, the procedures for treating unwieldy choice sets become more important (Parsons and Kealy 1992; Parsons and Needelman 1992; Lupi and Feather 1998).

The basic analytical result, which holds for a fixed sample and fixed model parameters, is that the omission of relevant substitute activities will tend to understate mean per-trip gains and overstate mean per-trip losses for the sample. This result applies to models of site choice that do not explicitly account for non-participation as an alternative in the choice set. The intuition is that models with too few alternatives in the choice set do not allow for substitution away from sites when quality decreases, thereby tending to overstate losses. Conversely, for improvements in quality, models with too few alternatives in the choice set do not allow for substitution into the sites where quality increases, thereby tending to understate gains. However, whether the magnitude of bias will be substantial will depend upon whether there is

[1] State surveys that restrict the opportunities considered to those within state boundaries may result in somewhat arbitrary cut-offs.

a substantial degree of substitution between the modeled and omitted activities—which is the empirical issue examined here.

To address the empirical relevance of the range of substitute activities modeled, we consider how the welfare measures for catch rate changes in Great Lakes trout and salmon species are affected by limiting the model to Great Lakes angling activities to the exclusion of inland freshwater opportunities. In the second section, we present the empirical models we employ. In the third section, we lay out the policy scenarios, and consider how best to present the welfare results to control for the discrepancies between the maintained assumptions of the analytical predictions and the conditions for the empirical tests. In the fourth section, we present the welfare results for the different models for policy scenarios involving different scales of changes in trout and salmon catch rates. In the final section, we draw some conclusions.

Model Structure and Estimation Results

To explore the sensitivity of welfare measures to the range of substitutes that are included in a model, we adapt a random utility model of fishing developed by Jones and Sung (1993). The Jones-Sung model has two basic components: a site-choice model and a participation model. The participation model estimates the frequency of day, weekend, and vacation trips as a function of the quality of these trips. The quality measures are the inclusive value indices of the site choice models. To streamline our analysis, we will focus on the day-trip site-choice model. We briefly describe the model below.

The behavioral data on fishing activities are from a mail survey sent to licensed anglers in Michigan during the 1983–84 fishing license year. The survey provides detailed information on the most recent fishing trip, including the species of fish sought, the location of trip, the duration of trip, and trip expenditures. A response rate of 59% was achieved. Additional details and a copy of the survey instrument are contained in the Jones and Sung report. The models we examine here are based on the respondents whose last trip was a day trip.

The basic model is a random utility model of the choice of fishing site for day trips in Michigan.[2] A nested-logit framework is employed to allow for the possibility that some fishing experiences are more closely related than others. The opportunities are grouped, or nested, by activities called "product lines". The product line definitions are based on a factor analysis of Michigan anglers' choices that identified distinct fishing experiences (Kikuchi 1986). The resulting product lines incorporate distinctions among types of water body (Great Lake, inland lakes and rivers/streams) and types of fish species (warm water and cold water).[3] Warm water species include walleye, yellow perch, and bass. Cold water species include trout and salmon. In addition, there is a product line for anadromous runs of salmon and steelhead. The six product lines in the baseline model are:

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[2] Since expositions of the random utility model are widely available in the literature, we do not replicate them here (see McFadden 1981; Bockstael, Hanemann, and Kling 1987; and Bockstael, McConnell and Strand 1991). For a recent review of nested-logit formulations of the random utility model, see Morey (1999).

[3] Some of the types of fishing identified by Kikuchi (1986) were combined due to thin data, *e.g.*, fishing for trout and salmon at inland lakes was combined with fishing for trout and salmon at inland rivers. Since the analysis is limited to the open-water season (April through September), Kikuchi's ice fishing product line is excluded. Additional details on how Kikuchi's factor and cluster analyses were used to select the nesting structure are provided in Jones and Sung (1993).

Product Line 1: Great Lakes cold water species (GLcd)
Product Line 2: Great Lakes warm water species (GLww)
Product Line 3: Anadromous runs (Anad)
Product Line 4: Inland lakes and streams cold water species (LScd)
Product Line 5: Inland lake warm water species (ILww)
Product Line 6: Inland stream warm water species (ISww)

The two-level nested approach allows the model to capture substitution possibilities across all the sites within a product line, as well as across product lines. The choice of which site to visit in a given product line depends on the quality of that site at the time of the trip and the cost of traveling to the site. Within each of the three inland product lines, anglers' choice sets include any of Michigan's 83 counties that provide fishing opportunities within the product line and are within the feasible driving distance. The Great Lakes and anadromous product lines are limited to approximately 40 coastal counties, (and some contiguous counties for anadromous runs.) See figure 1 for a map of Michigan that identifies which counties are included in the different product lines.

The feasible driving distance was set at two standard deviations above the mean day-trip driving distance reported in the survey (Jones and Sung 1993). The quality variables that describe the choice of county within a product line are listed in table 1 and are fully discussed in Jones and Sung (1993). In particular, attributes of the Great Lakes cold water (GLcd), Great Lakes warm water (GLww) and Anadromous run (Anad) product lines are described by average catch rates per-hour by species (group) and by month. The GLcd and Anad catch rates will be used in the policy

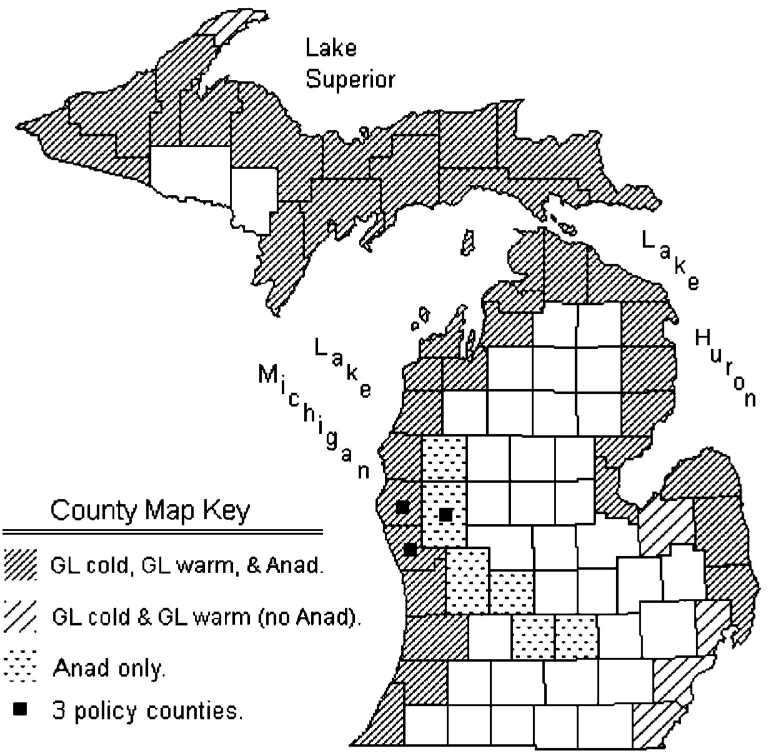

Figure 1. Great Lake and Anadromous Counties in Michigan

comparisons later in the paper. The catch rates were derived from an exogenous data source, the Michigan Department of Natural Resources (MDNR) Creel Survey data, and are specific to the month of the trip and to the county visited. For the three inland product lines, we use proxies for fishing quality, based on the quantity of water resources in a county site, categorized by the quality of the water resource and its status as main-stem/tributary.

The nested logit models were estimated sequentially. Model 1, which adopts the Jones and Sung model structure, serves as the baseline model and captures the broadest range of site substitution possibilities. In addition, we estimate two other

Table 1
Estimated Parameters of the Six Site Choice Models

1. Great Lakes Cold	
T–cost	–0.17**
AOC	–1.54**
%Forest	2.34**
Features	0.08
CR–Chinook	8.37**
CR–Coho	3.93*
CR–Lake Tr.	3.31*
CR–Steelhead	2.21
N = 328; χ^2 = 738	

2. Great Lakes Warm	
T–cost	–0.17**
AOC	–0.05
%Forest	–0.93
Features	0.20
CR–Y.Perch	0.08
CR–Walleye	–0.20
CR–N.Pike	0.73
CR–Bass	9.37
CR–Carp	2.97*
N = 641; χ^2 = 1,743	

3. Anadromous Runs	
T–cost	–0.16**
AOC	0.66**
AnadLake	0.63**
CR–Chinook	2.53**
CR–Coho	–0.85
CR–Steelhead	9.49**
N = 118; χ^2 = 277	

4. Rivers/Streams Warm	
T–cost	–0.26**
AOC	–0.06
%Forest	1.81**
Features	–0.29
TopQMain Ww	0.82**
TopQTrib Ww	0.56
2ndQMain Ww	–0.16
2ndQTrib Ww	–0.24*
NEC Warm	–1.39
Cntm S Ww	–0.002
N = 241; χ^2 = 887	

5. Inland Lakes Warm	
T–cost	–0.24**
AOC	–0.43**
%Forest	2.83**
Features	0.21
LkAcres Ww	0.007**
LkAcres 2Stry	0.0004
Cntm Lk Ww	–0.006
N = 947; χ^2 = 3,353	

6. Lakes/Streams Cold	
T–cost	–0.24**
AOC	–0.13
%Forest	4.90**
Features	–0.21
IscdFly	0.32
TopQMain Cd	–0.32
TopQTrib Cd	–0.59
2ndQMain Cd	0.48**
2ndQTrib Cd	0.44*
NEC Cold	–0.27
Cntm S Cd	–0.13*
LkAcres Cd	0.003
Cntm Lk Cd	0.10
N = 188; χ^2 = 671	

Notes: * indicates the parameter estimate is significant at the 10% level. ** indicates the parameter estimate is significant at the 5% level.

Variable Definitions:

T–cost:	Travel cost (1984 AAA rate of $0.23 per mile × distance × reported share of travel expenses).
AOC:	= 1, if International Joint Commission has designated an Area of Concern in the county; = 0 otherwise (indicator of pollution)
%Forest:	Percent of county covered by forest.
Features:	Number of unique features per county such as National Lake Shore.
CR:	Site/month/specie/county specific average catch rates for the various species as labeled.
AnadLake:	=1 if an anadromous lake is present along the run; = 0 otherwise.
Ww (Cd):	Warm water, (Cold water).
TopQMain:	Top quality main stem stream miles, for warm water or cold water.
TopQTrib:	Top quality tributary stream miles, for warm water or cold water.
2ndQMain:	Second quality main stem stream miles, for warm water or cold water.
2ndQTrib:	Second quality tributary stream miles, for warm water or cold water.
NEC:	Not Elsewhere Classified stream miles for warm water or cold water.
Cntm S:	Contaminated streams covered by fish consumption advisories.
LkAcres:	Acres of inland lakes by warm water, cold water and 2 story lakes.
Cntm Lk:	Contaminated lakes covered by fish consumption advisories.

product line choice models with restricted choice sets, in order to compare the sensitivity of model parameters, as well as the welfare analysis of various policies, to restrictions on the number of alternative product lines included in the model. Finally, we estimate a model that contains all of the activities (all 6 PLs), but each of the PLs that are not affected by the policy scenarios is modeled as an aggregate group represented only by a dummy variable. (In other words, for model 4 the inclusive value variable equals zero for all observations in the Great Lakes warm and the 3 inland product lines.) The four models are:

1. Baseline: all six product lines.
2. Three PLs: GLcd, GLww and Anad.
3. Two PLs: GLcd and Anad.
4. All six PLs, but only Glcd and Anad are fully modeled; other PLs are represented by a PL dummy.

Figure 2 illustrates the nesting structure for the sites (elemental alternatives) for each of the four models.

The rationale for specifying models 2 and 3 relates directly to our question of how many substitute activities should be modeled to capture the welfare effects of a policy change. All of the policy scenarios involve changes in trout and salmon catch rates in the GL cold and anadromous product lines. Model 3 only includes the product lines directly affected by the trout and salmon catch rate policies. The intermediate Model 2 also includes the Great Lakes warm water fishing product line. The ra-

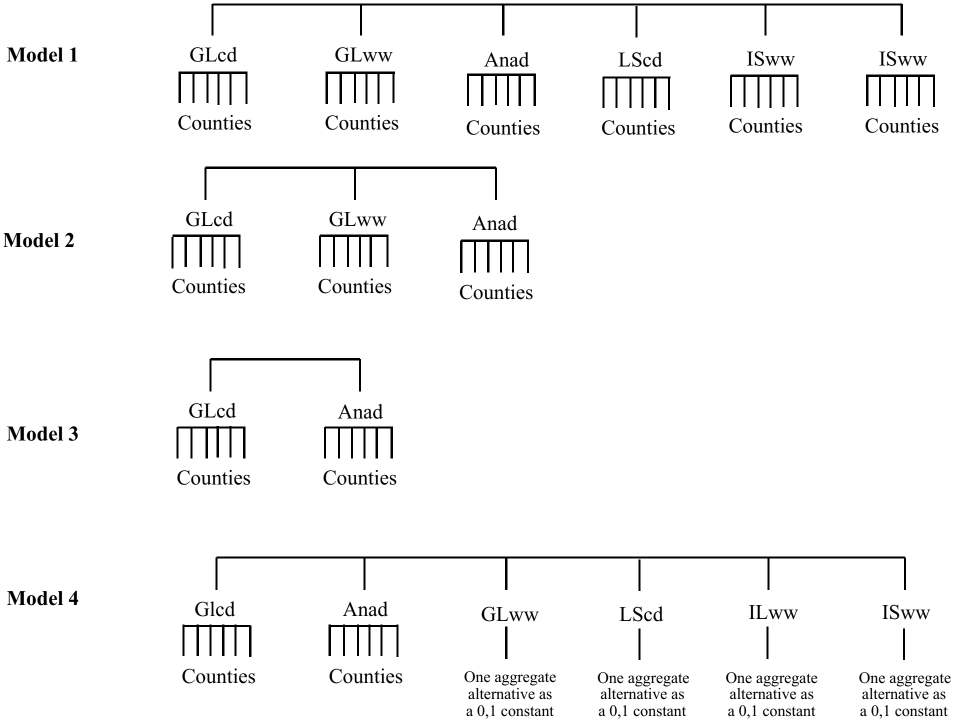

Figure 2. Range of Activities, Alternatives, and the Nesting Structures for Each Model

tionale behind Model 4 is that it does include all the activities, but it captures the inland ones in a rather coarse fashion. In some sense, this version of the model bears similarities to a nested-logit model that includes the alternative sites within GLcd and Anad and then aggregates all other recreation activities into a “don’t go” to GLcd/Anad alternative. A key difference is that the GLww and the inland product lines each get their own dummy variables to represent each of these activities.

Table 1 presents the empirical results for the conditional site choice portion of the model for day trips. The results are generally consistent with expectations. For fishing quality, the catch rates are generally significant for the Great Lakes cold water fishing and anadromous product lines, with some individual exceptions for species with low catch rates. In contrast, for the Great Lakes warm water product line, the only catch rate that is significant is carp. The performance of the water resource quantity variables is mixed for inland lake and river product lines. A complete discussion of each of the site choice models is provided in Jones and Sung (1993).

Table 2 presents the estimated parameters for each of the product line choice models. Since the models were estimated sequentially, the parameters in the conditional site choice models are the same for each of the product line choice models. (Of course, different product lines are included in different models.) Note that the sample size differs across the product line choice models because models 2 and 3 limit the number of product lines. Models 1 and 4 use the full sample of 2,463 day trips. Model 2 uses the 1,087 cases whose last trip type was in GLcd, GLww, or Anad. Model 3 uses the 446 cases whose last trip type was in GLcd or Anad.

Clearly, the estimated model parameters presented in table 2 depend on the number of product lines in the model. While estimated parameters from Models 1 and 2 are reasonably similar, the parameters for model 3 and 4 are quite different. The parameters for the supply and boat costs are positive for most of the models, contrary to expectations. The inclusive value parameter is also different for Models 3 and 4 when compared to Models 1 and 2. The inclusive value parameter will affect the degree of substitution across product lines as well as the degree of substitution within product lines. For Models 3 and 4, the inclusive value parameter is, in a sense, tailored to the GLcd and Anad nests whereas in Model 1 the inclusive value parameter is the same for all the nests in the models. The decrease in the estimated inclusive value parameter for Models 3 and 4 suggests that a version of Model 1 that permitted nest-specific inclusive value parameters might also result in a smaller inclusive value parameter for the GLcd and Anad nests.

Welfare Measures Across Models and Policies

As discussed above, we estimated three models with restricted choice sets, in addition to baseline Model 1 with the full set of fishing activities, in order to capture a range of possible data restrictions researchers might confront or self-impose when determining the scope of a model. To assess the effect of limiting the scope of the substitution possibilities, we will compare the welfare results across the various models for twelve policy scenarios. All of the policy scenarios affect trout and salmon catch rates in the Great Lakes cold water and anadromous run product lines—two of the six different fishing activities included in the full model. The policies varied in the size of the effect on catch rates and the extent of sites affected, to examine if any welfare differences across models are sensitive to the scale of the policy impacts in question.

For the policy analysis, we calculate the expected compensating variation (CV) conditional on having taken a trip (Morey 1999; McFadden 1981). The CV is defined for each individual in the relevant sample as

$$CV = [\ln(D^1) - \ln(D^0)]/\mu \tag{1}$$

where superscripts 0,1 denote the pre-, post-policy site quality levels; ln(D) is the inclusive value index for nested logits; and μ is the weighted marginal utility of income estimated for the full model, where the weights are the probability of participating in each product line in the base case.[4] For our model,

$$D^0 = \sum_{m=1}^{M} \left\{ \sum_{j=1}^{J_m} \exp\left[s(\alpha_m + \gamma Z_m + \beta X_{mj}^0) \right] \right\}^{(1/s)} \tag{2}$$

where m indexes product lines, j indexes sites, s is the inverse of the estimated parameter on the inclusive value, α_m is the product line dummy for PL m, Z_m are the variables that vary across product lines but do not vary across sites within the product lines (such as the boat cost and supply cost variables described in table 2), γ is the estimated parameter vector for the Z_m variables, X_{mj} are the variables describing site j within product line m, and β_m is the vector of estimated parameters for the site level variables within product line m.

As noted above, the basic analytical result for a fixed sample and fixed model parameters is that the omission of relevant substitute activities will understate per-trip gains and overstate per-trip losses for the sample. Whether the magnitude of bias will be substantial will depend upon whether there is a substantial degree of substitution between the modeled and omitted activities—which is an empirical issue. This result applies to models of site choice that do not explicitly account for non-participation as an alternative in the choice set.

However there are discrepancies between what can be modeled empirically and the maintained hypotheses of the analytical prediction—neither the sample nor the full set of behavioral parameters is held constant. We can see the effects of this clearly if we examine the welfare measure more closely. Consider the marginal welfare measures calculated from model i for a change in quality at site j in product line 1, q_{1j}, which equals:

$$\partial CV^i / \partial q_{1j} = \Pr^i(PL = 1) \Pr(j|PL = 1)(\beta_q / \mu) \tag{3}$$

where $\Pr^i(PL = 1)$ is the probability of choosing product line 1 using model i; $\Pr(j|PL = 1)$ is the conditional probability of choosing site j given product line 1 was chosen; and β_q/μ is the ratio of the parameter on quality, β_q, and the marginal utility of income parameter, μ. To recover the exact CV in equation (1), equation (3) is integrated over the changes in all the quality variables q_{mj} that are changing in the given policy scenario. (Hanemann 1982).[5] Therefore the exact measure captures changes that occur in $\Pr^i(PL = 1)$ and $\Pr(j|PL = 1)$, as q_{1j} changes.

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[4] One difficulty we face in calculating the welfare measures is that the sequential estimation procedure does not result in a single estimate of the travel cost parameter which can then be used as the marginal utility of income. The models also include cost variables at the product line level, which further complicates the issue. Here, we acknowledge the potential mis-specification of the product line costs, and focus on how to calculate the welfare measures given multiple travel cost parameters. From the derivation in Hanemann (1982), Jones and Sung (1993) show how use of a weighted marginal utility of income yields an approximation of the welfare measure for a random utility model with travel cost parameters that differ across nests. The weights are the product line shares. For Model 1, this approach results in a value for the marginal utility of income of about 0.21. We adopt this as the value of μ that is used for each of the models. Use of the common weighted average μ for all the models makes the comparison more consistent across models.

[5] One can readily demonstrate that Hanemann's marginal welfare measure applies to the nested model by applying Theorem 5.2 from McFadden (1981).

Examining equation (3), note that since the models were estimated sequentially, the Pr($j|PL$ = 1)(β_q/μ) term in the right hand side of (3) does not change across models. However, the product line choice probabilities in the marginal welfare measure, the $Pr^i(PL = 1)$ terms, do differ for each model—as does the elasticity of the product line probabilities with respect to changes in quality. In our empirical applications, the product line probabilities differ primarily because the scope of the samples for which they are estimated are so different. The sample definition for Models 1 and 4

Table 2
The Four Alternative Product Line Choice Models

Variable	Model 1 All 6 PLs	Model 2 Only 3 PLs: GLww GLcd & Anad	Model 3 Only 2 PLs: GLcd & Anad	Model 4 All 6 PLs*
IV	0.928	1.048	0.180	0.410
	(26.6)	(16.6)	(1.66)	(12.1)
Supply cost	0.034	0.081	0.309	0.041
	(3.36)	(3.45)	(4.44)	(4.27)
Boat cost	0.015	0.00001	–0.152	0.006
	(1.97)	(0.001)	(–3.27)	(0.77)
PL2	1.576	1.856		1.139
	(13.3)	(7.48)		(9.95)
PL3	–0.999	–1.603	–4.12	–0.694
	(–5.61)	(–6.71)	(–4.35)	(–3.97)
PL4	–1.968			–0.178
	(–12.9)			(–1.32)
PL5	0.367			1.624
	(2.70)			(12.6)
PL6	–0.188			0.142
	(–1.43)			(1.12)
Sample size	2,463	1,087	446	2,463
LogL	–3,422	–777	–221	–3,817
χ^2	2,402	944	204	1,612

Note: t statistics appear in parentheses below the parameter estimates.

Variable Definitions:

- IV is the inclusive value index for the respective site choice models.
- PL2 through PL6 are the product line dummy variables.
- Supply cost and Boat cost are the predicted costs for the product line which are in addition to the travel costs. These predicted costs are individual specific and based on regressions which were run on survey expenditure data to estimate these costs as a function of product line, party size, and boat ownership.

Model Definitions:

1. Baseline Jones and Sung product line choice model with all six activities fully modeled.
2. PL model with three activities: GL cold, GL warm and anadromous, which are each modeled in full.
3. PL model with two activities: GL cold and Anadromous PLs, which are modeled in full.

* 4. Similar to model 1 with all six activities, yet only the GL cold and Anadromous PLs are modeled with all the sites; the choice sets for the other PLs consist of a single alternative (a dummy) to represent the aggregate group.

is the full recreational angling sample; for Models 2 and 3 it is the subsets of anglers who were observed to participate in selected activities. The elasticity of the product line probabilities will differ across the empirical models because the scope of the samples permit differing degrees of substitution across product lines and because the product line parameters differ (table 2).

Consider first the case of policy scenarios in which the probabilities for product lines excluded in the restricted models do not change substantially due to site quality changes. In this case the analytical results do *not* predict losses to be substantially overstated or gains substantially understated by excluding the product lines. For small changes in quality, differences in the elasticity of the product line probabilities will be less pronounced. In this case, the marginal welfare measure with the product line probability evaluated at the baseline quality level is a reasonable approximation for the exact measure (Hanemann 1982). However, differences in the empirical welfare measures will arise across models for this case due to differences in the product line choice probabilities. Given the product line specific dummies in each of the models, the estimated average product line choice probabilities will be approximately equal to the sample share choosing any product line for the model in question. In particular, for model 1, $Pr^1(PL = 1) \approx S_1/S$ while for model 3, $Pr^3(PL = 1) \approx S_1/(S_1 + S_3)$. Here, S_i represents the number of sample members in product line *i* and *S* represents the entire sample, so that S_1/S is the share of the model 1 sample that chose $PL = 1$ and $S_1/(S_1 + S_3)$ is the share of the model 3 sample that chose $PL = 1$. (The product line numbers in table 1 reflect the numbering of the site choice models for each fishing activity.)

We can readily see that the critical issue in calculating per-trip mean CV on a consistent basis across models is, what is the population over which the CVs are averaged? The explicit assumption in the model with the full set of activities is that all anglers have some probability of participating in all activities; therefore in that model, the mean per trip CV is calculated over all anglers. If in calculating per-trip means for the more restricted model 3 (containing only 2 product lines), we alternatively employ the (implicit) assumption that the full set of trout and salmon anglers is $(S_1 + S_3)$, we clearly will not generate comparable estimates of mean CV. Consequently we impose a consistent basis for averaging the mean trip CV data, where the means are calculated over the full sample of recreational anglers—and we implicitly assume CV = 0 for those individuals engaging in activities not included in the model. To highlight the distinction, table A-2 in the Appendix reports comparisons between mean per trip CVs for each model relative to model 1, calculated over the models' respective analysis samples.

The extrapolation controls as best we can for the different sample sizes, and different implicit assumptions across models about the scale of the impacts in the angling population. With this adjustment, we expect to see roughly comparable empirical estimates across the models for scenarios of "limited impact", scenarios in which the probabilities for product lines excluded in the restricted models do not change substantially due to site quality changes. However the interesting question we can now evaluate more clearly is to what extent the exclusion of relevant activities will cause gains to be understated and losses to be overstated because the opportunities for substitution are limited—for scenarios of more than "limited impact". How great is the substitution between the Great Lakes and the inland product lines? At what scale of quality change, do the substitutions become "substantial"? In the empirical examples comparing the models, the parameters in the second level nest are not held constant across models. Therefore, the direct analytical results suggesting losses will be overstated and gains understated in more restricted models serves as general guidance rather than binding conditions.

Results

Table 3 presents the definitions for the twelve policy scenarios. All of the policies involve changes in the trout and salmon catch rates within the Great Lakes cold and anadromous product lines. Six policies involve increases in catch rates, and six policies involve decreases in catch rates. The policies differ in the size of the changes in catch rates and the number of sites affected. Refer back to figure 1 for a depiction of the location of the sites affected by the various scenarios. To provide a context for interpreting the catch rates changes, table A1 presents summary statistics for the hourly catch rates affected by the policies.

Table 4 presents the mean CV per trip averaged across all recreational fishing anglers (the full sample of 2,463) for the policy scenarios for each of the models. The reported means use the full set of anglers to facilitate comparison across models. Models 2 and 3 have restricted choice set so they exclude anglers whose last trip was not in the activities modeled. Since the values being measured are use values, in table 4 we assume that anglers who were not included in a model do not experience changes in welfare.[6] Table 4 also presents the ratio of the results of Models 2, 3, and 4 to the results for Model 1. The ranking of the policies is consistent across the models, following the expected pattern of increasing gains for scenarios 1 through 6 and increasing losses for scenarios 7–12. The welfare measures are typically small—in part because fewer than 1/5 of the initial trips are in the affected product lines.[7]

The comparison between Model 3, which has the most restrictive choice set, and Model 1 generally follows the predicted pattern. Relative to Model 1, the gains are underestimated by Model 3 to an increasing extent as the magnitude of the quality changes increases. In addition, the losses are overestimated to an increasing extent as the magnitude of the quality changes increases—though the distortions seem to follow a more consistent pattern for the quality declines. This finding reflects the choice set restriction embodied in Model 3. Model 3 does not permit anglers from other activities to switch *into* GL cold and Anad when the quality improves, and conversely, Model 3 does not allow anglers to switch *out of* GL cold and Anad to other activities when the quality declines—where they otherwise would in Model 1.

Model 2 includes a third product line, Great Lakes warm water fishing, which more than doubles the sample of anglers in the model, relative to Model 3. For the comparison of Model 2 and Model 1, the predicted relationships are less clear. The relative sizes of the restricted model CV to the full model CV do increase for the losses, but remain fairly constant for the gains—a pattern hinted at in the comparison between Models 3 and 1. However the ratios appear to be lower relative to expected: for example, the losses are not understated except for scenario 12, and the

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[6] Ideally one would like to compare how the models perform in terms of estimating the total aggregate values for the policies. A simple method of extrapolating the results of model k to the respective statewide population would use the following calculation: $(W^k/S^k)\times(S^k/S)\times N$ where N is the population of licensed anglers, S is the total sample, W^k is the sum of the welfare effects for the individuals in model k, and S^k is the size of the sample for model k (*i.e.*, $S = S^1 = 2{,}463$; $S^2 = 1{,}087$; and $S^3 = 446$). In Table A-2 in the appendix, we present the values based on (W^k/S^k). Since S^k varies across our models, we report (W^k/S) in Table 4 to facilitate comparisons across models. Note however that the values we report are per-trip values. Since anglers take different numbers of trips, W^k would ideally consist of the sum of each sample member's trip-weighted CV, T_iCV_i. In the data at hand, we only have information on each angler's last trip so each anglers' total trips are unknown.

[7] Another factor that affects the magnitude of the welfare measures is that baseline catch rates for many individual species-site-month-county observations are zero and remain zero under the policies examined here. We thank one of the reviewers for highlighting this point. In addition, the welfare measures are in 1984 dollars, only apply to day trips, and are based on models where time costs have not been incorporated into the travel costs.

ratio of the gains from Model 2 to Model 1 hover in the vicinity of 0.8 for policies 1 to 6. The results for Model 4 follow a pattern that is quite similar to Model 2. Figure 3 graphs the mean per-trip welfare measures for Models 1, 2 and 3. Model 4 is not presented due to its similarity to Model 2. The policies are arranged on the x-axis in order of relative value from the largest gains to the largest losses. Figure 3 illustrates the pattern that models with restricted choice sets tend to under-state per-trip gains and over-state per-trip losses because they limit the substitution possibilities.

The degree of similarity in the welfare measures between Models 2 and 4 and Model 1 is due to the limited extent to which catch rate changes in Great Lakes product lines result in changes in the inland product line choice probabilities. Table 5 illustrates the pattern of substitution predicted by the different models. The table reports product line probability predictions for a select set of the policy scenarios for Model 1. Table 5 also presents the product line probabilities for the most extreme scenarios for the other models. Inspecting the results for Model 1, we see that there is some degree of substitution in and out of the affected product lines for all scenarios, but the degree of cross-product line substitution is very limited for most of the scenarios. This result is due in part to policies examined and the degree of substitution possibilities within the product lines of the model. Note that there are 40 sites in the Great Lakes cold product line and 41 sites in the anadromous product line. Moreover, for all but policies 6 and 12, only sites on Lake Michigan experience

Table 3
Policy Scenarios

Six Policies with Increases in Catch Rates

1. A 10% increase in all catch rates in the GL cold and Anadromous run product lines at 3 Lake Michigan counties: Muskegon, Newaygo, and Oceana.
2. A 10% increase in all catch rates in the GL cold and Anadromous run product lines for all Lake Michigan counties.
3. A 50% increase in all catch rates in the GL cold and Anadromous run product lines at 3 Lake Michigan counties: Muskegon, Newaygo, and Oceana.
4. A 50% increase in all catch rates in the GL cold and Anadromous run product lines for all Lake Michigan counties.
5. A 100% increase in all catch rates in the GL cold and Anadromous run product lines for all Lake Michigan counties.
6. A 100% increase in all catch rates in the GL cold and Anadromous run product lines for all Great Lake counties.

Six Policies with Decreases in Catch Rates

7. A 10% decrease in all catch rates in the GL cold and Anadromous run product lines at 3 Lake Michigan counties: Muskegon, Newaygo, and Oceana.
8. A 10% decrease in all catch rates in the GL cold and Anadromous run product lines for all Lake Michigan counties.
9. A 50% decrease in all catch rates in the GL cold and Anadromous run product lines at 3 Lake Michigan counties: Muskegon, Newaygo, and Oceana.
10. A 50% decrease in all catch rates in the GL cold and Anadromous run product lines for all Lake Michigan counties.
11. A reduction to 0 of all catch rates in the GL cold and Anadromous run product lines for all Lake Michigan counties.
12. A reduction to 0 of all catch rates in the GL cold and Anadromous run product lines for all Great Lake counties.

Note: See figure 1 for a depiction of the sites for each product line and of the policy sites.

catch rate changes. Thus, within the affected product lines there is substantial opportunity for substitution into and out of other Great Lakes sites that are not affected by changes in catch rate. This is not the case for the largest scale scenarios, which proportionately affect catch rates at all sites with non-zero catch rates in the affected product lines—generating a 100% increase in catch rates for scenario 6, and a reduction to 0 for catch rates in scenario 12. For scenario 6, Model 1 predicts the participation probabilities will increase for Great Lake Cold by 41% and for anadromous by 80%; for scenario 12, Model 1 predicts the participation probabilities will decrease for Great Lake Cold by 31% and for anadromous by 29%.

In contrast, Model 3 allows substitution within the affected product lines, but the only cross product line substitution is limited to substitution between the two affected product lines. Consequently, Model 3 demonstrates very little change in the product line shares across the scenarios. Models 2 and 4 allow some cross-product line substitution, but for scenarios 6 and 12, the adjustment in and out of the affected product lines is about half that predicted by Model 1. Interestingly, though Model 4 incorporates all the product lines in a coarse manner, it does not generate

Table 4
Mean Per-Trip Welfare Measures, Averaged Across all Recreational Anglers, for the 4 Models Across the Policies

Policies	Model 1 All 6 PLs Total CV	Model 2 GLww, GLcd & Anad Total CV (ratio*)	Model 3 Gled & Anad Total CV (ratio)	Model 4 All 6 PLs** Mean CV (ratio*)
Increases in CR	$	$	$	
1. +10% ΔCR at 3 Lake Mi. sites	0.014	0.010 (0.75)	0.011 (0.82)	0.011 (0.77)
2. +10% ΔCR at all	0.044	0.038 (0.86)	0.044 (0.99)	0.038 (0.86)
3. +50% ΔCR at 3 Lake Mi. sites	0.087	0.062 (0.71)	0.064 (0.73)	0.064 (0.74)
4. +50% ΔCR at all Lake Mi. sites	0.263	0.215 (0.82)	0.231 (0.88)	0.216 (0.82)
5. +100% ΔCR at all Lake Mi. sites	0.663	0.509 (0.77)	0.497 (0.75)	0.512 (0.77)
6. +100% ΔCR at all GL sites	0.900	0.728 (0.81)	0.624 (0.69)	0.734 (0.82)
Decreases in CR				
7. –10 % ΔCR at 3 Lake Mi. sites	–0.012	–0.009 (0.76)	–0.010 (0.87)	–0.010 (0.79)
8. –10% ΔCR at all Lake Mi. sites	–0.041	–0.036 (0.88)	–0.042 (1.04)	–0.036 (0.89)
9. –50% ΔCR at 3 Lake Mi. sites	–0.048	–0.038 (0.80)	–0.046 (0.95)	–0.039 (0.82)
10. –50% ΔCR at all Lake Mi. sites	–0.173	–0.158 (0.91)	–0.201 (1.16)	–0.161 (0.93)
11. ΔCR to 0 at all Lake Mi. sites	–0.290	–0.316 (1.09)	–0.377 (1.30)	–0.283 (0.97)
12. ΔCR to 0 at all GL sites	–0.400	–0.415 (1.04)	–0.491 (1.23)	–0.431 (1.08)

Notes: * The ratio gives the CV result from the current column divided by the CV result for Model 1.
** Model 4 replaces non-policy product lines with a dummy for each product line (see figure 2).

substantially different levels of substitution in and out of the affected product lines when compared to Model 2. Even though trips to the affected product lines are less elastic in Model 2 than in Model 1, changes in trips to the Great Lake warm product line are greater than they are for Models 1. The reason for this is that in Model 2, trip changes are restricted to come from or go to the Great Lakes warm product line, whereas in Model 1 trip changes are also drawn from or go to the inland product lines. Thus, Model 2 has some participation shifting into (out of) Great Lake warm that shifts into (out of) inland product lines in Model 1.

The welfare measures in table 4 are calculated using a consistent definition of the sample rather than using the sample for the respective model. Table A-2 reports the mean per-trip CVs calculated only over the respective samples—not averaged over a common population. Based on the discussion in section III, averaging over

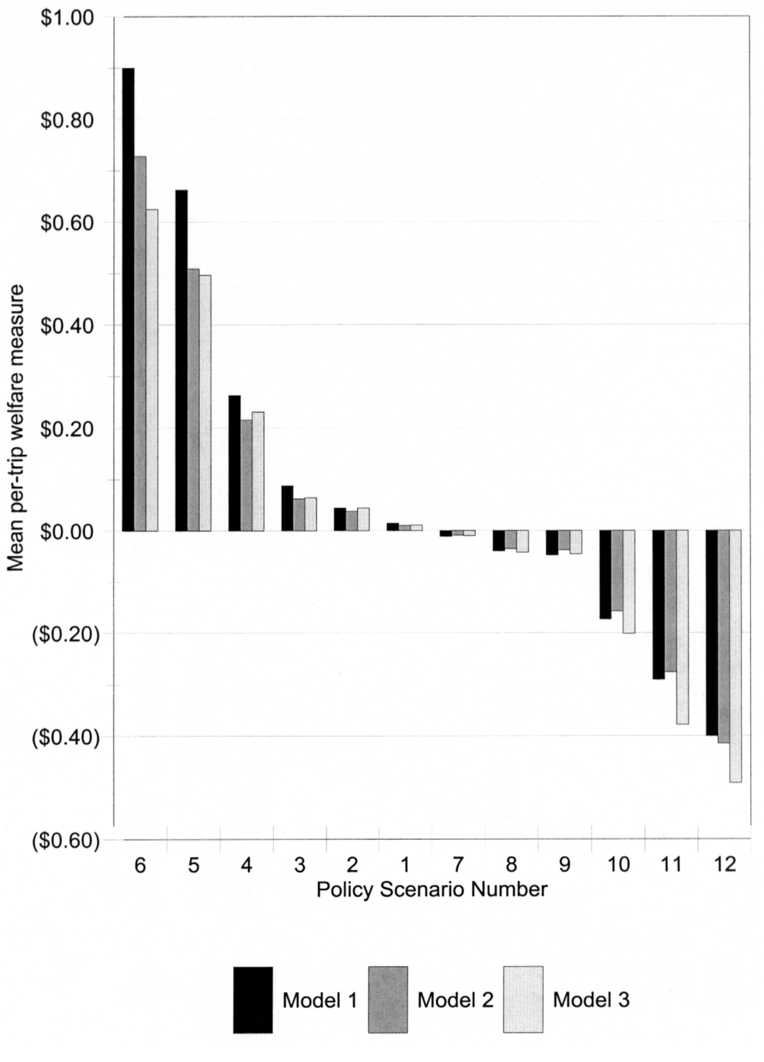

Figure 3. Mean Per–trip Welfare Measures for Models 1, 2, and 3 Across the Twelve Scenarios

the narrower samples in Models 2 and 3 both overstates the losses and overstates the gains relative to Model 1. Without accounting for the differences in the sample definitions, one might draw the wrong inference regarding the effect that restricting the range of activities in the choice set has on welfare measures. Moreover, were the results from table A-2 to be used for benefits transfer, one would need to take care to extrapolate to the correct population. Whereas table 4 results could be transferred to the full population of anglers, the results in table A-2 are only relevant to the population of anglers that corresponds to the population represented by the models with restricted choice sets.

Implications

The question we have explored in this paper is, "what is the impact on welfare analysis of using models with choice sets that limit the range of related substitute activities?" The basic analytical predictions are quite intuitive: welfare calculations with a site-choice travel cost model that omits relevant substitute activities will tend to understate gains and to overstate losses for a fixed sample and a fixed set of model parameters. The magnitude of bias in any particular case will be directly related to the degree of substitution between the omitted activities and the activities included in the model. In other words, the extent of the problem is strictly an empirical question.

In our application, we examine the welfare implications of changes in the quality of Great Lakes trout and salmon catch rates. Our empirical results indicate that models that only include Great Lakes fishing activities and anadromous runs, to the exclusion of inland fishing activities, yield relatively similar welfare results to models that include the full range of activities—except for the case of extreme scenarios. A critical caveat,

Table 5
Predicted Product Line Shares for Select Policies

	Policy	GLcd	Anad	Glww	Other PLs*
Model 1	policy 6	19.5	9.2	23.6	47.7
	policy 4	15.4	6.4	25.5	52.7
	policy 2	14.1	5.3	26.2	54.4
	baseline	13.8	5.1	26.3	54.8
	policy 8	13.5	4.9	26.5	55.1
	policy 10	12.2	4.3	27.0	56.5
	policy 12	9.5	3.6	28.0	58.9
Model 4	policy 6	16.2	6.8	24.5	52.5
	baseline	13.8	5.1	25.8	55.4
	policy 12	11.7	4.3	26.7	57.3
Model 2**	policy 6	15.2	7.3	21.6	
	baseline	13.5	4.9	25.8	
	policy 12	11.0	3.9	29.2	
Model 3**	policy 6	13.0	5.1		
	baseline	13.3	4.9		
	policy 12	13.3	4.8		

Notes: * The sum of the predicted shares for the other product lines (LScd, ILww, and ISww). ** Note that for models 2 and 3, the probabilities are the predicted sample shares adjusted so that they are comparable to models 1 and 4 with the full sample of 2,463. The adjustment multiplies the predicted shares by (1,087/2,463) for model 2 and by (446/2,463) for model 3.

which we discuss further below, is that the comparisons of mean trip CV must be made for a common population. The differences across models did not appear to be very substantial even for policies generating a 50% change in catch rates in approximately half of 40 sites in each of 2 product lines. We do observe that the results are more consistent for restricted models that nonetheless allow some substitution—from unaffected activities into and out of the affected activities. The findings are attributable to the relatively low predicted rates of substitution between inland and Great Lakes product lines. The empirical result is specific to this particular context, in which there is a particularly rich array of substitution possibilities within the Great Lake and anadromous product lines.

One key limitation of our analysis is that the product line levels of the nested models are not directly comparable in terms of their inclusive value parameters. It would be interesting to specify a version of the model that has the full range of activities and allows each nest to have different inclusive value parameters. It is likely that the performance of such a model might well approximate that of Model 4. However, regardless of the model specification, the key point remains that the effect on welfare measures from restricting activities from the choice set depends on the degree of substitution between the activities. In addition, in our comparisons, we hold the site choice portions of each model constant to reduce the moving parts. However, were the models to be estimated simultaneously, there are potentially many more estimated parameters that could change with different ranges of activities in the choice sets. Also, it is important to bear in mind that our results apply to models of recreational site choice that do not explicitly model participation by including a “don’t go” alternative in the choice set. In principle, the “don’t go” alternative in a repeated-logit model captures all activities and sites that are not explicitly modeled as alternatives in the choice set.

So, is it preferable to include more activities in a model? Naturally, the answer is that it depends. It is clear that the model parameters and the welfare measures depend on which model is employed. Moreover, because the scope of the model affects the relevant sample population, the model scope affects the entire research design and potentially affects the survey and analysis costs. Our results suggest that, for the smaller scale policies examined here, little would be lost by restricting attention to a model that only includes the activities affected by policies of interest.

Our results also highlight the need for caution when conducting benefits transfer exercises and comparing models that differ in their scope of activities and in their sample definitions. A key point to highlight is that comparisons of per trip welfare measures, for example for benefits transfer, must be made across comparable populations. Unlike experiments with choices sets where the analyst adjusts the choice sets by experimenting with which (non-visited) sites to include in an individual’s choice set, experiments that add activities will generally expand the sample to include those who participated in the new activities. The large differences between the mean CV estimates averaged over the model samples makes it clear that the appropriate estimate to transfer depends on the population to which the estimate will be transferred. The important point is to match the benefit estimate to the appropriate population. For example, a mean CV estimate from a model that only includes trout and salmon fishing should not be transferred to a general population of anglers (targeting any species), but might be suitable for a population of trout and salmon anglers. The encouraging result for benefits transfer is that for modest changes in quality, aggregate welfare estimates from a model with a limited range of activities closely mirror estimates from a model with broader scope. Of course, this conclusion is based on our analysis of models that did include a large number of substitutes *within* each activity and would not generally be expected to apply to models that are both limited in the range of activities and limited in the substitute sites within each activity.

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Table A-1
Mean Catch Rates per Hour (by Species by Month by Site), for Areas Affected by the Policies

	The 3 Lake Michigan GLcold & Anad Sites			All Lake Michigan GLcold & Anad Sites			All Great Lake GLcold & Anad Sites		
	Mean	Std. Dev.	Max	Mean	Std.Dev.	Max	Mean	Std. Dev.	Max
GLcold PL									
Chinook Salmon	0.08	0.04	0.14	0.06	0.04	0.22	0.04	0.04	0.22
Coho Salmon	0.01	0.01	0.03	0.01	0.03	0.17	0.01	0.04	0.27
Lake Trout	0.02	0.02	0.07	0.02	0.04	0.22	0.04	0.08	0.50
Steelhead	0.02	0.03	0.07	0.01	0.03	0.17	0.01	0.02	0.17
Anad PL									
Chinook Salmon	0.08	0.13	0.40	0.07	0.16	0.82	0.05	0.13	0.82
Coho Salmon	0.00	0.00	0.00	0.02	0.07	0.52	0.01	0.05	0.52
Steelhead	0.12	0.13	0.30	0.06	0.08	0.30	0.05	0.08	0.47

Note: * These are means (max) over all months and over the counties as defined by the column. For all rows the minimum of the catch rates over counties and months is zero. Note that there is a large number of site/month/species combinations where the catch rates are zero, and for these sites, the percentage change in catch rates policies considered here will have no effect.

Table A-2
Mean CV Calculated Over the Sample Used to Estimate the Respective Model

Policies	Model 1 All 6 PL's Total CV	Model 2 GLww, GLcd & Anad Total CV (ratio*)	Model 3 Gled & Anad Total CV (ratio)
Increases in CR	$	$	$
1. +10% ΔCR at 3	0.014	0.023	0.058
Lake Mi. sites		(1.69)	(4.28)
2. +10% ΔCR at all	0.044	0.086	0.211
		(1.94)	(4.77)
3. +50% ΔCR at 3	0.087	0.140	0.356
Lake Mi. sites		(1.61)	(4.08)
4. +50% ΔCR at all	0.263	0.487	1.195
Lake Mi. sites		(1.85)	(4.54)
5. +100% ΔCR at	0.663	1.154	2.829
all Lake Mi. sites		(1.74)	(4.27)
6. +100% ΔCR at	0.900	1.649	4.056
all GL sites		(1.83)	(4.51)
Decreases in CR			
7. –10 % ΔCR at 3	–0.012	–0.021	–0.052
Lake Mi. sites		(1.73)	(4.37)
8. –10% ΔCR at all	–0.041	–0.081	–0.198
Lake Mi. sites		(1.98)	(4.89)
9. –50% ΔCR at 3	–0.048	–0.086	–0.216
Lake Mi. sites		(1.80)	(4.53)
10. –50% ΔCR at all	–0.173	–0.358	–0.887
Lake Mi. sites		(2.07)	(5.11)
11. ΔCR to 0 at all	–0.290	–0.717	–1.560
Lake Mi. sites		(2.47)	(5.38)
12. ΔCR to 0 at all	–0.400	–0.940	–2.378
GL sites		(2.35)	(5.94)

Notes: Recall that the sample sizes are smaller for the per-trip models with restricted choice sets (Models 2 and 3). Thus, the means for Model 1 are based on the full sample size of 2,463. The means for Model 2 are based on the restricted sample of 1,087 anglers whose last day trip was in the GLcd, GLww, or Anad product lines. The means for Model 3 are based on the restricted sample of 446 anglers whose last day trip was in the GLcd or Anad product line. Results for Model 4 are not reported here since they are the same as reported in the Table 4 because it uses the full the sample.