# CHAPTER 6
# A COMBINED REVEALED PREFERENCE AND STATED PREFERENCE MODEL OF GREEN BAY FISHING

## 6.1 INTRODUCTION

In this chapter we present our main model used to estimate per fishing day values for changes in FCAs and catch times. The technical details of the model are presented in Appendices A and B. The model presented here is considered our main model because it is consistent with traditional recreational demand models and is a straightforward specification that can be expected to provide robust estimates; it uses all of the RP and SP data available. In Chapter 9 we explore the sensitivity of the damage estimates to preselected model variations. These variations, some of which add considerable elaboration, provide results consistent with (and generally not statistically significantly different from) the main model results, supporting the robustness of the main model.

This chapter describes the model developed to explain each angler's observed and stated Green Bay fishing choices as a function of a number of Green Bay characteristics. The parameters on these characteristics represent the relative importance of the Green Bay characteristics in determining the benefits an angler will get from fishing Green Bay. For example, the parameter on launch fee indicates the decrease in benefits from a day of fishing Green Bay if the launch fee is increased $1, and the parameter on average catch time for perch indicates the decrease in benefits from a day of fishing Green Bay if the catch time for perch increases one hour.

In our main model, all of the SP and RP data are combined for the estimation of the model. Three types of preference data are available: 1) anglers' preferred alternatives from the eight Green Bay choice pairs, 2) the expected number of Green Bay fishing days to be spent at the preferred Green Bay alternatives from the eight followup questions to the choice pairs, and 3) the number of fishing days in total to all sites and the number of days each angler fishes Green Bay under current conditions. The first two data types are SP data and the last data type is RP data. The estimates of the model parameters (reported in Chapter 7) are those parameter values that best explain all of the anglers' choices. As noted in Chapter 5, combining RP and SP data is widely supported because of the relative strengths of these two types of data. While both types of data provide information about behavior and tradeoffs, the relative strength of RP data is in predicting trip-taking behavior, and the relative strength of SP data is in determining the rates at which the angler is willing to trade off site characteristics.

This model assumes the angler, when he fishes, chooses the fishing site that gives him the largest net benefit. That is, he will choose Green Bay alternative A over B if he prefers A to B, and then he will choose Green Bay with conditions A over some other site if he expects the net benefit from fishing Green Bay under these conditions is greater than the net benefit from fishing elsewhere. If not, he will fish elsewhere. The model is designed to be a partial model in that it does not explain the angler's total number of fishing days, only the allocation of those fishing days between Green Bay and other sites. That is, the model is not designed to predict how an angler's total number of fishing days might increase if Green Bay conditions are significantly improved. It will, however, predict the extent to which an angler's current number of fishing days would be reallocated to Green Bay if Green Bay were improved.[1]

The model assumes that fishing is separable from nonfishing activities in that it assumes that how an angler chooses between Green Bay and other sites and how an angler chooses between Green Bay under different conditions does not depend on the costs or attributes of other activities. That is, how an angler would choose between Green Bay under different conditions does not depend on the characteristics of other fishing sites, and how an angler would choose between Green Bay and another site does not depend on the characteristics of nonfishing activities. While not always literally true, these are standard modeling assumptions. When examining choices over Green Bay alternatives under different conditions, the characteristics of other sites remain constant.

Because the model is not designed to predict how total fishing days would increase if Green Bay is improved, damage estimates derived from the model will be conservative. The component of benefits associated with the possibility that the angler might fish more, in total, if Green Bay is improved, rather than just fishing Green Bay some increased proportion of some constant number of days, is omitted. It is our intent to be conservative here.

In this chapter, the basics of the model are presented. The extensive technical and mathematical details of model development are presented in Appendices A and B.

## 6.2 FACTORS AFFECTING UTILITY FROM FISHING GREEN BAY

The utility (satisfaction) an angler receives from a day of fishing Green Bay is modeled to be a function of costs (which include the opportunity cost of travel and on-site time, plus monetary expenses including travel costs and any launch fee); the catch times for four different species groups targeted in Green Bay: trout/salmon, perch, walleye, and bass; and the level of FCAs

1. We restrictively assume all increased days to Green Bay are substituted from other fishing sites (and vice-versa for decreased fishing days at Green Bay). Actual increases in Green Bay fishing days may also come from increases in total fishing days, not just from substituting days from other sites. The assumption of no increase in total fishing days is more straightforward to model and requires fewer survey questions (e.g., we do not ask if total days change and by how much). The substitution assumption is implemented in the model by holding total fishing days constant, even though increases in fishing days may in fact occur when Green Bay is improved. Further, we restrict any expected increases in Green Bay days in the followup questions to be no more than the total fishing days at other sites under current conditions.

(which can be one of nine levels, including no FCAs). The utility angler *i* gets from fishing Green Bay is assumed to be:

$$U_i = b_y(-FEE) + b_{cp}ACT_p + b_{ct}ACT_t + b_{cw}ACT_w + b_{cb}ACT_b + b_{FCA2}FCA_2 + b_{FCA3}FCA_3 + \ldots + b_{FCA9}FCA_9 + e_{Gi},\ i = 1, \ldots, N \quad (1)$$

where *FEE* is the launch fee; *ACT* is the average time to catch a fish, indexed by the four species: *p* = perch, *t* = trout/salmon, *w* = walleye, and *b* = bass; *FCA* is a dummy variable indexed by each of the nine FCA levels ($\beta_{FCA1}$ is fixed at zero for identification), and $e_{Gi}$ is a stochastic term for capturing random effects on utility from fishing Green Bay.[2] The *FCA* variables are dummy variables, which take on a value of one for one of FCA Levels 2-9, and a value of zero for all others. Note again that *ACT* is the reciprocal of the associated catch rate. Money not spent fishing is assumed to be spent on a numeraire, a generic bundle with a price of $1.

Parameter $b_y$ indicates the increase in utility if the cost of the fishing day decreases one dollar and is typically referred to as the marginal utility of money. It is assumed to be a constant. This parameter is expected to have a positive sign, which also implies that the angler prefers a lower launch fee. Downward sloping demand (i.e., demand is a decreasing function of price) is a standard tenet of consumer economic theory and a universally observed phenomenon.

The catch parameters, $b_{cp}$, $b_{ct}$, $b_{cw}$, and $b_{cb}$, represent the change in utility from an increase in the time it takes to catch the four species. These parameters are expected to be negative (because the variable is catch *time* rather than catch *rate*); anglers like to catch fish, so they prefer to catch a fish in a shorter amount of time, or more fish in the same amount of time.

As also noted in Chapter 3, the answers to the attitudinal questions definitely indicate that anglers place importance on catching fish. For example, when anglers were asked to rate from one to five the importance of increasing catch rates in Green Bay, 68.5% responded with a three or higher. When asked to explain their ratings of Green Bay relative to other sites in the survey (Question 1), 29.1% voluntarily offered catch-related comments as their first explanation, again showing the importance of catch rate.

The $b_{FCA}$'s represent the change in utility from the different FCA levels. Because eight dummies representing nine possible FCA levels are used, the model allows a nonlinear relationship between severity of the FCA and the angler's utility. This feature, for example, allows the impact on utility of a change from FCA Level 4 to 3 to be different from the impact of a change from Level 9 to 8.

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2. Note that the full budget constraint is $b_y(Y_i - TC_{Gi} - FEE)$, where $Y_i$ is the angler's per-choice occasion income and $TC_{Gi}$ is angler *i*'s trip cost for Green Bay (excluding the launch fee). Since income and trip costs to Green Bay remain constant, they do not influence the probability of choosing one Green Bay alternative over the other, and they are omitted for convenience of presentation.

Because FCAs make anglers worse off, all of these parameters are expected to have a negative sign and to be nondecreasing in absolute value as the stringency of the advisory increases.

Attitudinal questions from the mail survey corroborate the negative effects of FCAs on anglers. When asked to rate the importance of different enhancement activities, such as cleaning up PCBs so that FCAs could be removed, increasing the catch rates, or adding parks or boat launches (Question 7), anglers identify PCB cleanup as more important than any other option. Further, when asked how bothered they are about different FCA levels on a one-to-five scale, the means for all FCA levels are greater than three, and increase with the severity of FCAs.

If in a pair-wise Green Bay choice the utility from alternative B is greater than the utility from alternative A, the angler chooses B. In this model, it is assumed that preferences are homogeneous; that is, all anglers have the same marginal utilities for changes in the site characteristics for Green Bay. This assumption is relaxed in Chapter 9, and while in some cases it is found that different anglers have significantly different preferences, the effect on mean values of allowing preferences to be heterogeneous across anglers is usually found to be very minor.

## 6.3 FACTORS AFFECTING UTILITY FROM FISHING ELSEWHERE

As stated earlier, the model also predicts the expected allocation of total 1998 fishing days between the Green Bay alternative (with the preferred characteristics) versus all other sites, which is represented as one generic other site. This other generic site may vary across anglers and simplifying assumptions must be made because data on trip costs and other characteristics for the other site are unobserved (but are assumed to remain constant over time). The utility from fishing the other site, $U_{Oi}$ , is assumed to be some constant that is the same for everyone (and estimated as a parameter in the model), plus a stochastic random component for the other site, which varies across anglers:[3]

$$U_{Oi} = b_0 + e_{Oi} \tag{2}$$

For each fishing day, an angler compares the utility from the preferred Green Bay alternative from the choice pair to the utility from the other non-Green Bay fishing site. If the utility from fishing Green Bay with the preferred set of characteristics is greater than the utility from fishing elsewhere, the angler will choose Green Bay for that fishing day, and vice versa. The estimated model parameters (see Chapter 7) are those estimates that best explain the expected allocations of the total 1998 fishing days to the preferred Green Bay alternatives from the choice pairs, each angler's current allocation of fishing days between Green Bay and other sites, and anglers' choices in the eight Green Bay pairs.

3. In Chapter 9 individual-specific characteristics are incorporated into $U_o$ .

## 6.4 ESTIMATION OF THE MODEL

In the empirical model, parameters are estimated using a mathematical search algorithm that makes the observed anglers' choices most likely. In other words, the estimated parameters maximize the likelihood of observing the anglers' chosen alternatives from the choice pairs, their allocations of current fishing days to the chosen alternatives, and finally, the reported current number of fishing days to Green Bay. The parameter estimates are called *maximum likelihood* estimates because they are estimates of the population parameters that maximize the likelihood of drawing the sample of the observed choices.

The *likelihood function* that is maximized is derived and presented in detail in Appendix A. In short, it is a complex joint probability over all of the individuals in the data set. For a single individual it is computed as the product of the probabilities of the chosen Green Bay alternatives over the eight choice-occasion pairs; multiplied by the product of the probabilities of the expected allocation of 1998 total days to the preferred Green Bay alternatives over the choice-occasion pairs, conditional on the chosen Green Bay alternatives; multiplied by the probability of the current allocation of 1998 total days to Green Bay under actual conditions. Maximizing the likelihood function is equivalent to maximizing the joint probability of observing the collective angler behavior and choices.