18 Combining stated-choice and stated-frequency data with observed behavior to value NRDA compensable damages: Green Bay, PCBs, and Fish Consumption Advisories

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18.1 Introduction

The paper uses a case study to demonstrate the use of stated-choice and stated-preference (i.e., contingent behavior) questions, combined with data on actual choices, to estimate compensable damages in a Natural Resource Damage Assessment (NRDA).[1] We summarize the stages in a NRDA, including survey design and implementation, data collection and analysis, model development and estimation, and damage calculations.

Simply put, a stated-choice question presents an individual with a number of alternatives, each described in terms of the levels of their common set of characteristics, and asks the individual to state his preferred alternative. Stated-choice techniques are used in marketing, transportation, and economic research to value products, environmental resources, and changes in transportation modes as a function of their characteristics.

Under Federal law responsible parties are liable for the damages to natural resources caused by the release of hazardous substances in accordance with the regulations at 43 CFR §11.81–11.84. Some of the major NRDAs in the last decade include US versus Exxon (Carson et al., 1992), Montana versus ARCO (Morey et al., 2002b), and the southern California bight (Carson et al., 1994).

A component of the first two of these assessments was estimating the damages to recreational users from the injuries. Such damages are deemed recreational use values (damages) and are measured in terms of willingness to pay (WTP) by users for the absence of injuries plus WTP by non-users that would be users in the absence of injuries. Use benefits that can only be experienced by being in proximity to the resource are typically considered easier to estimate than passive use benefits, because use damages partially exhibit themselves in terms of behavioral changes.[2] In this application, we only estimate a component of use damages.

Our method combines methods identified as acceptable in the DOI regulations [43 CFR §11.83(c)]. Choice-based methods are explicitly identified (as conjoint methods) in the NOAA NRDA regulations for use in valuing and scaling injuries and restoration (15 CFR part 990, preamble Appendix B, part G). In addition to estimating damages, stated-choice questions are a promising technique for making the determination of in-kind compensation and restoration, because in addition to monetizing damages, choice questions investigate how individuals make resource-to-resource tradeoffs. For this reason, stated-choice questions can be attractive to those who have no desire to estimate damages in monetary terms.

Estimating damages is essentially the task of estimating the target population's preferences for the resource in both its injured and non-injured state. One can gather information about preferences by observing choices, or by asking individuals about the choices they would make in hypothetical situations. Choice questions are a stated-preference (SP) technique for estimating preferences because the respondent is asked to state something about his preferences.[3] The same is true for stated-frequency questions. In contrast, revealed preference (RP) techniques observe an individual's actual choices in the market or other arenas, and inferences are made about the individual's preferences based on those observed choices. The emphasis here is on the use of SP techniques combined with RP techniques. SP techniques are often required because damages often cannot be estimated using only observed behavior. This is because resources similar to the injured resource, but without injuries, often do not currently exist. We present an example of how to ask and analyse stated-choice questions.

The application estimates compensable damages to anglers from fish consumption advisories caused by PCB contamination in Green Bay and the Lower Fox River of Wisconsin (Figure 18.1). PCBs, a hazardous substance under CERCLA, were released into the Lower Fox River of Wisconsin by local paper companies (Sullivan et al., 1983; WDNR, 1998; Stratus Consulting, 1999), primarily between the late 1950s and the mid 1970s. Interestingly, the PCB contamination resulted, in part, from the recycling of paper. Through time, PCBs have been and continue to be redistributed into the sediments and natural resources of the Lower Fox River and the Bay of Green Bay.

Through the food chain process, PCBs bio-accumulate in fish and wildlife. As a result of elevated PCB concentrations in fish, in 1976 the Wisconsin Department of Health and Human Services first issued fish consumption advisories (FCAs) for sport-caught fish in the Wisconsin waters of Green Bay, and in 1977 Michigan first issued FCAs for the Michigan

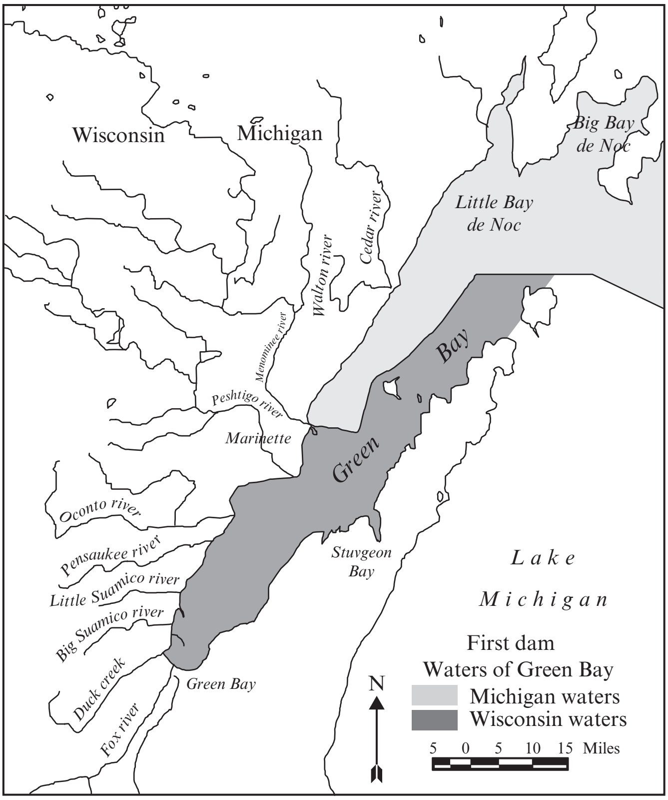

Figure 18.1

waters of Green Bay (Stratus Consulting, 1999). These FCAs for the waters of Green Bay continue today, although the specifics of the FCAs have varied through time. Even with significant removal of PCB contaminated sediment, the FCAs may continue for 100 years or more (Velleux and Endicott, 1994; WDNR, 1997).

Damage estimates generated by inputting primary data into a statistical model, which we do here, need to be supported by independent research and answers to attitudinal questions. Solicited opinions and attitudes help to determine the site characteristics important to the population, providing support for the statistical estimates of damages. In our case, there is also abundant literature demonstrating that FCAs damage anglers, in that anglers change where and how often they fish, change what they fish for and what they keep, change how they prepare and cook the fish they catch, and experience reduced enjoyment of the fishing experience.[4] A number of studies have estimated the damages associated with FCAs, but none specifically for Green Bay FCAs.[5] They indicate that such damages can be substantial. In addition to estimating the damages associated with Green Bay FCAs, our model estimates the benefits associated with increases in catch rates, so can be used to determine how much catch rates would have to increase to compensate the anglers for the presence of the FCA. Supporting these estimates, there are hundreds of articles that estimate significant values for changes in catch rates. Some that apply to the Great Lakes and Green Bay include Samples and Bishop (1985), Milliman et al. (1992), Lyke (1993), and Chen et al. (1999). If in-kind compensation is chosen for remediation or restoration, increased catch rates is a likely candidate for such compensation.

Recreational fishing damages from FCAs can be classified into the following four categories:

1. Reduced enjoyment from current Green Bay fishing days. Current Green Bay anglers may experience reduced enjoyment from their days at the site because of concerns about health safety and displeasure with catching contaminated fish. These concerns can result in changes in fishing locations within the waters of Green Bay, changes in target species type and size, and changes in behavior regarding keeping, preparing, and consuming fish.
2. Losses by Green Bay anglers from fishing at substitute sites. Because of FCAs, anglers who fish the waters of Green Bay may substitute some of their fishing days from the waters of Green Bay to other fishing sites that, in the absence of FCAs in the waters of Green Bay, would be less preferred sites.
3. Losses by Green Bay anglers who take fewer total fishing days. Because of FCAs, anglers who fish the waters of Green Bay may take fewer total fishing days than they would in the absence of injuries. For example, an angler may still take the same number of days to other sites, but take fewer days to the waters of Green Bay to avoid the FCAs.
4. Losses by other anglers and non-anglers. Because of FCAs, some anglers may completely forego fishing the waters of Green Bay. Other individuals who would fish the waters of Green Bay if it did not have FCAs may completely forego fishing.

The approach employed here estimates the damages in a conservative fashion: the damage estimates include categories 1, 2, and 3, but not category 4.

The primary focus of the assessment is to estimate open-water recreational fishing damages for the population of anglers who purchase

Wisconsin fishing licenses in eight Wisconsin counties near Green Bay and who are active in Green Bay fishing. We will refer to this group as our target population. Data collection focuses on the Wisconsin waters of Green Bay, because PCB loadings and the resultant FCAs are more severe for the Wisconsin waters of Green Bay than for the Michigan waters of Green Bay, and because the recreational fishing activity in the Wisconsin waters of Green Bay is much larger than in the Michigan waters of Green Bay. Anglers in the target population account for the vast majority of anglers and fishing days in the Wisconsin waters of Green Bay. Data collection focuses on open-water fishing (i.e., non-ice fishing) because it accounts for almost 90 per cent of all fishing on the waters of Green Bay.

The model combines data on actual fishing activities under current conditions (for example, days fishing in the Wisconsin waters of Green Bay) with data on how anglers would be willing to tradeoff changes in fishing characteristics (including catch rates, FCAs, and costs), and data on how many days anglers would fish Green Bay under alternative conditions. From the estimated model one can derive an estimate of WTP per Green Bay fishing day and per choice occasion for the absence of Green Bay FCAs. These latter WTP estimates, when multiplied by the assumed number of choice occasions for the anglers in our target population, are used to obtain estimates of the use damages to anglers from the PCB contamination.

The rest of the paper is organized as follows. Section 2 briefly describes the survey, sampling plan, and data collection effort. Section 3 summarizes the characteristics and attitudes of Green Bay anglers, and Section 4 considers the stated-choice and stated-frequency questions in more detail. Section 5 outlines the combined revealed and stated preference model of Green Bay fishing days. Section 6 reports estimates of 1998 damages, and Section 7 concludes.

18.2 Primary data collection

A three-step procedure was used to collect data from a random sample of individuals in the target population. First, a random sample of anglers was drawn from lists of 1997 license holders in the county courthouses in the eight counties near the Bay of Green Bay: Brown, Door, Kewaunee, Manitowoc, Marinette, Oconto, Outagamie, and Winnebago. This population includes residents of these counties, as well as residents of other Wisconsin counties, and non-residents who purchased their Wisconsin fishing licenses in these eight counties. We chose this target population for two reasons: most Green Bay fishing days are by these anglers, and fishing license data in Wisconsin are stored only in country court houses on records that cannot be removed, making it expensive to obtain a random sample of all Wisconsin license holders who fish Green Bay.

Second, a telephone survey was completed in late 1998 and early 1999. From the courthouse sample, the telephone numbers were obtained and a telephone contact was attempted with 4597 anglers; 3190 anglers completed the telephone survey for a 69 per cent response rate. The telephone survey collects data from all anglers on the number of total days fished in 1998, how many days were in the waters of Green Bay, and on attitudes about actions to improve fishing. Anglers who had participated in open-water fishing in the Wisconsin waters of Green Bay in 1998 (the target population) were recruited for a follow-up mail survey: 92 per cent of the open-water Green Bay anglers agreed to participate in the mail survey (the third and final step). Of the 820 anglers mailed the survey, 647 (79 per cent) completed and returned the survey. In terms of the socio-economic information collected during the phone survey, the Green Bay anglers who completed the mail survey do not differ significantly from those who did not.

The core of the mail survey is a series of eight choice questions used to assess damages for reductions in enjoyment for current open-water fishing days in the Wisconsin waters of Green Bay. Figure 18.2 is an example. In each question, respondents are provided two alternatives (A and B), each with different levels of fishing characteristics for the waters of Green Bay, and asked to choose whether alternative A or alternative B is preferred. Fishing characteristics include catch rates and FCA levels for yellow perch, trout and salmon, walleye, and smallmouth bass; and an angler's share of the daily launch fee.

After each choice pair, the following follow-up question about the expected number of days the angler would visit the preferred site was asked:

> How often would you fish the waters of Green Bay if it had the conditions described by the alternative you just chose (A or B)? Your answer could depend on a number of factors:
>
> How many days you typically fish in a year and how many of those days are spent fishing the waters of Green Bay.
>
> How much you enjoy fishing the waters of Green Bay compared to other places you might fish.
>
> How far you live from Green Bay compared to other places you might fish.
>
> The cost of fishing the waters of Green Bay compared to other places you might fish.
>
> Whether you think the conditions for the waters of Green Bay in the alternative you just chose are better, worse, or about the same as current conditions.

If you were going to fish the waters of Green Bay, would you prefer to fish the waters of Green Bay under alternative A or alternative B? *Check one box in the last row*

	Alternative A	**Alternative B**
Yellow Perch		
Average catch rate for a typical angler	40 minutes per perch	30 minutes per perch
Fish consumption advisory...	No more than one meal per week	No more than one meal per week
Trout and Salmon		
Average catch rate for a typical angler	2 hours per trout/salmon	2 hours per trout/salmon
Fish consumption advisory...	Do not eat	No more than one meal per month
Walleye		
Average catch rate for a typical angler	8 hours per walleye	4 hours per walleye
Fish consumption advisory...	Do not eat	No more than one meal per month
Smallmouth bass		
Average catch rate for a typical angler	2 hours per bass	2 hours per bass
Fish consumption advisory...	No more than one meal per month	Unlimited consumption
Your share of the daily 1aunch fee	Free	$3
Check the box for the alternative you prefer	☐	☐

Figure 18.2 Example choice question

> The more you fish the waters of Green Bay the less time you will have for fishing elsewhere.
> Excluding ice fishing, how many days, on average, would you fish the waters of Green Bay in a typical year if the conditions on the waters of Green Bay were those described in the alternative you chose? Fill in the blank.
>
> ———— days fishing the waters of Green Bay in a typical year.

This follow-up question allows for the estimation of damages associated with substituting days from the waters of Green Bay to other fishing sites or activities because of FCAs.

The survey also asked a number of attitudinal questions about Green Bay and its characteristics, and collected socio-economic data about the angler's household and the number of fishing days since the angler was surveyed by phone.

18.3 Green Bay angler profile

Eighty-five per cent of the anglers active in the Wisconsin waters of Green Bay had heard or have read about the FCAs, and, in general, the anglers' perceptions of the specific advisory levels (i.e., how often one could eat fish of each species) are consistent with the published FCAs. Seventy-seven per cent of the anglers identify behavioral responses to the FCAs in the Wisconsin waters of Green Bay, with 30 per cent of active anglers reporting they spend fewer days fishing the Wisconsin waters of Green Bay because of the FCAs. Over half the anglers have changed the species or size of fish they keep to eat, and over half have changed the way the fish they keep are cleaned, prepared, or cooked.

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, 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. That is, damages are a function of the scope of the injuries.

While anglers indicated that increasing catch rates is not as important as removing PCBs, not surprisingly, catching fish is an important part of fishing. For example, when anglers were asked to rate from one to five the importance of increasing catch rates in Green Bay, 68.5 per cent responded with a three or higher.

18.4 The Green Bay stated choice questions

Consider presenting a current Green Bay angler with the following simple choice pair: Green Bay with a \$5 launch fee and an average catch rate of one fish per hour, versus Green Bay with an \$8 launch fee and an average catch rate of one fish every 30 minutes. If an angler chooses the second alternative (higher cost and catch rate), and assuming his choice represents his preferences, his WTP per Green Bay fishing day for the doubled catch rate is at least \$3. If the angler chooses the first alternative, the WTP is less than \$3. Many different choice pairs can be generated by varying the launch fee and catch rates. For example, if there are three launch fees and four catch rates, there are 12 possible alternatives and 66 possible pairs. If site characteristics include cost, catch rate, and FCA level, choice pairs can determine how an angler would trade off less stringent FCAs at the site for higher cost, better catch rates for higher cost, or better catch rates for more stringent FCAs.

After each Green Bay choice question, the follow up question gives the angler the opportunity to indicate whether he considers the chosen Green Bay alternative better or worse than current conditions. For example, an angler could choose an alternative and then report he would fish Green Bay less, or even zero times, if the conditions were as in the chosen alternative.

SP data has some distinct advantages. Morikawa et al. (1990) states, 'for example, since SP data are collected in a fully controlled "experimental" environment, such data has the following advantages in contrast with RP data that are generated in natural experiments: (1) they can elicit preferences for non-existing alternatives; (2) the choice set is pre-specified; (3) collinearity among attributes can be avoided; and (4) range of attribute values can be extended.' Researchers estimating the value of environmental goods are often valuing a good or condition that does not currently exist, for example, Green Bay absent PCB contamination and FCAs. In addition, because SP data allow the researcher to control more variables and because there are more unknowns influencing the decisions in RP data, the SP data often contain less noise and measurement error (Louviere, 1996).

We combine the SP data with data on observed fishing days under current conditions, allowing the amount of noise in the SP data to differ from the amount of noise in the RP data.[6] SP and RP data provide different information about anglers' preferences, so combining them into an integrated model leads to better estimates of those preferences.

There is the incentive to make choices consistent with one's preferences, if the choices have consequences. The anglers who took our survey, current Green Bay anglers, have knowledge of the resource and its PCB injuries, care about those injuries, and felt that their answers to the choice questions would be examined by policy makers.

With choice questions, it is important to include as characteristics all the significant characteristics of the injured resource including the characteristic(s) that are impacted by the injuries, but the total list of included characteristics must be small. In recent environmental applications the number has ranged from two to nine; Morey et al. (2002c) has two and Johnson and Desvousges (1997) have nine.

If a number of different Green Bays existed that differed only in terms of their FCA levels, one could determine how anglers value different FCA levels by observing how fishing days are allocated among these different sites, but such a natural experiment does not exist. Lake Michigan has similar FCAs for PCBs, but it is a much larger water body that generally requires larger boats to fish and has varying fish species from the waters of

Green Bay. The inland lakes are much smaller and do not suffer from PCB contamination; many have FCAs, but not for PCBs.

18.4.1 Choice set characteristics

As indicated in Figure 18.2, each Green Bay alternative was described to respondents in terms of nine characteristics: a launch fee; the average amount of time necessary to catch a fish (catch time) for each of the four species (yellow perch, trout/salmon, walleye, and smallmouth bass); and an FCA level for each of the four species.

We include catch times (the reciprocal of catch rates) and costs in our characteristics set because a large body of recreational fishing literature has shown consistently that these are important characteristics of site choice. Further, catch times are included to support any subsequent computation of damages from reduced catch times and to compute benefits from increased catch rates if such a program is part of a restoration package.[7] We include FCAs as a key feature of the damages caused by the PCB contamination and because recent literature demonstrates the importance of FCAs to recreational fishing. Our focus groups, pre-tests, and the attitudinal questions on the mail survey all confirm the importance of these characteristics.

For reductions in PCB levels, the FCAs for all species will decrease or remain the same (depending on the change in PCB levels); they will not move in opposite directions. This is reflected in the design of our FCA characteristics. We define nine FCA levels covering the FCA for each of our four species of interest. Level 1 indicates PCB levels are sufficiently low such that all species may be eaten in unlimited quantities; there is no health risk from consumption. Level 9 is the most restrictive: trout/salmon, walleye, and bass should not be eaten, and a perch meal should be consumed once a month at most. In general, the stringency of FCAs for particular species increases or stays the same moving from lower to higher levels, with two exceptions.[8]

The actual FCAs for the waters of Green Bay vary by fish size and location, whereas our nine FCA levels do not. Taking account of variations due to location and size, the least restrictive advisories in 1998, by species, were once a week for perch, and once a month for trout/salmon, bass, and walleye. This corresponds to our Level 4, which is a conservative representation of the current FCA conditions in the Wisconsin waters of Green Bay for each of the four species.

The cost characteristics used to describe each Green Bay alternative is the ‘share of the daily launch fee’. For angling trips that did not involve a boat, respondents were told twice they should ‘think of the daily boat launch fee as a fee you would have to pay to fish the waters of Green Bay’, so the cost variable in the choice question has a meaning to all respondents.[9] This presentation strategy was tested in the pre-tests and found to be accepted in a manner consistent with the design of the choice questions. For each Green Bay alternative, the launch fee took one of nine levels: free, \$2, \$3, \$5, \$7, \$9, \$10, \$12, or \$15, which includes fees that are lower than and higher than the current average fee.[10]

Supporting recreational facilities, such as more boat launches, picnic tables, and walking trails, are not included as characteristics in the choice questions because anglers in the focus groups, pre-tests, and the attitudinal questions on the mail survey indicated relatively little concern about changes in these site characteristics.[11] We concluded that addressing recreational facilities would not improve the damage assessment, but would complicate survey design and the cognitive burden for respondents. Therefore, our model is not capable of determining compensation in terms of improvements in recreational facilities (parks, picnic benches, boat ramps, etc.), which are types of restoration alternatives often proposed by potentially responsible parties (PRPs).

The Green Bay choice pairs do not ask the individuals where they would fish if they had the choice between different sites, but whether they would prefer to fish the same site under conditions A or B; that is, the choice-pair questions ask anglers to choose which Green Bay they would prefer, not how often they would go.[12] Given this, the answers to the choice pairs can be used to estimate how much anglers would prefer a Green Bay fishing day with no FCAs to fishing Green Bay under current conditions, but cannot, by themselves, be used to determine how often an angler would fish Green Bay under different conditions and the related values for changes in site visits.[13]

Given the number of characteristics and the levels they can take, there are 1620 possible Green Bay alternatives and a large number of possible pairs. Eighty of these pairs were chosen so that there would be sufficient independent variation in the levels of the six different characteristics to identify the influence of each.[14]

The 160 members of the set were randomly divided into 80 pairs, which in turn were randomly allocated among ten versions of the survey instrument. None of the simple correlations between the characteristics in the 160 alternatives is significantly different from zero, indicating independent variation among the characteristics.

18.4.2 Evaluation of choices across alternatives

Overall, the anglers' choices are very consistent with the characteristics they rate as important in other survey questions and with their reported preferences such as species target preference. Only 138 (2.7 per cent) of the choice pairs were left unanswered. This is consistent with our finding from the focus groups and pre-tests that most anglers found the survey interesting and the choice tasks reasonable. Remember that we surveyed only current Green Bay anglers. In 40.5 per cent of sample pairs, anglers chose the more costly alternative, which indicates that Green Bay anglers are willing to pay for better Green Bay conditions.

For most anglers, their chosen alternatives indicate consistent preferences across the choices; that is, the criteria on which they base the pair-wise choices appear to stem from stable preferences. The pair-wise choices are also consistent with anglers' answers to other questions in the survey. In practice we do not expect every choice for all anglers to be perfectly consistent, which the method and statistical evaluation are designed to accommodate through the random element in angler choices. In reviewing each angler's responses for consistency, only a few anglers in our sample made choices that may indicate that their choices were based on something other than their preferences, such as always choosing the first or second alternative in each of the eight choices. For example, only eight anglers (1.2 per cent) always chose the first or second alternative, and it is still possible those alternatives were always their preferred ones.

After the angler answered the eight choice pairs, the next survey question inquired about the importance of each of the Green Bay characteristics in making the pair-wise choices. FCAs for perch and walleye and perch catch rates are the three characteristics considered to be the most important in choosing among the pairs. This is to be expected as perch is a frequently targeted and frequently caught species on Green Bay, and fishing activity in Green Bay for walleye has been rapidly growing. The choices of anglers who indicate that they typically target a particular species demonstrate that catch time and FCA for that species is more important than catch times and FCAs for other species.

Choices vary by anglers as a function of target species. In addition, women rate the FCAs more important and catch time less important than do men. This is not surprising since consumption of PCB-contaminated fish by pregnant women can affect a child's development.[15] Anglers with higher education levels generally have lower mean importance ratings, as do anglers with higher income levels. Anglers who fished 15 or more days on the open waters of Green Bay in 1998 have the same or slightly higher importance ratings for all characteristics than those who fished less than five days.

In general, anglers' intentions are consistent with their actual pair-wise choices; anglers who report catch as very important tend to choose alternatives with higher catch rates than those who view rate catch as unimportant, and anglers who report FCAs as important tend to choose alternatives with less stringent FCA levels.

18.4.3 The expected days follow-up question to each choice pair

As noted in Section 18.2, after each choice pair, the angler was asked:

> How often would you fish the waters of Green Bay if it had the conditions described by the alternative you just chose (A or B)?

The answers to these expected days follow-up questions, along with the number of days the angler fished Green Bay in 1998, will be used to estimate how the number of fishing days in Green Bay would change if there were a change in its characteristics. One would expect that, for some anglers, an improvement in conditions would lead to an increase in fishing days.

The question also gives the angler the ability to express possible displeasure with the chosen alternative by reporting that he would reduce or stop fishing Green Bay entirely if it had the conditions of the chosen alternative, for example, if the respondent feels the chosen alternative is inferior to Green Bay under current conditions. That is, the respondent has the ability to 'just say no'.[16] Alternatively, if the respondent feels the chosen alternative is superior to Green Bay under current conditions, he has the option of saying he will fish Green Bay more. The angler also can report that he would continue to fish Green Bay his current number of days.

When presented with a pair where both alternatives are unappealing, and with no way to express displeasure with these options, some individuals either may not respond out of protest or may not respond due to an inability to identify the preferred alternative. To avoid such possibilities some authors have advocated a third 'opt-out' alternative, such as 'would not fish' or 'would fish elsewhere'.[17] Our expected days question plays the role of such a third alternative, while avoiding one of its disadvantages: giving the respondent an easy way to avoid difficult choices. Choosing will be difficult when the angler is almost indifferent between the two sets of Green Bay characteristics. However, if the individual makes these choices, he reveals the rate at which he is willing to trade off site characteristics. There is no fundamental reason individuals cannot choose between alternatives they dislike, or between options both better than the status quo, and such choices provide valuable information about preferences.

In 69.9 per cent of the answered expected days questions, anglers report a number of Green Bay fishing days greater than their current 1998 numbers. If 1998 is assumed to be a typical year and a base for comparison, these responses indicate that anglers feel the preferred alternative in the pair is better than the status quo. In 8.0 per cent of the answered questions, anglers report their current number of Green Bay fishing days. In 22.1 per cent, anglers report an expected number of Green Bay fishing days less than their current numbers, indicating anglers feel the alternatives in the pair are inferior to current conditions. Eighty-five of the anglers (13 per cent) provide an answer of zero days to Green Bay in response to at least one of their Green Bay alternative choices; that is, they say they would not fish if the conditions were as described in that pair. Zero fishing days was reported for just over 4 per cent of the follow up questions.

On average, the number of expected days is higher when site quality is better. For all nine characteristics, the mean level for higher-than-current expected days is better than or the same as the mean level for lower-than-current expected days. There were 222 respondents (34 per cent) who did not vary their expected days responses throughout the eight pair questions. This is consistent with many of the comments in the focus groups about time constraints, entrenched fishing patterns, and dependencies on fishing partners. It is also consistent with the responses to Question 11 of the mail survey, where 68 per cent of the anglers indicated they had not reduced the number of days spent fishing Green Bay in response to FCAs.

That an angler does not change his or her number of fishing days in response to the change in environmental characteristics does not indicate that he or she would not benefit from an improvement in FCAs or catch rates. If conditions are improved, constraints can keep the angler from increasing fishing days, but each day fished will be enjoyed more. If conditions worsen, the angler still might prefer fishing Green Bay to doing something else, he just prefers it less. When the quality of a product is improved or its price is decreased, many consumers do not buy more of it, but they do get greater benefits from the amount they purchase. Also, if a product's quality decreases or price increases, many consumers will not purchase less in the short run. Sixty-six per cent of the anglers did vary their answers to the expected days questions over the eight pairs, indicating that, for the majority of anglers, the number of days they fish Green Bay will vary as a function of changes in the characteristics of Green Bay, even in the short run.

18.5 A combined revealed and stated preference model of Green Bay fishing days

The model is estimated using all of the SP and RP data: (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 follow-up questions to the choice pairs, and (3) the number of days each angler fishes Green Bay under current conditions. While different 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.

The choice data use as their foundation a probit model; it assumes the utility one receives from a commodity is a function of the characteristics of the commodity plus an additive, normally distributed, random component. There are two commodities: a Green Bay fishing day and a composite of all other alternatives, so two conditional indirect utility functions are specified and estimated. The random components associated with the three data types are allowed to differ and to be correlated.

Each angler *i*'s chosen alternative in each stated-choice pair *j* is assumed to be a draw from a Bernoulli distribution whose parameter is the probability, P_{ij}, that the utility from the chosen alternative is greater than the utility from the other Green Bay alternative. It is a function of the attributes of the two alternatives.

The answer to each follow-up question on the number of days to be spent at the preferred Green Bay alternative, n_{ij}, is assumed to be a draw from a binomial distribution, where the number of trials is the angler's total number of choice occasions, n_i, and the parameter is the probability, P^0_{ij}, the utility from the chosen alternative is greater than some other non-Green Bay alternative, conditional upon the preferred Green Bay alternative being chosen. This conditional probability is a function of the attributes of both Green Bay alternatives, and the attributes of the 'other alternatives'. The total number of choice occasions for all anglers is assumed to be 50; very few anglers spent more than 50 days fishing Green Bay.

An angler's observed number of days to Green Bay under current conditions, is assumed to be a draw from a binomial distribution, where the number of trials is the angler's total number of choice occasions and the parameter is the probability, P^G_i, that the utility from Green Bay under current conditions is greater than the utility from fishing elsewhere. The likelihood function is:

$$L = \prod_{i=1}^{647} \left[\binom{n_i}{n_i^G} (P_i^G)^{n_i^G} (1 - P_i^G)^{n_i - n_i^G} \prod_{j=1}^{8} \binom{n_i}{n_{ij}} (P_{ij}^0)^{n_{ij}} (1 - P_{ij}^0)^{n_i - n_{ij}} P_{ij} \right].$$

More details are presented in Breffle et al. (1999). The maximum likelihood estimates are consistent, even if random components are correlated across pairs. If the additional assumption is made for each individual that the random components are independent across pairs, then the estimates are also asymptotically efficient.

The model is designed to be a complete demand system in that it explains the angler's allocation of choice occasions between Green Bay and all other activities, including fishing all other sites. That is, the model is designed to predict how an angler's total number of Green Bay fishing days might change if Green Bay conditions are changed.

The utility an angler receives from a day of fishing Green Bay is assumed to be a function of costs (which include the opportunity cost of travel time, plus monetary expenses including travel costs and any launch fee); the catch times for four different species groups: trout/salmon, perch, walleye, and bass; and the level of FCAs (which can be one of nine levels, including no FCAs). The deterministic component of utility for Green Bay is assumed to be the same across data types; only the structure of the stochastic component is allowed to vary.

Data on trip costs and the characteristics of other sites could not be collected; there are hundreds of alternative sites. Because of this, the utility from other activities is assumed to be a function of angler characteristics plus a stochastic random component that varies across anglers. These characteristics include gender, age, whether the angler owns a boat or is retired, and whether Lake Michigan is a relatively cheap substitute.

The signs of the estimated parameters indicate anglers are worse off as catch times increase, as FCAs increase, and as costs increase. The FCA parameter estimates show that, as the severity of FCAs increases, so does the damage, but not necessarily in a linear fashion. Retired anglers, male anglers, and anglers who own boats are likely to fish Green Bay more; younger anglers and anglers with Lake Michigan as a cheap substitute fish Green Bay less often. All of the parameter estimates are statistically significant and, in addition, have small confidence intervals. The model correctly predicts 72 per cent of the 5038 choice pairs.

The model can predict how changes in FCAs (or other Green Bay characteristics such as catch time) will affect the number of fishing days spent at Green Bay versus other activities. With the elimination of FCAs in Green Bay, the number of Green Bay days would increase by about 2 per cent.

18.6 Estimates of 1998 damages

From the estimated model, one can derive an estimate of the compensating variation per Green Bay fishing day associated with the elimination or reduction of the FCAs, and an estimate of the expected compensating variation for the elimination or reduction of the Green Bay FCAs. The first is just the estimated change in the utility from a Green Bay fishing day, converted into dollars by dividing it by the estimated marginal utility of money.[18]

Our estimate of WTP per Green Bay fishing day for the absence of FCAs (FCA level 4 to level 1) is \$7.71 for 1998.[19] This value is a dollar estimate of the reduced enjoyment for a Green Bay fishing day because of the FCAs; that is, what a Green Bay angler would pay per Green Bay fishing day to eliminate the need for FCAs. \$7.71 is 10 per cent of the average of current expenditures per Green Bay fishing day (\$74.32). This value is also within the range of per-day estimates for FCAs reported in the valuation literature discussed previously. One could also offset the current damages from the FCAs with improved catch rather than money. The model estimates indicate that, to do this, catch rates for all four species would have to more than double.[20]

Our estimate of the average annual expected compensating variation for the elimination of the Green Bay FCAs is $111.[21] It is what a Green Bay angler would pay per year to eliminate the need for Green Bay FCAs. It takes account of the fact that the angler might increase the number of fishing days to Green Bay in the absence of Green Bay FCAs. The 95 per cent confidence interval on the $111 estimate is $96 to $128. Based on an earlier version of this model submitted a few years ago, the yearly damage claim for Green Bay was $2.67 million with a confidence interval of $2.13 million to $3.22 million.

18.7 Concluding remarks

The FCAs currently affect more than 255 000 Green Bay fishing days per year, and more days in past years. They reduce the enjoyment of these 255 000 fishing days, and cause fishing days to be allocated to other sites and other activities when they would have been to Green Bay in the absence of PCB contamination.

The value of recreational fishing losses (damages) estimated here is consistent with the literature on recreational fishing impacts and damages from FCAs. About three-quarters of those anglers who continue to fish the Wisconsin waters of Green Bay report behavioral responses to the FCAs, and other anglers report no longer fishing the waters of Green Bay due to FCAs, all of which are comparable to other studies about FCAs on the Great Lakes.

The intent has been to provide to those involved in the process of NRDA litigation an example of how the answers to stated-preference choice and frequency questions can be combined with revealed-preference data to better estimate the damages from PCB contamination.

Notes

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1. The assessment, Breffle et al. (1999), can be downloaded at (www.colorado.edu/Economics/morey/).
2. Passive use benefits are benefits one can receive without being at or near the site. For example, an individual might benefit from knowing that salmon are prospering in the Columbia River basin even though he has no intention of of viewing, catching, or eating them. Passive use damages are the loss of such passive use benefits.
3. Choice questions are increasingly used to estimate the value of environmental goods. See, Layton and Brown (1998), Magat et al. (1988), Morey et al. (1997, 2002a,b and c), Morey and Rossmann (2003), Ruby et al. (1998), Swait et al. (1998), Viscusi et al. (1991), and Mathews et al. (1997), which is a NRDA application.
4. See, for example, Fiore et al. (1989), West et al. (1989), Connelly et al. (1990), Silverman (1990), Connelly et al. (1992), Vena (1992), Knuth et al. (1993), West et al. (1993), Knuth (1996), and Hutchinson (1999).
5. See, for example, the random-utility models of Herriges et al. (1999), Chen and Cosslett (1998), Lyke (1993), Montgomery and Needelman (1997), Hauber and Parsons (1998), Jakus et al. (1997 and 1998), and Parsons et al. (1999).
6. Combining SP and RP data is widely supported. See, for example, McFadden (1986), Ben-Akiva and Morikawa (1990), Morikawa et al. (1990), Cameron (1992), Louviere (1992), Hensher and Bradley (1993), Adamowicz et al. (1994, 1997), Ben-Akiva et al. (1994), Swait et al. (1994), Morikawa et al. (1991), Louviere (1996), Kling (1997), and Mathews et al. (1997).

   Like all data on preferences (including actual choices (RP data)), the responses to choice questions may contain biases or random errors. The random errors are a component of the statistical model. Choosing can be difficult if the individual is almost indifferent between two alternatives. If each respondent is asked to answer a number of choice questions, there can be both learning and fatigue. Respondents can become frustrated if they dislike all of the available alternatives, and they may have no incentive for sufficient introspection to determine their preferred alternative. In addition there can be a bias towards the status quo, the respondent might ignore his constraints, and the respondent might behave strategically.
7. For each Green Bay alternative, the perch catch time took one of five levels: every 10, 20, 30, 40, or 60 minutes. For the other species, catch time took one of six levels: a fish every hour, every two hours, four hours, six hours, eight hours, or every twelve hours. In Green Bay, perch take less time to catch than other sport fish. These ranges were chosen on the basis of historical Wisconsin Department of Natural Resources (WDNR) catch data and feedback from anglers during pre-testing, and were chosen to include catch characteristics that are both better and worse than Green Bay conditions in recent years prior to the 1998 survey. The long-run averages (1986–1998) are 31 minutes per perch, 7.8 hours per trout/salmon, 6.9 hours per walleye, and 5.0 hours per bass. Average catch time has increased dramatically in recent years.

   Mail survey respondents were asked what they felt were the current average catch times (for all anglers, not just themselves) on the Green Bay waters. The means of the responses indicate that anglers have perceptions about average catch times that are consistent with the WDNR data for perch, but are substantially shorter than the WDNR data for other species. This might be because the respondents overestimate what other anglers catch, are optimistic, are better anglers than most, or because their perceptions correspond to long-run averages.
8. Note that in the presentation of the pairs (see Figure 18.2), the FCAs in each of the alternatives are reported by species, but because they are based on nine aggregate levels they do not vary in unrealistic ways by species across the alternatives. This design and presentation of the FCA characteristics account for the fact that the FCAs are correlated across species through their underlying cause, PCB contamination, but take into account the fact that FCAs vary by species, and that different anglers might be interested in different species. Perceived FCAs and actual FCAs are generally consistent.

9. Most Green Bay fishing is by boat.
10. We collected launch fee data for 37 launches. Fifty-one per cent of these sites charged \$3.00 to launch a boat; the average was \$2.84, and the range was \$0.00 to \$7.00. In the mail survey (Q38), anglers were asked, 'Approximately what do you think is the average daily boat launch fee for the waters of Green Bay?' The mean of the angler estimates is \$4.41, the median is \$4.00, and the mode is \$3.00. The cost range in the choice questions is broader than actually observed to allow for higher cost tradeoffs with less stringent FCAs and higher catch rates. This range was determined from the focus groups and pre-tests and spans the partial range of cost differentials anglers indicated were acceptable for changes in FCAs and catch rates.
11. For example, in focus groups anglers were asked: 'What was the most important factor in your decisions when you first decided to fish Green Bay? What two or three factors contribute most to your enjoyment of fishing trips to Green Bay? What two or three factors detract most from your enjoyment of fishing trips on the waters of Green Bay? If you could change anything about fishing on the waters of Green Bay, what would you change?' Only one angler mentioned launch facilities and no anglers mentioned other facilities. Pre-test anglers also rated enhanced facilities for fishing in the waters of Green Bay, and, as in the final survey, recreational facilities were always rated much lower than catch times and FCAs.
12. In contrast, one could develop choice pairs where there are two or more sites available and ask which site the individual would visit. Examples include Magat et al. (1988), Viscusi et al. (1991), Adamowicz et al. (1994, 1997), Mathews et al. (1997), Ruby et al. (1998), and Morey et al. (2002a). Choice studies such as this one that ask the individual to choose over different 'states' include Johnson et al. (1995), Adamowicz et al. (1996), Roe et al. (1996), Johnson and Desvousges (1997), Morey et al. (1997 and 2002c), Morey and Rossmann (2003), Stevens et al. (1997), Layton and Brown (1998), and Swait et al. (1998).
13. Many studies use only choice questions to estimate preferences. In these cases, one must be sure that the choice questions provide everything one needs to know about preferences, including how behavior would change if site characteristics change. In this assessment, the choice questions are only one component of the data.
14. The experimental design for the choice study was accomplished using the conjoint design software of Bretton Clark (1990).
15. A typical result in the risk literature is that women are more risk averse than men (see, for example, Slovic, 1987).
16. If the angler does not like the alternatives, he also has the option of not choosing from that pair (this happened in less than 3 per cent of the pairs). In addition, 172 (3.3 per cent) of the expected days follow-up questions were unanswered. Ten anglers (1.5 per cent) left all eight of these follow-up questions blank, and 53 respondents (8.2 per cent) left one or more of them blank. Blanks on the follow-up questions were assumed to contain no information about the individual's preferences; they were not interpreted as responses of zero days.
17. With questions involving a choice of moose hunting site, Adamowicz et al. (1997) included as a third alternative, 'Neither site A nor site B. I will NOT go moose hunting.' Along with two water-based recreational sites Adamowicz et al. (1994) included as a third alternative, 'Any other nonwater related recreational activity or stay at home.' With choice pairs over mountain bike sites, Morey et al. (2002a) included no 'opt-out' alternative other than the option of not answering a choice pair. Through focus groups and the survey, they found respondents able and willing to answer most of the pairs. Ruby et al. (1998) investigated the inclusion and form of 'opt-out' alternatives, and found that the form of the 'opt-out' can matter.
18. Note that, since for this calculation there is just one alternative in each state of the world, one obtains an estimate of the compensating variation per Green Bay fishing day rather than, as is typical, an estimate of the expected value of this compensating variation.
19. For more on the difference between WTP per day and per fishing day see Morey (1994).
20. Note that increasing catch rates by this amount would not compensate the anglers for past damages.

21. The stated-frequency data, when compared with use under current conditions (the RP data), indicate that anglers may be overly optimistic in stating how much they would fish under various Green Bay conditions. If the model is calibrated so that the predicted mean number of fishing days to Green Bay under current conditions is exactly equal to the observed mean in the RP data, the expected annual compensating variation falls from $111 to $76.

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