DRAFT

Estimate of Recreational Fishing Losses Due to Fish Consumption Guidelines in the Waters of the Turtle River, Buffalo River, South Brunswick River, Purvis Creek, and Gibson Creek, Georgia

National Oceanic and Atmospheric Administration
Office of Response and Restoration
Assessment and Restoration Division
Silver Spring, MD

April 6, 2010

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

GLOSSARY

The following definitions are specific to terms used throughout this report.

Benefit Transfer- An economic valuation method that involves using welfare losses from the literature that were estimated at another site or sites, usually by other researchers, as an estimate of the welfare losses at the policy site of interest. Benefit transfer is the method used in this study to estimate recreational fishing damages.

Consumer Surplus- The difference between the maximum amount of money an angler is willing to pay for the recreational experience and what he or she is actually required to pay.

Damages- The sum of welfare losses across all anglers in all time periods, appropriately discounted to a present value.

Discounting- The process of determining the present value of an amount of money from a previous or future time period. Discounting is the process by which the social rate of time preference for the consumption of goods and services is incorporated into the damage estimates.

Fish Consumption Guideline (FCG)- A recommendation published by a state government agency to restrict human consumption of certain fish and shellfish caught in certain waterbodies. Within this report, "FCG" refers, synonymously, to both fish consumption guidelines and advisories.

Revealed Preference (RP) Methods- Econometric methods used to estimate the value of goods or services by observing actual decisions made by consumers. Examples include travel cost and hedonic pricing methods.

Stated Preference (SP) Methods- A family of economic methods used to estimate the value of goods or services by asking respondents about their preferences for one or more goods or services in a survey or controlled experiment format.

Value- In the context of recreational fishing, value cannot be estimated directly from market prices (there are none). Rather value is based on consumer surplus which is estimated from travel cost expenditures or stated preference techniques.

Welfare Loss- The difference between consumer surplus without fish consumption guidelines and consumer surplus with the existing fish consumption guidelines.

EXECUTIVE SUMMARY

On March 18, 1992, the Georgia Department of Natural Resources published fish consumption guidelines (FCGs) for waters near the LCP facility. The FCGs were issued because of high levels of polychlorinated biphenyls (PCBs) and mercury found in the tissue of harvested seafood. Since they were first issued, the advisories have been altered twice to expand the geographic extent and the number of species covered. The economic valuation literature indicates that recreational anglers experience a loss of consumer surplus when preferred fishing locations are affected by contamination. This analysis estimates the damages associated with that loss of consumer surplus.

The National Oceanic and Atmospheric Administration's Marine Recreational Fishery Statistics Survey estimates that over four million recreational fishing trips were taken to the inland saltwater zone of Glynn County, Georgia between 1992 and 2004. A fraction of these trips is allocated to the affected area (i.e., to the FCG zones) based on the geographic extent of the FCG areas as a percentage of the total surface area of Glynn County. To account for the presence of a degraded baseline (i.e., the FCG areas specified in this report might be less desirable for fishing than other areas of Glynn County), a fractional multiplier of 0.75 is then applied to this estimate of trips. The historical mean number of trips to the affected area is used to estimate the anticipated future number of affected trips.

Literature-based values are used in a benefit transfer analysis to estimate the amount of damages. A range of $6.12 to $12.48 (2007$) is used as the initial per-trip loss conditional upon taking a trip to an affected site. The per-trip loss used in each year for each of the four river reaches covered by the advisories varies based on the severity of the advisories in conjunction with a consideration of relative geographic/physical characteristics of each of the FCGs. Two scenarios are run, one with the FCGs beginning to show improvement in 2012 (the lower bound damage estimate) and one with FCGs beginning to show improvement in 2018 (the upper bound scenario); both assume a linear 30-year recovery period for lifting of the FCGs altogether from their respective starting year. The total damages for anglers that fish in the affected areas are estimated to be between $5,383,905 and $5,999,574 (2007$). No damages are estimated for those anglers that changed the location of their fishing trip(s) to avoid the contaminated areas or those anglers that choose to forego fishing trips altogether because of the contamination.

1. Introduction

The purpose of this report is to describe the estimation of recreational fishing damages associated with fish consumption guidelines that have been published by the State of Georgia for waterways near the LCP facility in Glynn County, Georgia. This report contains seven sections and an appendix. Section 2 explains the fish consumption guidelines for the Turtle, Buffalo, and South Brunswick Rivers, and Purvis and Gibson Creeks. The background research and benefit transfer values for recreational fishing losses are described in Section 3. The fourth section covers the estimate of fishing trips taken to the region. Section 5 combines the per-trip values from the benefit transfer analysis with the number of fishing trips affected to produce a damage estimate. The sixth section reviews uncertainty associated with the damage estimate and details various assumptions made in the calculations. The literature cited section follows, and the report concludes with an appendix that reviews the limited economic valuation literature on fish consumption guidelines.

2. Fish Consumption Guidelines

On March 18, 1992, the Georgia Department of Natural Resources publicized fish consumption advisories for waters near the LCP facility. These advisories were issued because of high levels of polychlorinated biphenyls (PCBs) and mercury found in the tissue of harvested seafood. In 1995, the state changed nomenclature from "advisories" to "guidelines". Throughout this report, both the advisories in effect from 1992 through 1994 and the guidelines in effect from 1995 through the present will be referred to as fish consumption guidelines (FCGs)[1]. Table 1 displays the PCB and mercury threshold levels associated with the various FCGs[2].

[1] Data on the FCGs for 1992 through 1994 are from Georgia Department of Natural Resources Environmental Protection Division press releases from March 18, 1992, June 24, 1993, and May 20, 1994. Data on FCGs after 1994 come from the annual Georgia Department of Natural Resources publication "Guidelines for Eating Fish from Georgia Waters".

[2] Information on FCG threshold levels was obtained in personal communication with Ms. Linda Harn, Environmental Program Manager of the Georgia Department of Natural Resources Environmental Protection Division's Intensive Surveys Unit, on October 23, 2006.

Table 1. Contaminant concentration threshold levels for FCGs in the State of Georgia.

FCG Level	PCBs in Fish Tissue (μg/g wet weight)	Hg in Fish Tissue (μg/g wet weight)
No restrictions	< 0.1	< 0.23
No more than 1 meal per week	0.1 – 0.3	0.23 - 0.70
No more than 1 meal per month	0.3 – 1.0	0.70 – 2.30
Do not eat	> 1.0	> 2.30

The original FCGs, issued in 1992, covered two reaches: 1) the Turtle River from the Highway 303 bridge to channel maker No. 9, and 2) Purvis and Gibson Creeks. Both FCGs advised not to eat "crabs, oysters, or other seafood" caught in these waters. These FCGs were in effect through 1995.

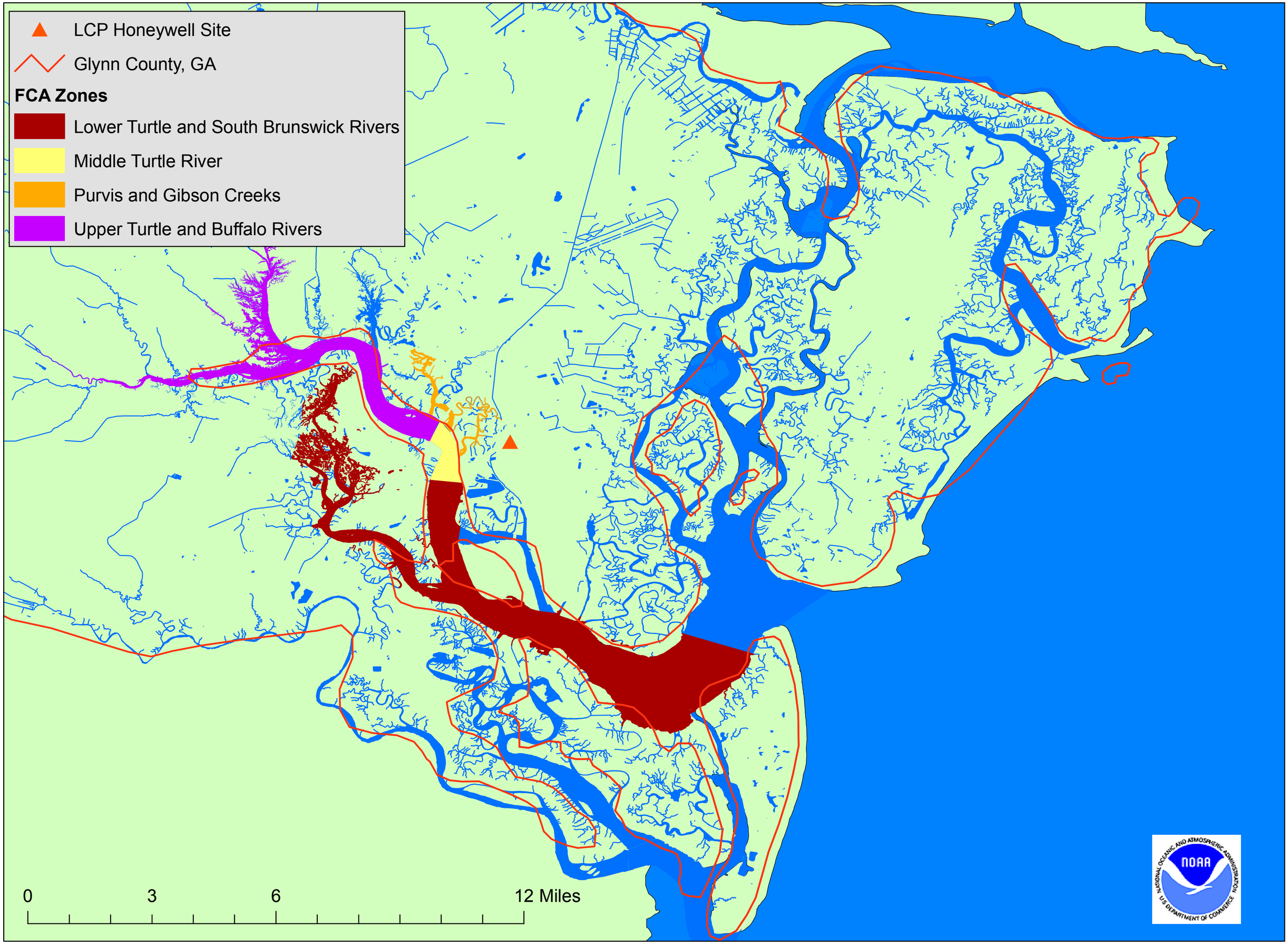
Several changes were made in 1996. The reaches covered by FCGs expanded from two to four:

1) Purvis and Gibson Creeks,
2) Buffalo and Turtle Rivers upriver from the Highway 303 bridge,
3) Turtle River between the Highway 303 bridge and channel marker No. 9, and
4) South Brunswick and Turtle Rivers from channel marker No. 9 downriver to Dubignons and Parsons Creeks.

These four zones are delineated in the Figure. The FCGs varied by reach, and, in general, the FCGs were more restrictive closer to the LCP site. The FCGs remained the same for Purvis and Gibson Creeks: eat no seafood. Upriver of the Highway 303 bridge, it was advised that anglers consume A) no black drum, clams, mussels, or oysters, B) no more than one meal per month of croaker and spotted sea trout, and C) no more than one meal per week of blue crab, red drum, and flounder. In the Turtle River between the Highway 303 bridge and channel marker No. 9, the FCGs were to eat A) no clams, mussels, or oysters, B) no more than one meal per month of blue crab, black drum, red drum, croaker, and spotted sea trout, and C) no more than one meal per week of flounder. In the South Brunswick and Turtle Rivers from channel marker No. 9 downriver to Dubignons and Parsons Creeks, it was advised to consume A) no clams, mussels, or oysters, B) no more than one meal per month of black drum and spotted sea trout, and C) no more than one meal per week of blue crab and croaker. These FCGs remained constant from 1996 through 2003.

Figure. LCP Honeywell NRDA

Location of Fish Consumption Advisory Zones in Glynn County, GA



The FCGs were changed again in 2004. There were two classes of revisions. First, most species in most reaches either retained the same FCG category or moved to a less restrictive FCG category. However, this trend does not hold for two species in the reach furthest from the LCP site, which will be highlighted below. Second, FCGs were added for four species that had not previously had FCGs: mullet, spot, kingfish, and sheepshead. In Purvis and Gibson Creeks, it was advised that anglers eat A) no croaker, mullet, clams, mussels, or oysters, B) no more than one meal per month of shrimp, blue crab, black drum, spotted sea trout, spot, kingfish, and sheepshead, and C) no more than one meal per week of red drum and flounder. Upriver of the Highway 303 bridge, it was advised that anglers consume A) no mullet, clams, mussels, or oysters, B) no more than one meal per month of croaker, black drum, spot, kingfish, and sheepshead, and C) no more than one meal per week of blue crab, spotted sea trout, red drum, and flounder. In the Turtle River between the Highway 303 bridge and channel marker No. 9, the FCGs were to eat A) no mullet, spot, clams, mussels, or oysters, B) no more than one meal per month of blue crab, black drum, croaker, spotted sea trout, kingfish, and sheepshead, and C) no more than one meal per week of red drum and flounder. In the South Brunswick and Turtle Rivers from channel maker No. 9 downriver to Dubignons and Parsons Creeks, it was advised to consume A) no clams, mussels, or oysters, B) no more than one meal per month of croaker, mullet, spot, and kingfish, and C) no more than one meal per week of blue crab, black drum, spotted sea trout, and red drum. These FCGs are applicable from 2004 through the present.

These FCGs are graphically summarized in Tables 2 and 3. Table 2 first divides the FCGs by year, and then secondarily by reach. This permits comparison of the FCGs among reaches within a specific time period. Table 3 first divides the FCGs by reach, and then secondarily by date. This display facilitates examination of how the FCGs change over time within each reach.

Table 2. Fish consumption guidelines in the waters near the LCP site, by year, by reach.

Dates	River Reach	Clams, Mussels, & Oysters	Shrimp	Blue Crab	All Other Seafood	Black Drum	Croaker	Spotted Sea Trout	Red Drum	Flounder	Mullet	Spot	Kingfish	Sheepshead
1992 to 1995	Purvis & Gibson Creeks													
	Upriver of Hwy 303													
	Hwy 303 to Marker 9													
	Marker 9 to Dubignon Crk													
1996 to 2003	Purvis & Gibson Creeks													
	Upriver of Hwy 303													
	Hwy 303 to Marker 9													
	Marker 9 to Dubignon Crk													
2004 to 2008	Purvis & Gibson Creeks													
	Upriver of Hwy 303													
	Hwy 303 to Marker 9													
	Marker 9 to Dubignon Crk													

Legend:

- Do not eat
- Do not eat (covered as part of the "All Other Seafood" category)
- Eat no more than 1 meal per month
- Eat no more than 1 meal per week
- No restrictions

Table 3. Fish consumption guidelines in the waters near the LCP site, by reach, by year.

River Reach	Dates	Clams, Mussels, & Oysters	Shrimp	Blue Crab	All Other Seafood	Black Drum	Croaker	Spotted Sea Trout	Red Drum	Flounder	Mullet	Spot	Kingfish	Sheepshead
Purvis & Gibson Creeks	1992-1995													
	1996-2003													
	2004-2008													
Upriver of Hwy 303	1992-1995													
	1996-2003													
	2004-2008													
Hwy 303 to Marker 9	1992-1995													
	1996-2003													
	2004-2008													
Marker 9 to Dubignon Creek	1992-1995													
	1996-2003													
	2004-2008													

Legend:

- Do not eat
- Do not eat (covered as part of the "All Other Seafood" category)
- Eat no more than 1 meal per month
- Eat no more than 1 meal per week
- No restrictions

Analysis of the FCG changes reveals a few noteworthy alterations. First, with only one exception, no species for which any FCG had been issued has had the FCG eliminated (labeled as "no restrictions"). The exception is that the ban on eating shrimp between the Highway 303 bridge and Marker 9 that was in effect from 1992 through 1995 was lifted in 1996. Second, two FCGs increased in severity (became more restrictive) in the 2004 revisions, and both were in South Brunswick and Turtle Rivers from channel maker No. 9 downriver to Dubignons and Parsons Creeks. Croaker changed from one meal per week to one meal per month, and red drum went from being unrestricted to having a restriction of one meal per week. Third, four new species were added to the FCGs in 2004. There are sixteen potential species-reach combinations. Four of these had FCGs to eat none, eleven were to eat no more than one meal per month, and one was to eat no more than one meal per week. None of the four new species is without a restriction in any of the four reaches.

3. Literature Review and Analysis of Economic Losses Associated with Fish Consumption Guidelines

FCG Benefit Transfer Background

The value of a recreational fishing trip is defined as the consumer surplus derived from the trip. Consumer surplus is the difference between the maximum amount the angler is willing to pay for the recreational experience and what he or she is actually required to pay. If consumer surplus is positive, meaning the angler is willing to pay more than the actual cost of the trip, the individual derives an economic benefit from the trip and will go fishing. If consumer surplus is zero, the individual is indifferent between taking the trip and doing some other activity. In this case, he or she may or may not go fishing. If consumer surplus is negative, the angler is better off not fishing and will forego the trip.

The economic damages associated with the issuance of FCGs are derived from consumer surplus changes. The angler's welfare loss is the difference between the consumer surplus for a trip without the FCG and the consumer surplus for a trip with the FCG. This consumer surplus change is individual-specific. Estimating the surplus change (damages) depends, in large part, on observing the behavioral change of the angler. Welfare losses associated with FCGs can be divided into three categories:

1) *Losses for anglers that continue to fish at the FCG site*. Even if an angler continues to fish at a site with an FCG, he may still experience a loss of consumer surplus. The angler may switch from consumption to catch-and-release fishing. He may change his target species from one that was formerly preferred but now has a restrictive FCG to one that was formerly less preferred but has a less restrictive (or no) FCG. He also may change his food preparation methods to avoid those tissues that contain the highest concentration of the contaminant(s). Finally, he may continue to fish as before, but enjoy the experience less because he is aware he is catching and/or consuming fish that have been contaminated. For these anglers, the loss is some fraction of the without-FCG consumer surplus.

2) *Losses for anglers that fish at a substitute site*. It is assumed that once an angler decides to go fishing, the site he selects is the one that provides the greatest utility. If an angler's consumer surplus for the FCG site falls below the surplus associated with a substitute site because of the FCG, the angler will take a trip to the second site. The difference between the surplus that would have been realized at the FCG site but for the FCG and the surplus realized at the substitute site is a welfare loss attributable to the FCG.
3) *Losses for anglers that choose to forego fishing*. Some anglers will elect to forego fishing altogether once the FCG has been issued. For these anglers, the entire consumer surplus from angling is lost.

This study uses the benefit transfer approach to value the losses. Benefit transfer involves using the welfare losses[3] estimated at another site, usually by another researcher, as an estimate of the welfare losses at the policy site of interest. A distinct advantage of this approach is that it usually requires less time and money to complete compared with a primary travel cost or stated preference study. Benefit transfer is most accurate when the scenario covered in the primary research closely matches the scenario at the policy site of interest. This similarity applies not only to the nature of the FCGs in effect at both sites, but also applies to the types of sites, their substitutes, and the angling populations of each. Most studies that appear in the literature focus on the first and second categories of losses described above, primarily because it is much easier to obtain data on the number of trips being taken to the affected and substitute sites. Since this analysis uses the benefit transfer approach, our estimates will not include the welfare losses suffered by anglers that forego trips. In this regard, our results will most likely be underestimates of the recreational loss associated with the FCGs.

When estimating the effect of FCGs on the value of recreational fishing, there are two general approaches. The first focuses on quantifying the losses that accrue to those anglers that continue to fish at the affected site(s) (category 1 above). Intuition tells us that many or most anglers taking trips to the affected sites will derive less consumer surplus from the experience. To estimate damages, this approach requires a per-trip loss estimate that is conditional on the trip being taken to the affected site(s) and an estimate of the number of trips still being taken to the affected site(s). However, as noted above, this approach does not account for the losses that accrue to those that fish at substitute sites.

The second approach captures both the losses that accrue to those still fishing at the affected site(s) and those that substitute trips to alternative sites (categories 1 and 2 above). However, this approach is somewhat less intuitive. The researcher estimates a model that predicts the mean value (consumer surplus) of a trip taken to all sites in the

[3] Benefit function transfer is a similar valuation approach in which the utility model and its estimated parameter values are transferred from the primary study location to the policy site, instead of transferring a point estimate of welfare loss. If the scenarios and populations of the primary study and policy sites are similar, and the necessary data is available at the policy site for the model's variables is available, then benefit function transfer can provide a more accurate welfare estimate than the simpler benefit transfer method. However, in most cases, including this study, the required information to usefully transfer the functions is not available.

defined choice set. Some, but not all, of the fishing sites in the choice set have FCGs. The researcher then uses the model to predict the change in the mean value for all trips if the FCGs are removed. The difference between the mean value with and without FCGs is the measure of economic loss per-trip regardless of the site selected. To calculate total damages, the mean per-trip loss is multiplied by the total number of trips taken to all sites in the choice set. When estimated correctly, the mean per-trip loss is accurately weighted to account for the loss suffered by anglers that continue to fish at the FCGs site(s), the loss for those that choose to fish at substitute locations because of the FCGs, and the number of trips taken to each site.

For the purposes of this estimate of recreational fishing losses, the Trustees have only estimated damages for those anglers that continue to fish in the FCG-affected areas (category 1 only). Because the method selected for this analysis allocates the total number of Glynn County inland zone trips evenly across fishable waters, a fractional multiplier is used to account for the possibility that anglers might alter their choice of fishing sites based on the presence of non-LCP-related industrial activities and contamination in the FCG zones, and the existence of the FCGs themselves (see Section 4).

FCG Literature Review and Evaluation

A literature search for economic valuation studies that produced an estimate of the economic value or benefit for the removal of fish consumption advisories or toxic contamination yielded eleven studies. Nine of these use the travel cost method to produce lower-bound estimates of per-trip losses. A tenth study is a combined revealed preference (RP) and stated preference (SP) survey conducted using a boat launch fee as the monetizing variable. The eleventh study combined revealed and stated preference data, and is not primary research. All studies reviewed report per-trip losses using the second approach outline above, which captures two categories of losses. However, several studies report the parameter estimates from their models. It is possible to determine the welfare loss conditional upon taking a trip to the FCG zone by dividing the FCG dummy variable's parameter by the monetizing variable's parameter estimate (α_1/β).

A brief description of the ten of the eleven valuation studies is included in the Appendix. A more detailed review of the eleventh study by Breffle *et al.* (1999) can be found later in this section.

Direct comparison of the loss estimates derived from these eleven studies is complicated by two factors. First, for the nine travel cost studies, the mileage and time costs vary considerably. In constructing the monetizing variable, researchers often combine the mileage cost for the roundtrip distance from the respondent's home to the recreational site with some measure of the opportunity cost of time. The mileage cost is routinely that provided by the Internal Revenue Service as the tax deductible rate for business use, which varies by year. Inflating the value estimates to a common time point should minimize the real differences in this component, assuming the mileage rate and the consumer price index (CPI) change by approximately the same percentage each year. In

recent years, the reimbursable mileage rate has increased more rapidly than the CPI, suggesting that using the CPI to inflate per-trip values may result in underestimates of the value of a recreational angling trip, and underestimate the damages. The opportunity cost of time, however, is less uniform. Most researchers use some fraction of the respondent's hourly wage rate as the opportunity cost of time, with the fraction varying from 25% to 100%. Economic theory does not provide guidance on what fraction is most appropriate to use. The studies reviewed herein span the gamut of possibilities: Chen and Cosslett (1998) do not use an opportunity cost of time in their travel cost variable (0% of the wage rate), Herriges, Kling, and Phaneuf (1999) use 33%, and most other studies use 100%. Jakus and Shaw (2003) do not detail the composition of their travel cost variable.

The second complicating factor is that the number of FCG sites included in choice set, and the percentage of the choice set they represent, vary by study. For instance, six of the twelve (50%) sites in the Jakus and Shaw study have FCGs, while only 23 of the 2,561 sites (<1%) in Montgomery (1997) have advisories. Absent information on the relative usage at each site, one would expect that policy scenarios that eliminate FCGs at a high proportion of the choice set sites would yield larger welfare change estimates for all trips taken to choice set sites. The uniformity of per-trip losses for all trips to choice set sites found in these eleven studies does not support this expectation.

Excluding the Jakus and Shaw study, the per-trip value estimates for all trips taken to choice set sites constitute a relatively small range. While certain individual model specifications are lower, the middle value of $1.91[4] found by Jakus, Dadakus, and Fly (1998) appears to be the lowest mean or central estimate of any study. At the upper end, the Breffle *et al.* (1999) central value of $5.33 appears to be at the high end of the range. The mean of the means (or central values) of these ten economic studies is approximately $3.21 per trip for all trips to choice set sites.

Ignoring the Parsons and Hauber (1998) smallest choice set (which produced a loss estimate of $272.14), the range of welfare loss estimates conditional upon taking a trip to a FCG site is $2.28 to $48.19. The majority of these estimates are between $12 and $39, with a relatively even distribution of estimates across this $27 range.

Because of the specificity included in the report, the Trustees have selected the Breffle *et al.* study as the one most appropriate to use in this benefit transfer analysis. The purpose of the research was to determine recreational fishing damages resulting from the release of PCBs into the waters of Green Bay. The report was commissioned as part of the Lower Fox River / Green Bay natural resource damage assessment.

The authors used a mail survey,

[4] All values reported herein are in 2007$. Since most studies that were reviewed did not explicitly note which dollar-year their estimates were reported in, it is assumed that they are reported in the dollar-year of data collection. If data collection spanned multiple years, the most recent year of data collection was selected. The reported values were inflated from the last year of data collection to 2007$ using the U.S. Bureau of Labor Statistics' CPI Inflation Calculator at http://data.bls.gov/cgi-bin/cpicalc.pl. The Breffle *et al.* study explicitly reports values in 1998$. Jakus, McGuiness, and Krupnick explicitly report values in 2000$.

> "to collect data for estimating damages associated with PCB contamination and the resultant FCAs. The core of this 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. 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 a daily fee. By varying the levels of the characteristics (e.g., catch rates, FCA levels, and the amount of fees) across alternatives and questions, the survey provides input data for computing the amount of money the anglers would be willing to pay (or the increases in fish catch rates the anglers would be willing to give up) to reduce or eliminate FCAs, as well as the amount of money the anglers would be willing to pay for increased catch rates. As part of each choice question, a followup question asks how often the respondent would fish the Wisconsin waters of Green Bay under the alternative they select. This followup question allows for the estimation of damages associated with substituting days from the waters of Green Bay to other fishing sites because of FCAs."
>
> Breffle *et al.* (1999), page 1-8

The research combines all available SP and RP data to estimate the welfare loss 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 are those parameter values that best explain all of the anglers' choices…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.
>
> 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."
>
> Breffle *et al.* (1999), page 6-1 to 6-2

There were a total of nine combinations of FCGs for the four species examined by the researchers. The baseline FCG condition was no restriction on any of the four species (FCG Level 1). The most restrictive combination was a ban on consumption of three species, and a limit of no more than one meal per month of the fourth species (FCG Level 9). Table 4 details the nine FCG combinations used in the study and the welfare losses conditional upon taking a trip to an affected site for each.

Table 4. Description of fish consumption guidelines used by Breffle *et al.*

FCA Group	Fish Guild	FCA Recommendation	Per-Trip Loss for Trip to FCG Site (α_1/β)	
			Reported (1998$)	Inflated (2007$)
FCG Level 1	Yellow perch	Unlimited	$0.00	$0.00
	Trout/salmon	Unlimited		
	Walleye	Unlimited		
	Smallmouth bass	Unlimited		
FCG Level 2	Yellow perch	Unlimited	$1.81	$2.28
	Trout/salmon	Eat no more than 1 meal a week		
	Walleye	Eat no more than 1 meal a week		
	Smallmouth bass	Unlimited		
FCG Level 3	Yellow perch	Unlimited	$4.86	$6.12
	Trout/salmon	Eat no more than 1 meal a month		
	Walleye	Eat no more than 1 meal a month		
	Smallmouth bass	Eat no more than 1 meal a week		
FCG Level 4	Yellow perch	Eat no more than 1 meal a week	$9.75	$12.28
	Trout/salmon	Eat no more than 1 meal a month		
	Walleye	Eat no more than 1 meal a month		
	Smallmouth bass	Eat no more than 1 meal a month		
FCG Level 5	Yellow perch	Unlimited	$11.22	$14.14
	Trout/salmon	Eat no more than 1 meal a month		
	Walleye	Do not eat		
	Smallmouth bass	Eat no more than 1 meal a month		
FCG Level 6	Yellow perch	Unlimited	$9.91	$12.48
	Trout/salmon	Do not eat		
	Walleye	Eat no more than 1 meal a month		
	Smallmouth bass	Eat no more than 1 meal a month		
FCG Level 7	Yellow perch	Unlimited	$14.32	$18.04
	Trout/salmon	Do not eat		
	Walleye	Do not eat		
	Smallmouth bass	Eat no more than 1 meal a month		
FCG Level 8	Yellow perch	Eat no more than 1 meal a week	$19.78	$24.92
	Trout/salmon	Do not eat		
	Walleye	Do not eat		
	Smallmouth bass	Eat no more than 1 meal a month		
FCG Level 9	Yellow perch	Eat no more than 1 meal a month	$21.71	$27.35
	Trout/salmon	Do not eat		
	Walleye	Do not eat		
	Smallmouth bass	Do not eat		

Table A1 (see appendix) shows the estimates of the per-trip benefits from this study for both all trips to choice set sites and welfare losses conditional upon taking a trip to an FCG site. The per-trip benefit for all trips to choice set sites of removing the least restrictive FCG scenario (FCG Level 2) is $1.03, and the benefit of removing the most severe FCG scenario (FCG Level 9) is $10.73. They estimate that removing the FCG combination that most closely matches the current state of the waters of Green Bay (FCA Level 4) is $5.25 per trip. The per-trip welfare benefit conditional upon taking the trip to a FCG site is $2.28 for the least restrictive FCG combination, $12.48 for a moderate FCG combination, and $27.35 for the most restrictive combination.

This study produced welfare loss estimates that are associated with specific combinations of advisories for four species. All other studies produced a single estimate based on lifting an unreported number and severity of FCGs. It should be noted that most of the welfare losses conditional upon taking a trip to an affected site estimated by Breffle *et al.* are at the lower end of the range reviewed in the literature.

Selection of Per-Trip Welfare Losses for Damage Estimation

For the purposes of this estimate of damages associated with FCGs in the waters surrounding the LCP facility, the Trustees have made the restrictive assumption that welfare losses are confined to anglers that continue to fish in areas affected by the FCGs (category 1 losses described above). The Trustees have assumed that there has been no substitution of sites from within the FCG areas to sites with no FCGs (category 2 losses). Additionally, the Trustees have assumed that there has been no reduction in fishing effort associated with the FCGs (category 3 losses). By assuming no substitution and no impact on total fishing effort, it is not necessary to estimate welfare impacts to any anglers other than those that currently fishing in the waters covered by the FCGs. These restrictive assumptions likely lead to a lower bound estimate of the damages associated with the contamination. Site specific surveys of both anglers and the general population would be necessary to relax these assumptions and produce a more accurate estimate of damages.

As noted above, all studies in the literature report per-trip losses which capture both category 1 and category 2 losses. The purpose of these studies is to determine the economic benefit of removing all FCGs from all sites within the target population's choice set of fishing sites. This method is acceptable when information on the choice set is known and the policy scenario under consideration is lifting of all FCGs. However, because site specific information on angler behavior is not available for the waters of Glynn County and because the purpose of this study is to estimate the economic losses of FCGs at a single fishing site, the losses commonly reported in the literature are poor choices for use in benefit transfer for this case. The alternative approach taken in this study is to use the information provided in the literature to calculate the welfare losses conditional upon taking a trip to an FCG site. This method will isolate category 1 losses on a per-trip basis, and will serve as a more appropriate value to transfer to the waters surrounding the LCP facility. It is possible to determine the welfare loss conditional upon taking a trip to the FCG zone by dividing the FCG dummy variable's parameter by the monetizing variable's parameter estimate (α_1/β). These values are shown in Table 4

for the Breffle *et al.* study and in the right-most columns of Table A1 for all studies reviewed.

Rather than trying to exactly match each area with FCGs to a particular FCG level from the Breffle *et al*. study by severity alone, the Trustees instead considered both the severity of the FCG level in each area and the geographic/physical characteristics of each area. In this manner, the FCG levels and associated per-trip losses from Breffle *et al.* should be viewed as a mechanism for relative scaling between the different areas of the Glynn County assessment area.

The Breffle *et al.* FCG 9 combination includes a do not eat advisory for three species and a one meal per month advisory for the fourth species (see Table 4). In terms of severity, this combination is the closest to the blanket *do not eat* FCGs for:

- Purvis and Gibson Creeks: 1992-2003, and
- Highway 303 to Marker No. 9: 1992-1995.

However, the Trustees have decided not to use the FCG 9 combination loss of $27.35 per trip for these areas in these time periods. Instead, a loss of $12.48 per trip associated with FCG 6 (see next paragraph) was assigned to trips taken in these areas in these time periods after considering the physical/geographic attributes of the Glynn County fishery in combination with the severity of the FCGs. This adjustment accounts for the different characteristics of the Green Bay fishery, where the Breffle *et al.* study originated, when compared with the Glynn County fishery. For example, Green Bay has a large, open water area for recreational fishing with target species that include salmon, trout and walleye, while the Glynn County assessment area is confined to largely river-based recreational fishing opportunities that target drum, mullet and spot, among other species.

The Breffle *et al.* FCG 5 and FCG 6 combinations include a do not eat advisory for one species, a one meal per month advisory for two species, and no advisory for the fourth species. The FCG 5 and FCG 6 combinations differ according to which species have which severity of FCG, and are estimated to have welfare losses of $14.14 and $12.48 per trip, respectively. Considering severity characteristics alone, these combinations are the closest to the FCGs for:

- Purvis and Gibson Creeks: 2004-2008,
- Upriver of Highway 303: 1996-2008, and
- Highway 303 to Marker No. 9: 1996-2008.

This analysis uses the lower estimate of $12.48 per trip for Purvis and Gibson Creeks in 2004-2008. For the other two areas (upriver of Highway 303 and Highway 303 to Marker No. 9) during the 1996-2008 period, the FCG 3 level loss (see next paragraph) was assigned to trips taken. This modification to a strict FCG-based assignment of value is based on the judgment that Purvis and Gibson Creeks are closest to the source of the contamination, running through the site, and would therefore offer a different fishing experience than the other two areas, which are located on the main stem of the Turtle

River. Given the geographic location of the other two areas (upriver of Highway 303 and Highway 303 to Marker No. 9), they are grouped with the area of Marker No.9 to Dubignon Creek and assigned a similar FCG 3 level loss as described below. In this way, all locations on the main stem of the Turtle River are treated similarly for the time period of 1996-2008.

The Breffle *et al.* FCG 3 combination includes a one meal per month advisory for two species, a one meal per week advisory for one species, and no restriction on the fourth species. This combination is closest to the FCGs for:

- Marker No. 9 to Dubignon Creek: 1996-2008.

This analysis uses the FCG 3 combination loss of $6.12 per trip for this area in this time period as well as for the areas (1) upriver of Highway 303 and (2) from Highway 303 to Marker No.9 for the reasons described previously.

4. Quantification of Recreational Fishing Trips

The Marine Recreational Fishery Statistics Survey

The purpose of the Marine Recreational Fishery Statistics Survey (MRFSS) is to establish a database to facilitate the estimation of the impact marine recreational fishing has on marine resource stocks. NOAA Fisheries has conducted the MRFSS since 1981, and it is the only known time series dataset that estimates the number of annual recreational angling trips taken in Glynn County.

The MRFSS data is collected via two complementary surveys. The first is a telephone survey of households in coastal counties[5]. Some of the information collected through this random digit dial survey includes the number of marine recreational anglers in the household, the number of fishing trips taken in the previous two months, the mode of each trip, and the location (county) of each trip. Nationally, the MRFSS telephone survey is conducted in six 2-month "waves" each year. The telephone survey for each wave is conducted in the two-week period that includes the last week of the wave and the first week of the following wave. Telephone surveys from 1979 and 1980 indicated that a very small proportion of marine recreational catch along the Atlantic and Gulf coasts is taken in the months of January and February (wave 1). Because of the low level of recreational fishing, the MRFSS is no longer conducted during this period. The "annual" trip estimates produced by MRFSS only represent the ten-month period from March through December. Therefore, their results are likely underestimates of the true number of trips taken each year. An additional source of underestimation is the fact that the telephone and intercept surveys described below only include fin fishing effort in their

[5] MRFSS generally defines a "coastal" county as those that are within 25 miles of the coast. However, for the South Atlantic and Gulf during the May through October waves, "coastal" is defined as those within 50 miles of the coast.

trip estimation, thus any potential shell fishing trips taken in Glynn County are not counted.

The second survey is conducted by intercepting anglers at locations where they gather just after completing a fishing trip (marina, boat ramp, beginning of pier, etc). Intercept data includes, among other things, the number, weight, and length of all fish caught by species, state and county of residence, number of trips per year, the mode of fishing, and the primary area of fishing. Depending on location, approximately 70-90% of the anglers intercepted live within the geographic area covered by the telephone survey.

Both surveys collect data on the mode and zone of fishing. MRFSS tracks three modes: head or charter boat, private or rental boats, and shore (including all man-made structures, beaches, and banks). There are three zones of fishing: inland (all salt or brackish water from the coast inland to the limit of tidal influence), coastal (from the coast seaward to the 3 nautical mile state limit[6]), and offshore (in federal waters from 3 to 200 miles from the coast). Where coastal barrier islands are present, these define the coast. Therefore, back bays, lagoons, or coastal sounds between barrier islands and the mainland shoreline are captured in the "inland" category.

The MRFSS defines recreational fishing effort as the estimated number of fishing trips taken by individual anglers. The number of trips is estimated for each state, coastal county, mode, and wave. Telephone survey data are used to calculate the mean number of trips taken per household. This mean is then multiplied by the number of full-time occupied households in the coastal county, which is updated annually. This forms the primary base estimate of number of trips taken. However, as noted, the telephone survey fails to capture 10-30% of those intercepted on site because their residence is outside of the telephone coastal county area. It also fails to capture anglers that do not own telephones. Data from the intercept survey is used to adjust the telephone survey estimate for these two factors. Information on the MRFSS, including a detailed program overview, can be found at http://www.st.nmfs.gov/st1/recreational/index.html.

It should be explicitly noted that the MRFSS effort estimates have been subject to recent criticism. The Committee on the Review of Recreational Fisheries Survey Methods ("the Committee") was formed by the National Research Council of the National Academies to critique the current MRFSS sampling and estimation processes, and provide recommendations[7]. The Committee determined that significant weaknesses exist in the current MRFSS protocols that call in to question the validity of various estimates. Among their numerous conclusions and recommendations, the Committee states that,

- "The current methods used in the MRFSS for sampling the universe of anglers and for determining their catch and effort are inadequate. Sampling of each group of anglers (i.e., private, guided, head boat, charter boat) presents challenges that can differ across the groups….Both onsite and offsite methods suffer from

[6] For those states that have jurisdiction over waters greater than 3 miles from the coast, the "coastal" zone is defined to include those additional areas.
[7] The full review report can be found online at http://fermat.nap.edu/catalog/11616.html.

weaknesses that may lead to biases in catch and effort estimation. Finally, the estimation procedure for information gathered onsite does not use the nominal or actual selection probabilities of the sample design and therefore has the potential to produce biased estimates for both the parameters of interest and their variances." (page 6 of the report)

- "Onsite methods fail to intercept anglers who have private access to fishing waters or intercept them only sporadically." (page 6)
- "Offsite sampling methods that rely on telephone interviews are complicated by the increasing use of cellular telephones, especially in surveys of residents of coastal counties…If cellular telephones are excluded, then undercoverage of the survey will be increasingly problematic over time as the number of people who use only cellular telephones is growing." (page 6)
- "The existing random digit dialing survey suffers in efficiency from the low proportion of fishing households among the general population and may allow bias in estimation from its restriction to coastal counties only." (page 7)
- "Unknown biases in the estimators from these surveys arise from reliance on unverified assumptions. Unless these assumptions are tested and the degree and direction of bias reliably estimated, the extent to which the biases affect final estimates will remain unknown." (page 9)
- "The statistical properties associated with data collected through different survey techniques differ and often are unknown. The current estimators of error associated with various survey products are likely to be biased and too low. It is necessary, at a minimum, to determine how those differences affect survey results that use differing methods." (page 9)

Despite the issues raised by the Committee, this analysis will quantify the number of recreational fishing trips using MRFSS data. Even with its limitations, the MRFSS is the only known time series of recreational fishing effort estimates for Glynn County. It should be noted that while the Committee has raised several issues with the current MRFSS protocol, the direction of any bias associated with the methodology is indeterminate.

Quantification of Recreational Trips to FCG Reaches: 1992-2004

The Trustees are unaware of any data source that estimates the number of trips specifically taken to the four FCG reaches. Therefore, this estimate of recreational loss will couple historical MRFSS data with the assumption that Glynn County inland zone fishing is evenly distributed over space and a fractional multiplier.

As of the initial drafting of this report, the most recent data available through the MRFSS is for 2004. Dr. Tom Sminkey, a NOAA statistician for the MRFSS, provided estimates of the number of annual inland fishing trips taken to Glynn County for the period 1992 through 2004. Ms. M. Kathryn Knowlton of the Georgia Department of Natural Resources Coastal Resources Division coordinates the MRFSS for the State of Georgia. She reviewed the data provided by Dr. Sminkey, and verified that the estimates are within the expected range based on her professional experience with recreational fishing in

coastal Georgia[8]. These estimates are included in Table 5. Also included are the annual proportional standard errors (PSEs). PSE is the standard error expressed as a percentage of the estimate, and is a measure of precision of the estimate. Smaller PSEs indicate more precise estimates. A PSE of 20% or less is generally considered acceptable for these data.

Table 5. MRFSS estimates for inland marine fishing trips taken to Glynn County, 1992-2004.

Year	Raw # of Trips	Proportional Standard Error
1992	271,494	11.4
1993	296,974	9.8
1994	479,897	12.2
1995	408,258	12.4
1996	378,503	11.8
1997	240,980	10.1
1998	177,550	10.1
1999	215,331	11.0
2000	266,533	13.8
2001	233,369	13.0
2002	269,052	11.0
2003	394,077	11.5
2004	444,509	13.1
Sum	4,076,527	--

Using geographic information system (GIS) software, the percentage of total Glynn County inland zone waters covered by each of the four FCG zones was calculated. The total Glynn County inland water zone is estimated to be 76,976 acres. It is likely that this is a slight overestimate of the zone for two reasons. First, the northeastern and southwestern bounders of the county are the midlines of various waterways. To reduce the complexity of the GIS exercise, the entireties of these waterways are assumed to be in Glynn County. Second, all rivers and streams in the county are assumed to be tidally influenced, and hence within the MRFSS definition of the inland zone. If there are nontidal freshwater rivers and streams in the county, their inclusion in this exercise would lead to an overestimate of the size of the zone. An overestimate of the size of the inland zone will lead to an underestimate of those fishing trips allocated to each of the four FCG reaches. The area of each of the four FCG zones is also calculated using GIS software. Table 6 details the area and the percentage of the total Glynn County inland water zone covered by the FCGs. The four FCG zones comprise nearly 13.4% of the county's total inland water zone.

[8] Personal communication on December 19, 2005 and January 11, 2006.

Table 6. Proportion of the Glynn County inland water zone covered by FCGs, by reach.

Zone	Acres	% of Total Area
Glynn County Inland Water Zone	76,976	100.000%
Purvis & Gibson Creeks	242	0.315%
Upriver of Highway 303	2,523	3.278%
Highway 303 to Marker 9	397	0.515%
Marker 9 to Dubignon Creek	7,149	9.287%
Total FCG Area	10,311	13.395%

An estimate of the number of recreational fishing trips taken to each of the four FCG zones is derived by multiplying the yearly MRFSS estimate of the total number of trips to the county's inland zone (Table 5 data) by the percentage of the zone's area covered by each FCG (Table 6 data). This product is the number of affected nominal trips to each zone, and these estimates are presented in Table 7. The estimates are only produced for those years in which the reach had an FCG. Therefore, the waterways upriver of the Highway 303 bridge and downriver of Marker 9 have zero estimated affected trips for 1992 through 1995.

Table 7. Estimated number of nominal and discounted recreational fishing trips by reach, 1992-2004.

Year	Number of Affected Nominal Trips by Reach					Number of Affected Inflated* Trips by Reach				
	P&G Creeks	UpRiver of Highway 303	Highway 303 to Marker 9	Marker 9 to Dubignon Creek	Total	P&G Creeks	UpRiver of Highway 303	Highway 303 to Marker 9	Marker 9 to Dubignon Creek	Total
1992	855	0	1,399	0	2,254	1,372	0	2,245	0	3,617
1993	935	0	1,530	0	2,465	1,457	0	2,384	0	3,841
1994	1,511	0	2,472	0	3,984	2,286	0	3,740	0	6,026
1995	1,286	0	2,103	0	3,389	1,888	0	3,089	0	4,977
1996	1,192	12,407	1,950	35,151	50,701	1,700	17,690	2,780	50,117	72,287
1997	759	7,899	1,241	22,380	32,279	1,051	10,935	1,719	30,979	44,682
1998	559	5,820	915	16,489	23,783	751	7,822	1,229	22,160	31,962
1999	678	7,059	1,109	19,998	28,844	885	9,210	1,447	26,092	37,634
2000	839	8,737	1,373	24,753	35,702	1,063	11,068	1,739	31,356	45,226
2001	735	7,650	1,202	21,673	31,260	904	9,408	1,479	26,655	38,446
2002	847	8,820	1,386	24,987	36,040	1,012	10,531	1,655	29,835	43,033
2003	1,241	12,918	2,030	36,598	52,787	1,439	14,975	2,354	42,427	61,194
2004	1,400	14,571	2,290	41,281	59,542	1,576	16,400	2,577	46,462	67,015
Sum	12,839	85,881	21,002	243,308	363,029	17,383	108,038	28,436	306,082	459,941
Mean	988	9,542	1,616	27,034	39,180	--	--	--	--	--

*The base period for inflating and discounting the number of trips is 2008.

The number of affected trips is reduced by the use of a fractional multiplier in this analysis. This step is important since, as described above, the number of trips to the FCG areas is estimated by multiplying total Glynn County fishing trips from the MRFSS data by the percentage of total Glynn County inland waters impacted by FCGs. Without using a fractional multiplier, such a proportional analysis assumes that the inland water FCG areas in Glynn County are as attractive and accessible to fishers as other inland waters that are unaffected by FCGs. Therefore, this multiplier accounts for the possibility that the presence of FCGs may have led some anglers to visit substitute sites, thereby decreasing the number of affected trips and that there may be fewer access points in close proximity to the affected reaches. This multiplier also accounts for the presence of other facilities along the affected reaches (e.g., treatment plants) that might negatively impact the number of fishing trip taken in the FCG areas. The Trustees have used a multiplier of 0.75 (75%) based on best professional judgment to estimate these effects. As discussed further below, the damage calculations using this adjusted number of trips are displayed in Tables 8 and 9.

Table 8. Estimated discounted recreational trips to affected reaches, applicable per-trip welfare losses, and total recreational loss damages assuming improvement in FCAs beginning in 2012 and a 30-year linear recovery timeframe.

Year	P&G Creeks		Upriver of Highway 303		Highway 303 to Marker 9		Marker 9 to Dubignon Creek		Total Damages
	Trips	Loss/Trip	Trips	Loss/Trip	Trips	Loss/Trip	Trips	Loss/Trip	
1992	1,029	$12.48	0	$0.00	1,683	$12.48	0	$0.00	$33,851
1993	1,093	$12.48	0	$0.00	1,788	$12.48	0	$0.00	$35,950
1994	1,715	$12.48	0	$0.00	2,805	$12.48	0	$0.00	$56,401
1995	1,416	$12.48	0	$0.00	2,317	$12.48	0	$0.00	$46,584
1996	1,275	$12.48	13,267	$6.12	2,085	$6.12	37,588	$6.12	$339,904
1997	788	$12.48	8,201	$6.12	1,289	$6.12	23,234	$6.12	$210,102
1998	564	$12.48	5,866	$6.12	922	$6.12	16,620	$6.12	$150,291
1999	664	$12.48	6,907	$6.12	1,086	$6.12	19,569	$6.12	$176,963
2000	798	$12.48	8,301	$6.12	1,305	$6.12	23,517	$6.12	$212,662
2001	678	$12.48	7,056	$6.12	1,109	$6.12	19,991	$6.12	$180,777
2002	759	$12.48	7,898	$6.12	1,241	$6.12	22,376	$6.12	$202,348
2003	1,079	$12.48	11,232	$6.12	1,765	$6.12	31,820	$6.12	$287,745
2004	1,182	$12.48	12,300	$6.12	1,933	$6.12	34,847	$6.12	$315,116
2005	809	$12.48	7,820	$6.12	1,324	$6.12	22,156	$6.12	$201,657
2006	786	$12.48	7,593	$6.12	1,285	$6.12	21,510	$6.12	$195,784
2007	763	$12.48	7,371	$6.12	1,248	$6.12	20,884	$6.12	$190,081
2008	741	$12.48	7,157	$6.12	1,212	$6.12	20,276	$6.12	$184,545
2009	719	$12.48	6,948	$6.12	1,176	$6.12	19,685	$6.12	$179,170
2010	698	$12.48	6,746	$6.12	1,142	$6.12	19,112	$6.12	$173,951
2011	678	$12.48	6,549	$6.12	1,109	$6.12	18,555	$6.12	$168,885
2012	658	$12.06	6,359	$5.92	1,077	$5.92	18,015	$5.92	$158,500
2013	639	$11.65	6,173	$5.71	1,045	$5.71	17,490	$5.71	$148,578
2014	620	$11.23	5,994	$5.51	1,015	$5.51	16,981	$5.51	$139,098
2015	602	$10.82	5,819	$5.30	985	$5.30	16,486	$5.30	$130,045
2016	585	$10.40	5,650	$5.10	956	$5.10	16,006	$5.10	$121,401
2017	568	$9.98	5,485	$4.90	929	$4.90	15,540	$4.90	$113,151
2018	551	$9.57	5,325	$4.69	902	$4.69	15,087	$4.69	$105,278
2019	535	$9.15	5,170	$4.49	875	$4.49	14,648	$4.49	$97,768
2020	520	$8.74	5,020	$4.28	850	$4.28	14,221	$4.28	$90,605
2021	504	$8.32	4,873	$4.08	825	$4.08	13,807	$4.08	$83,778
2022	490	$7.90	4,731	$3.88	801	$3.88	13,405	$3.88	$77,271
2023	475	$7.49	4,594	$3.67	778	$3.67	13,014	$3.67	$71,072
2024	462	$7.07	4,460	$3.47	755	$3.47	12,635	$3.47	$65,168
2025	448	$6.66	4,330	$3.26	733	$3.26	12,267	$3.26	$59,548
2026	435	$6.24	4,204	$3.06	712	$3.06	11,910	$3.06	$54,200
2027	422	$5.82	4,081	$2.86	691	$2.86	11,563	$2.86	$49,114
2028	410	$5.41	3,963	$2.65	671	$2.65	11,226	$2.65	$44,277
2029	398	$4.99	3,847	$2.45	651	$2.45	10,899	$2.45	$39,681
2030	387	$4.58	3,735	$2.24	632	$2.24	10,582	$2.24	$35,315
2031	375	$4.16	3,626	$2.04	614	$2.04	10,274	$2.04	$31,169
2032	364	$3.74	3,521	$1.84	596	$1.84	9,974	$1.84	$27,235
2033	354	$3.33	3,418	$1.63	579	$1.63	9,684	$1.63	$23,504
2034	343	$2.91	3,319	$1.43	562	$1.43	9,402	$1.43	$19,967

2035	333	$2.50	3,222	$1.22	545	$1.22	9,128	$1.22	$16,616
2036	324	$2.08	3,128	$1.02	530	$1.02	8,862	$1.02	$13,443
2037	314	$1.66	3,037	$0.82	514	$0.82	8,604	$0.82	$10,441
2038	305	$1.25	2,948	$0.61	499	$0.61	8,353	$0.61	$7,603
2039	296	$0.83	2,863	$0.41	485	$0.41	8,110	$0.41	$4,921
2040	288	$0.42	2,779	$0.20	471	$0.20	7,874	$0.20	$2,389
2041	279	$0.00	2,698	$0.00	457	$0.00	7,644	$0.00	$0
SUM									$5,383,905

Table 9. Estimated discounted recreational trips to affected reaches, applicable per-trip welfare losses, and total recreational loss damages assuming improvement in FCAs beginning in 2018 and a 30-year linear recovery timeframe.

Year	P&G Creeks		Upriver of Highway 303		Highway 303 to Marker 9		Marker 9 to Dubignon Creek		Total Damages
	Trips	Loss/Trip	Trips	Loss/Trip	Trips	Loss/Trip	Trips	Loss/Trip	
1992	1,029	$12.48	0	$0.00	1,683	$12.48	0	$0.00	$33,851
1993	1,093	$12.48	0	$0.00	1,788	$12.48	0	$0.00	$35,950
1994	1,715	$12.48	0	$0.00	2,805	$12.48	0	$0.00	$56,401
1995	1,416	$12.48	0	$0.00	2,317	$12.48	0	$0.00	$46,584
1996	1,275	$12.48	13,267	$6.12	2,085	$6.12	37,588	$6.12	$339,904
1997	788	$12.48	8,201	$6.12	1,289	$6.12	23,234	$6.12	$210,102
1998	564	$12.48	5,866	$6.12	922	$6.12	16,620	$6.12	$150,291
1999	664	$12.48	6,907	$6.12	1,086	$6.12	19,569	$6.12	$176,963
2000	798	$12.48	8,301	$6.12	1,305	$6.12	23,517	$6.12	$212,662
2001	678	$12.48	7,056	$6.12	1,109	$6.12	19,991	$6.12	$180,777
2002	759	$12.48	7,898	$6.12	1,241	$6.12	22,376	$6.12	$202,348
2003	1,079	$12.48	11,232	$6.12	1,765	$6.12	31,820	$6.12	$287,745
2004	1,182	$12.48	12,300	$6.12	1,933	$6.12	34,847	$6.12	$315,116
2005	809	$12.48	7,820	$6.12	1,324	$6.12	22,156	$6.12	$201,657
2006	786	$12.48	7,593	$6.12	1,285	$6.12	21,510	$6.12	$195,784
2007	763	$12.48	7,371	$6.12	1,248	$6.12	20,884	$6.12	$190,081
2008	741	$12.48	7,157	$6.12	1,212	$6.12	20,276	$6.12	$184,545
2009	719	$12.48	6,948	$6.12	1,176	$6.12	19,685	$6.12	$179,170
2010	698	$12.48	6,746	$6.12	1,142	$6.12	19,112	$6.12	$173,951
2011	678	$12.48	6,549	$6.12	1,109	$6.12	18,555	$6.12	$168,885
2012	658	$12.48	6,359	$6.12	1,077	$6.12	18,015	$6.12	$163,966
2013	639	$12.48	6,173	$6.12	1,045	$6.12	17,490	$6.12	$159,190
2014	620	$12.48	5,994	$6.12	1,015	$6.12	16,981	$6.12	$154,554
2015	602	$12.48	5,819	$6.12	985	$6.12	16,486	$6.12	$150,052
2016	585	$12.48	5,650	$6.12	956	$6.12	16,006	$6.12	$145,682
2017	568	$12.48	5,485	$6.12	929	$6.12	15,540	$6.12	$141,438
2018	551	$12.06	5,325	$5.92	902	$5.92	15,087	$5.92	$132,742
2019	535	$11.65	5,170	$5.71	875	$5.71	14,648	$5.71	$124,431
2020	520	$11.23	5,020	$5.51	850	$5.51	14,221	$5.51	$116,493
2021	504	$10.82	4,873	$5.30	825	$5.30	13,807	$5.30	$108,911
2022	490	$10.40	4,731	$5.10	801	$5.10	13,405	$5.10	$101,672
2023	475	$9.98	4,594	$4.90	778	$4.90	13,014	$4.90	$94,762
2024	462	$9.57	4,460	$4.69	755	$4.69	12,635	$4.69	$88,169
2025	448	$9.15	4,330	$4.49	733	$4.49	12,267	$4.49	$81,879
2026	435	$8.74	4,204	$4.28	712	$4.28	11,910	$4.28	$75,881
2027	422	$8.32	4,081	$4.08	691	$4.08	11,563	$4.08	$70,162
2028	410	$7.90	3,963	$3.88	671	$3.88	11,226	$3.88	$64,713
2029	398	$7.49	3,847	$3.67	651	$3.67	10,899	$3.67	$59,521
2030	387	$7.07	3,735	$3.47	632	$3.47	10,582	$3.47	$54,577
2031	375	$6.66	3,626	$3.26	614	$3.26	10,274	$3.26	$49,871
2032	364	$6.24	3,521	$3.06	596	$3.06	9,974	$3.06	$45,392
2033	354	$5.82	3,418	$2.86	579	$2.86	9,684	$2.86	$41,132
2034	343	$5.41	3,319	$2.65	562	$2.65	9,402	$2.65	$37,081

2035	333	$4.99	3,222	$2.45	545	$2.45	9,128	$2.45	$33,232
2036	324	$4.58	3,128	$2.24	530	$2.24	8,862	$2.24	$29,575
2037	314	$4.16	3,037	$2.04	514	$2.04	8,604	$2.04	$26,104
2038	305	$3.74	2,948	$1.84	499	$1.84	8,353	$1.84	$22,809
2039	296	$3.33	2,863	$1.63	485	$1.63	8,110	$1.63	$19,684
2040	288	$2.91	2,779	$1.43	471	$1.43	7,874	$1.43	$16,722
2041	279	$2.50	2,698	$1.22	457	$1.22	7,644	$1.22	$13,916
2042	271	$2.08	2,620	$1.02	444	$1.02	7,422	$1.02	$11,259
2043	263	$1.66	2,543	$0.82	431	$0.82	7,206	$0.82	$8,745
2044	256	$1.25	2,469	$0.61	418	$0.61	6,996	$0.61	$6,367
2045	248	$0.83	2,397	$0.41	406	$0.41	6,792	$0.41	$4,121
2046	241	$0.42	2,328	$0.20	394	$0.20	6,594	$0.20	$2,001
2047	234	$0.00	2,260	$0.00	383	$0.00	6,402	$0.00	$0
SUM									$5,999,574

Because the public has a social rate of time preference for all goods and services, analysis of nominal service provision is not extremely useful in the context of a natural resource damage assessment. Services lost in the past are worth more than those lost or gained in the future. Therefore, losses from the past must be inflated to a constant unit, and losses in the future must be discounted back to the same constant unit. In practice, it is irrelevant whether the number of trips or the per-trip value is corrected for the social rate of time preference. To facilitate estimation of total damages in Section 5, this report inflates or discounts the number of affected trips to a constant base year. Per-trip lost values in 2007$ are then applied to these discounted trips in the next section's damage calculation. The number of inflated affected recreational angling trips for 1992 through 2004 is shown in Table 7. The base period for inflating and discounting is 2008, and a 3% social rate of time preference is used (NOAA 1999).[9]

Quantification of Recreational Trips to FCG Reaches: Post-2004

Quantification of recreational fishing losses post-2004 (the most recent year for which data are available) requires two assumptions. First, the predicted number of trips taken in future years relies on an assumption of how fishing effort in the county will change over time. There are at least three methods that can be used to predict future effort. The simplest method would be to assume that the mean number of trips that have been taken since the FCGs were established continues in the future. A second method would be to assume that 2004 is a representative level of fishing effort, and can reasonably be assumed to continue in the future. The third method is to use a regression equation, which shows a statistically significant increasing trend in fishing effort, for the 1998 through 2004 period to predict the level of future use. This method would result in an increasing number of trips each year. For the purposes of this estimate of recreational fishing losses, the Trustees have used the historical mean number of trips to each reach to approximate the expected number of nominal trips affected in the post-2004 period. Using this mean number accounts for the fact that there has been an increasing trend during certain time periods and a decreasing trend in other time periods. Since 1990, Glynn County has experienced, and is expected to continue to experience, a significant population increase[10]. As more residents settle in Glynn County, it is reasonable to expect that more recreational fishing trips will be taken. Use of the historical mean therefore likely underestimates the level of future trips given this population increase. It is unknown what a realistic rate of change in future trips might be.

The last row of Table 7 displays the mean number of trips to each reach during the FCG periods. A total of 39,180 trips per year are estimated to be taken to the affected area, with the majority of these being downriver of Marker No. 9. This annual effort estimate

[9] The formula used for discounting and inflating is Number of $Trips_b$= Number of $trips_t/(1+r)^{t-b}$, where t is the year for which the number of trips is estimated and b is the base year for calculation. As shown by the formula, trips occurring after the base year would be discounted by $(1+r)^{t-b}$, where *r* is the rate of time preference, while trips occurring before the base year would be inflated by $(1+r)^{t-b}$.

[10] The 1990 and 2000 censuses estimated 62,496 and 67,568 residents of Glynn County, respectively. This is an 8.1% increase in population over the decade. The U.S. Census Bureau Population Estimates Program estimated that the Glynn County population was 71,357 as of July 1, 2004. This is a 5.6% increase in population over less than four years. Data from http://www.census.gov/popest/counties/index.html.

is equivalent to approximately 107 trips per day over more than 30 linear miles of waterways. When the 75% multiplier is applied, the annual effort estimate converts to approximately 80 trips per day in the FCG-affected areas.

The second assumption required for the quantification of future recreational trips concerns when the FCGs are likely to be lifted for the waters near the LCP facility. As the recreational fishing losses are attributable to the imposition of the FCGs, the calculation of damages will only be for the time period in which the FCGs are expected to be in effect. Damages cease once the FCGs are eliminated. Ms. Linda Harn is the Environmental Program Manager of the Georgia Department of Natural Resources Environmental Protection Division's Intensive Surveys Unit, and she coordinates publication of the state's fish consumption guidelines. She has noted that Georgia has never lifted a FCG for PCBs, though they have changed (both increased and decreased) the severity of FCGs for PCBs[11]. She is also unaware of any other state that has lifted a PCB FCG, and is not able to offer a projected date for lifting the FCGs associated with the waters surrounding the LCP facility. Dr. Randall O. Manning of the Georgia Department of Natural Resources Environmental Protection Division is the toxicologist that reviews and approves all FCGs in the state. He concurred that there was little past evidence that can be used to predict when the FCGs for PCBs may be lifted. He stated that, barring a change in the toxicity values used when determining the FCG levels, it is reasonable to assume that FCGs for PCBs will persist in the waters surrounding the LCP site for at least another 20 years[12], and based on the site environmental contamination data, the Trustees anticipate concentrations in fish to remain high for a longer period.

This estimate of recreational fishing losses uses reach-specific recovery projections. These projections are based upon professional judgment, as there is neither a trend in fish tissue contaminant concentrations nor any examples in the southeastern United States of fish advisories for PCBs being lifted. This analysis uses a projection that all FCGs will be lifted within 30 years. This assumption is subject to revision. The analysis acknowledges the uncertainty about when recovery from the FCGs will begin by providing a lower bound of recovery starting in 2012 and an upper bound of recovery starting in 2018. Following the beginning of recovery in either 2012 or 2018, the FCGs are assumed to linearly improve from their level at that point until being completely lifted within 30 years (the value lost per trip declines linearly over time to $0 from either $12.48 or $6.12, depending on the reach considered). This use of a linear improvement is consistent with the linear approach employed in the Habitat Equivalency Analysis used at the site for evaluation of ecological injury. It is possible, and perhaps likely, that FCGs will still be in effect beyond the timeline shown in this analysis given the lack of a history of completely lifting such FCGs and the absence of an improving trend in fish tissue concentrations.

There should be a logical link between 1) contaminant threshold concentrations and the recovery projections for injuries to fish in the waters surrounding the LCP facility and 2) the FCG threshold concentrations and the projections for lifting FCGs for recreational

[11] Personal communication on January 4, 2006.
[12] Personal communication on January 10, 2006.

fishing. At this time, the Trustees are considering a 30-year recovery time period for the fish injury category and are using 0.5 ppm ww of Aroclor 1268 as the minimum threshold for assessing service loss. In this analysis of recreational fishing damages, the Trustees have elected to assume that all FCGs are lifted within 30 years. However, this assumption violates the logical link that must exist between the fish and recreational fishing injury categories. As illustrated in Table 1, the 0.5 ppm concentration falls into the middle of the range of the one meal per month FCG, the second-most restrictive FCG. Therefore, if mean concentrations of Aroclor 1268 fall to 0.5 ppm in 30 years as currently assumed in the fish injury analysis, severe FCGs would still be in place. Mean concentrations would have to fall to below 0.1 ppm for all FCGs to be lifted. By assuming that all FCGs will be lifted in the same year that the fish injury ceases, the Trustees are likely underestimating the recreational loss damages.

5. Damage Estimate

To calculate recreational fishing welfare losses for those anglers that continue to fish in the FCG zones, the estimated number of inflated/discounted trips is multiplied by the fractional multiplier of 0.75 and then by the appropriate per-trip loss estimate in constant 2007$. The number of inflated/discounted trips and the per-trip loss estimates are displayed in Tables 8 and 9 for each FCG reach in each year. For a 30-year recovery period, Table 8 shows the lower bound scenario of recovery of FCGs beginning in 2012, while Table 9 shows the upper bound scenario of recovery of FCGs beginning in 2018. Given these two scenarios, the estimate of total damages for recreational fishing trips taken to FCG sites ranges between $5,383,905 and $5,999,574.

6. Uncertainty Associated with the Damage Estimate

The Trustees acknowledge that there is significant uncertainty in the damage estimate produced in this analysis of recreational fishing losses. Reliance on MRFSS data on fishing effort and benefit transfer of per-trip values instead of primary data collected from Glynn County mandates that a number of assumptions be used in the analysis. This section explicitly reviews some of the uncertainty associated with the various calculations and the assumptions included in this report. When possible, the expected direction of any over- or underestimate is noted.

Several assumptions have been made concerning the number of recreational fishing trips taken to the FCG-affected areas. As a first approximation, the Trustees assumed that total inland saltwater fishing effort in Glynn County is evenly distributed across all fishable inland saltwater areas on a per-acre basis. This is likely an unrealistic assumption. It is likely that recreational fishing is patchy, and where anglers choose to fish is influenced by the locations of access points, human population centers, and physical features that may increase catch rates, among other things. Without additional primary data collection, it is not possible to determine whether this assumption leads to an underestimate, overestimate, or accurate estimate of the number of fishing trips taken in the FCG-affected areas.

To this first approximation estimate, the Trustees applied a fractional multiplier to the per-acre number of annual fishing trips within the FCG-affected area. The purpose of this multiplier is to acknowledge that the presence of FCGs may have led some anglers to visit substitute sites. It also acknowledges that the areas covered by the FCGs may be less appealing that other inland saltwater fishing areas within the county and that there may be fewer access points in close proximity to the affected reaches. Without additional primary data collection, it is not possible to determine whether this assumption leads to an underestimate, overestimate, or accurate estimate of the number of fishing trips taken in the FCG-affected areas.

The northern and southern boundaries of Glynn County follow the midline of various rivers and creeks. In calculating the total inland saltwater area available for fishing, the GIS analysis included the entire width of those waterways in the total Glynn County stream/river area calculation. Overestimating the area of fishable water in Glynn County by using the entirety of the boundary waterways would reduce the per-acre level of fishing effort. In addition, the Trustees have assumed that all inland waterways are tidally influenced and captured in the MRFSS definition of the inland zone. To the extent that there are nontidal fresh streams and rivers in Glynn County, this decision will reduce the per-acre level of fishing effort. It is likely that these decisions lead to an underestimate of the recreational fishing damages. However, the magnitude of this bias is likely insignificant in the overall analysis.

Several assumptions have also been made about the appropriate values to use in the benefit transfer. First, the method selected assumes that it is appropriate to apply different per-trip values to trips taken to areas with different severities of FCGs. It seems logical that the welfare loss associated with a trip to a site with an FCG of one meal per week for a single species would be less than the welfare loss associated with a trip to a site where consumption of all seafood is prohibited. The only study in the literature that differentiates per-trip values in this manner is Breffle *et al.*, which is one of the factors that were considered when the Trustees selected this study for use in this analysis. It is likely that this assumption neither over- nor underestimates the damages, and produces a more accurate estimate than applying values from studies with an unknown number and severity of FCGs.

Second, it is assumed that the substitutes, fishing site characteristics, and population characteristics of the Green Bay study are sufficiently similar to the Glynn County area to meet the suitability criteria of benefit transfer. Without greater knowledge of these factors, it is not possible to know whether transfer of the Green Bay per-trip values is an over- or underestimate of damages. However, it should be noted that the per-trip values in Breffle *et al.* conditional upon taking a trip to an FCG-affected site are at the low end of the literature's range for such value estimates. Selection of a study with below average per trip values should minimize the magnitude of any bias in the damage estimate that may arise from the research and policy locations being significantly different.

Third, when multiple FCG combinations from the Breffle *et al.* closely matched the severity of FCGs in Glynn County, the Trustees decided to use the combination with the lower per-trip loss. For instance, the FCG 5 and FCG 6 combinations differ according to

which species groups have which severity of FCG, and are estimated to have welfare losses of $14.14 and $12.48 per trip, respectively. The Breffle *et al.* FCG 6 combination was used instead of the FCG 5 combination. This decision leads to a lower estimate of damages as compared with using the mean of the two FCG combinations or the higher per-trip loss. Additionally, the Breffle *et al.* FCG 9 combination includes a do not eat advisory for three species and a one meal per month advisory for the fourth species. This combination is close to, but less severe than, the blanket do not eat FCGs for Purvis and Gibson Creeks in 1992 to 2003 and Highway 303 to Marker No. 9 in 1992 to 1995. Since the FCG 9 combination allows some consumption, it would be expected that a total ban on consumption would result in a per-trip loss greater than the $27.35 reported in Breffle *et al.* However, the Trustees have decided to apply a loss of $12.48 per trip associated with FCG 6 to trips taken in these areas in these time periods. Selection of certain Breffle *et al.* FCG combinations to serve as proxies for the FCG combinations in the waters surrounding the LCP facility likely leads to an underestimate of the damages.

Another primary assumption made in this analysis is that anglers have not altered their fishing sites as a result of the FCGs. In addition, the overall level of fishing effort is assumed to be unaffected by the presence of FCGs. In terms of the three potential categories of loss outlined at the beginning of section 3, the Trustees have assumed that all losses are confined to those anglers that still choose to fish in waters covered by the FCGs (there are no category 2 or 3 losses). These assumptions are likely unrealistic. It would be expected that the utility derived from fishing at a previously less desired site may exceed that of fishing at the previously most desired site once the FCGs are implemented. Therefore, it is likely that some anglers substituted trips that would have been taken in the FCG-affected areas with trips to areas without FCGs. These anglers experience a welfare loss that is unaccounted for in this analysis. Site-specific primary data would be necessary to estimate the magnitude of such substitution. In addition, decreasing utility of fishing under FCG conditions likely has led to a lower level of recreational fishing effort than would have been the case without the contamination. Welfare losses accrue to those anglers that choose to forego trips because of the FCGs. The assumption that there are no category 2 or 3 losses likely leads to an underestimate of the recreational fishing damages.

The MRFSS's data used in this analysis of fishing effort are "annual" estimates, but are only collected in waves 2 through 6 (March through December) of each year. As it is a nationwide survey, MRFSS has determined that recreational fishing effort is low enough during wave 1 for most of the country that the resources that would be expended on collecting data during these months would be better spent increasing the sample size in other waves with higher levels of use. Therefore, the "annual" estimates used in this analysis assume that there are zero recreational fishing trips taken in January or February in Glynn County. This is likely an unrealistic assumption as the weather in southern Georgia would certainly permit recreational fishing. Assuming that there are no affected trips in January and February of each year likely leads to an underestimate of the recreational fishing damages.

Post-2004 estimates of the number of trips taken to each reach are based on the mean number of trips taken to the reach during the FCG period (1992 to 2004 for Purvis and

Gibson Creeks and the Turtle River from the Highway 303 bridge to Marker 9, and 1996 to 2004 for the reaches above the Highway 303 bridge and below Maker 9). Use of this mean ignores the substantial population increase that Glynn County has experienced and is likely to continue experiencing. As the population increases, it would be expected that the number of recreational fishing trips would also increase. Use of the mean also ignores the statistically significant upward trend in fishing effort estimated by MRFSS for the 1998 through 2004 period. Use of the FCG period's mean number of fishing trips to the affected reaches likely underestimates the damages for post-2004 years.

7. Literature Cited

Breffle, WS, ER Morey, RD Rowe, SM Waldman, and SM Wytinck (1999). "Recreational fishing damages from FCAs in the waters of Green Bay". Stratus Consulting, Inc.

Chen, HZ and SR Cosslett (Aug 1998). "Environmental quality preference and benefit estimation in multinomial probit models: a simulation approach." *American Journal of Agricultural Economics* 80:512:20.

Hauber, AB and GR Parsons (Aug 2000). "The effect of nesting structure specification on welfare estimation in a random utility model of recreation demand: an application to the demand for recreational fishing." *American Journal of Agricultural Economics* 82:501-14.

Herriges, JA, CL Kling, and DJ Phaneuf (1999). "Chapter 6: Corner solution models of recreation demand: A comparison of competing frameworks". In Valuing Recreation and the Environment. JA Herriges and CL Kling (eds). Northampton, MA: Elgar.

Jakus, PM, M Downing, MS Bevelhimer, and JM Fly (1997). "Do sportfish consumption advisories affect reservoir anglers' site choice?" *Agricultural and Resource Economics Review* 26: 196-204.

Jakus, PM, D Dadakas, and JM Fly (1998). "Fish consumption advisories: incorporating angler-specific knowledge, habits, and catch rates in a site choice model." *American Journal of Agricultural Economics* 80(5): 1019-24.

Jakus, P, M McGuiness, and A Krupnick (2002). "The benefits and costs of fish consumption advisories for mercury". Resources for the Future. Discussion Paper 02-55. pp. 141.

Jakus, PM and WD Shaw (2003). "Perceived hazard and product choice: an application to recreational site choice." *Journal of Risk and Uncertainty* 26(1):77-92.

McConnell, KE and IE Strand (1994). The economic value of mid and south Atlantic sportfishing, Volume 2: 134. College Park, MD: University of Maryland.

Montgomery, M and M Needelman (May 1997). “The welfare effects of toxic contamination in freshwater fish”. *Land Economics* 73(2):211-23.

National Oceanic and Atmospheric Administration (February 19, 1999). “Discounting and the treatment of uncertainty in natural resource damage assessment”. Technical Paper 99-1. Silver Spring, MD: Damage Assessment Center, Resource Valuation Branch.

Parsons, GR, and AB Hauber (Feb 1998). “Spatial boundaries and choice set definition in a random utility model of recreation demand”. *Land Economics* 74(1):32-48.

Parsons, GR, PM Jakus, and T Tomasi (1999). “A comparison of welfare estimates from four models for linking seasonal recreational trips to multinomial logit models of site choice.” *Journal Environmental Economics and Management* 38:143-157.

Appendix. Literature Review of the Economic Valuation of Fish Consumption Guidelines and Advisories

A literature search for economic valuation studies that produced a welfare estimate for fish consumption advisories or toxic contamination removal yielded eleven studies. Nine of these use the travel cost method to produce lower-bound estimates of per-trip losses. A tenth study is a combined revealed and conjoint analysis stated preference survey conducted using a boat launch fee as the monetizing variable. The eleventh study combined revealed and stated preference data, and is not primary research. The Breffle *et al.* study selected for use in benefit transfer to the waters of Glynn County was reviewed previously. This appendix provides a brief summary and evaluation of the remaining ten studies.

With the exception of the Herriges, Kling, and Phaneuf study, the reported per-trip welfare improvements are for the elimination of all FCGs from all sites within the choice set. Table A1 summarizes some of the most important information about each, including the welfare loss estimates that are both reported and derived as conditional upon taking a trip to the FCG site.

Four of the nine travel cost studies were conducted on reservoir fishing in Tennessee. Jakus *et al.* (1997) estimated separate repeated discrete choice models for middle and eastern Tennessee. Each region had fourteen reservoirs in the choice set. The middle region had two sites with FCGs and the eastern region had six FCG sites. The middle Tennessee region model produced a per-trip welfare benefit for all trips to choice set sites of removing the FCGs of $2.56 and the eastern model estimated a benefit of $3.96. The authors estimate that the value of removing just the FCG from the most popular reservoir in the eastern region is $2.20 per trip. The derived per-trip loss conditional on taking a trip to a FCG site is $33.21 and $8.24 for middle and eastern Tennessee, respectively.

Jakus, Dadakas, and Fly (1998) refined these estimates for the eastern region by segmenting the angling population into those that did and did not know of the advisories, and those that were consumption versus catch-and-release anglers. For all anglers, they estimated the per-trip welfare benefit for all trips to choice set sites of removing FCGs from all six sites at $9.33 given the unrealistic assumption that all anglers knew of the FCG. In actuality, they found that only 65% of anglers were aware of the advisories. When the model controls for knowledge of the FCG, the per-trip loss declines to $1.91. The corresponding welfare losses conditional upon taking a trip to a FCG site are $19.65 and $6.21, respectively. Finally, when the researchers use just the sample segment that is aware of the FCGs, and control for whether the angler is a consumption or catch-and-release angler, the welfare benefit of removing the FCGs is -$0.32 per trip. This negative welfare benefit can be logically explained. Only 22.5% of the fishers at these reservoirs are strictly consumption anglers. In the presence of the FCG, it is expected that consumption anglers will either keep fewer fish from the FCG site or substitute to non-FCG sites. The result is that the fishing mortality is decreased because of the FCGs at those sites. This decreased mortality leads to an increase in the stock size, and, presumably, a greater catch rate for the catch-and-release anglers. Intuitively, anglers are willing to pay more for a trip in which they will catch many fish. In this situation, with a

very high proportion of catch-and-release anglers, the authors found that the loss to catch-and-release anglers from the elimination of the FCG outweighs the benefit to consumption anglers. Using this model's results, consumption anglers taking a trip to a FCG site experience a loss of $19.05 whereas catch-and-release anglers experience a welfare gain of $7.97. It is not expected that this situation will be frequently found in other locations with a greater percentage of consumption anglers.

A perceived risk approach to modeling recreational site choice, rather than using the standard qualitative method of including the FCG as a dummy site characteristic, was pursued by Jakus and Shaw (2003). The study location is again the eastern region of Tennessee. They constructed the perceived risk variable by examining the number of fish that consumption anglers kept at various reservoirs, and combined this in a two-level nested logit model. They found a mean per-trip welfare improvement for removing all FCGs of $24.78 for all anglers, $44.61 for consumption anglers, and $9.48 for catch-and-release anglers. These estimates are substantially higher than many others reviewed. This difference can be partially explained by the sample used to estimate the model. The most popular reservoir is located very near the population center in this region. This reservoir has FCGs for eight species, while the other five reservoirs in the choice set with FCGs have them for no more than two species. The authors surmise that the imperfection in the travel cost variable may be biasing the parameter estimate for FCG elimination. In essence, they hypothesize that the close proximity of this very popular and FCG-heavy reservoir is not being completely captured in the travel cost variable, and is influencing the FCG parameter. It is not possible to determine the welfare losses conditional upon taking a trip to a FCG site given the reported data.

The fourth Tennessee study focused on the middle region reservoirs and was completed by Parsons, Jakus, and Tomasi (1999). The primary purpose of this study was to examine four different econometric methods of linking site choice random utility maximization (RUM) models with season trips models. As with the other Tennessee studies, their policy scenario to be valued was the removal of FCGs from all sites. The four models produced very similar per-trip welfare estimates for all trips to choice set sites: $2.26, $2.35, $2.26, and $2.34. The corresponding welfare loss estimates conditional upon taking a trip to a FCG site are $27.97, $29.34, $28.79, and $30.67.

Another concentration of study has been freshwater systems of upstate New York and Maine. Montgomery and Needelman (1997) estimate the benefit of eliminating all toxic contaminants from New York State lakes and ponds so that the fish are safe enough to require no toxicity warning. Using a three-step repeated discrete choice model, they estimated that removing contaminants from 23 of 2,561 sites would result in a per-trip welfare increase of $2.50. The welfare loss conditional on taking a trip to a contaminated site is $27.95.

Parsons and Hauber (1998) examined the effect of choice set definition on welfare estimates for removing toxic advisories from Maine lakes and freshwater rivers. They estimated a single RUM model with 17 successively larger choice sets. They found that welfare estimates declined to and then stabilized after all sites within 1.2 hours of the angler's home had been included in the choice set. The mean per-trip welfare increase

with this size choice set is $2.40 and the median is $2.68. The loss conditional upon taking a trip to a location with a toxic advisory in this size choice set is $41.50. The fourteen mean estimates with choice sets larger than 1.2 hours range from $1.51 to $3.46. The range of welfare losses conditional upon taking a trip to a toxic advisory site is $16.94 to $272.14.

Hauber and Parsons (2000) also focused on Maine lakes and freshwater rivers. The primary purpose of this study was to examine the effect of nine different model nesting structures on welfare estimates. The benefit of removing FCGs for all sites within the choice set is consistent, although slightly lower, than that found by Parsons and Hauber (1998). In this study, they estimate the mean per-trip benefit to be $2.00 and the median is $2.04. The minimum is $1.84 and the maximum is $2.19, per-trip for all trips to choice set sites. Parameter estimates are not reported for this study, so it is not possible to derive welfare losses conditional upon taking a trip to a toxic advisory site.

Three studies focus on Great Lakes fishing. The first is the Breffle *et al.* study reviewed previously. In the second, Chen and Cosslett investigated the benefit of improving 14 of 41 sites listed as areas of concern for toxics in Lake Michigan. They estimated a single model of recreation demand using three methods, and found per-trip welfare benefits of $1.44, $6.05, and $6.76 for all trips to choice set sites. The lowest estimate was obtained from a random parameter multinomial probit model, which is not commonly used in the field of valuation economics. The corresponding losses conditional upon taking a trip to a site listed as an area of concern are $39.37, $18.08, and $21.25.

Wisconsin Great Lakes fishing data was used to estimate two models relating to toxic contamination reduction by Herriges, Kling, and Phaneuf (1999). The policy scenario in this study was a 20% reduction in toxin levels, not the removal of all FCGs in the choice set. Using a relatively standard linked site selection-participation model, the authors found per-trip welfare benefits for trips to all choice set sites of $4.79 for toxin reduction. They also employed a more unusual Generalized Leontief model to estimate per-trip welfare benefits of $0.74. It is not possible to derive welfare losses conditional upon taking a trip to a toxin site given the data reported.

The eleventh study reviewed is a form of benefit transfer. Jakus, McGuiness, and Krupnick (2002) estimate the welfare loss attributable to a hypothetical FCG for mercury in striped bass (rockfish) in the Chesapeake Bay. These authors note that Jakus, *et al.* (1997) is the only study in the literature that contains both a welfare estimate for the loss associated with an FCG and an estimate for the total consumer surplus of a recreational fishing trip. Jakus, *et al.* (1997) found that the FCA results in a consumer surplus loss of 7%. Jakus, McGuiness, and Krupnick (2002) apply this 7% reduction to the recreational fishing values estimated by McConnell and Strand (1994) for Chesapeake Bay fishing. The authors estimate that the hypothetical FCG results in a per-trip loss of $2.89. Though this study involves no primary research, it is important for several reasons. First, all other studies reviewed have been applied in freshwater systems. This study combines information from a freshwater FCG study with that of saltwater valuation research to produce a saltwater FCG estimate. Second, the $2.89 per-trip loss for all trips to choice set sites is near the center of the range provided by the other studies reviewed. This

indicates consistency between the per-trip values of fresh and saltwater fishing in the absence of FCGs. It is not possible to determine the loss conditional upon taking a trip to an FCG site from the information provided.

Table A1. Recreational fishing literature review for fish consumption advisory/contamination welfare changes.

Study	Location/ Type	Date of Data Collection	Travel Cost		FCA/Toxin Type	Value Estimate	Per-Trip Loss to All Sites in Choice Set		Per-Trip Loss for Trip to FCG Site (α_1/β)	
			Mileage Cost	Cost of Time			Reported	2007$[A]	Reported	2007$[A]
(1) Jakus, Downing, Bevelhimer, & Fly (1997)	Tennessee Reservoirs	1994	$0.30	Full wage 50 mph travel rate	Mid TN: 2/14 sites w/FCAs for PCBs	Remove FCAs from 2 sites	$1.85	$2.56	$23.97	$33.21
					East TN: 6/14 sites w/FCAs for PCBs	Remove FCAs from 6 sites	$2.86	$3.96	$5.95	$8.24
						Remove FCA from most popular site	$1.59	$2.20	C	C
(2) Jakus, Dadakas, & Fly (1998)	East TN Reservoirs	1997	$0.30	Full wage 50 mph travel rate	6/14 sites w/FCAs for PCBs	Remove 6 FCAs, all anglers	$7.29	$9.33	$15.36	$19.65
						Remove 6 FCAs, only anglers knowing of FCA	$1.49	$1.91	$4.85	$6.21
						Remove 6 FCAs, only anglers knowing of FCA, control for consumption/C&R	($0.25)	($0.32)	$14.89 ($6.23)[B]	$19.05 ($7.97)
(3) Jakus & Shaw (2003)	East TN Reservoirs	Mar 1997–Feb 1999	Not specified	Not specified	6/12 sites w/FCAs for PCBs	Remove 6 FCAs, all anglers	$20.10	$24.78	C	C
						Remove 6 FCAs, consumption anglers	$36.19	$44.61	C	C
						Remove 6 FCAs, C&R anglers	$7.69	$9.48	C	C
(4) Parsons, Jakus, & Tomasi (1999)	Middle TN Reservoirs	1997	$0.30	Full wage 50 mph travel rate	2/14 sites w/FCAs for PCBs	Remove 2 FCAs, HLM Model	$1.77	$2.26	$21.86	$27.97
						Remove 2 FCAs, MRW Model	$1.84	$2.35	$22.97	$29.39
						Remove 2 FCAs, PK Model	$1.77	$2.26	$22.50	$28.79
						Remove 2 FCAs, FHT Model	$1.83	$2.34	$23.97	$30.67

Table A1. Recreational fishing literature review for fish consumption advisory/contamination (continued)

Study	Location/ Type	Date of Data Collection	Travel Cost		FCA/Toxin Type	Value Estimate Reported	Per-Trip Loss to All Sites in Choice Set		Per-Trip Loss for Trip to FCG Site (α_1/β)	
			Mileage Cost	Cost of Time			Reported	2007$[A]	Reported	2007$[A]
(5) Montgomery & Needelman (1997)	NY State Lakes/Ponds	1989	$0.25	Proxy for Full wage	23/2561 sites w/toxic advisories	Remove 23 toxic advisories	$1.51	$2.50	$16.88	$27.95
(6) Parsons & Hauber (1998)	Maine Lakes & Rivers	1989	$0.30	Full wage	Unspecified # of river reaches have toxic advisories	Remove all river toxic advisories; 1 model estimated 17 times w/expanding choice sets	Min: $0.91	$1.51	$10.23	$16.94
							Mean: $1.45	$2.40	$29.10	$48.19
							Med: $1.62	$2.68	$20.84	$34.51
							Max: $2.09	$3.46	$164.33	$272.14
(7) Hauber & Parsons (2000)	Maine Lakes & Rivers	1989	$0.30	Full wage	Unspecified # of river reaches have toxic advisories	Remove all river toxic advisories; 9 different nesting models estimated; same deterministic portion of U(.)	Min: $1.11	$1.84	C	C
							Mean: $1.21	$2.00	C	C
							Med: $1.23	$2.04	C	C
							Max: $1.32	$2.19	C	C
(8) Chen & Cosslett (1998)	Michigan Great Lakes	1983-1984	$0.28	None	14/41 sites are areas of concern (AOCs) for toxics	Remove all AOCs; FPMNL Model	$3.06	$6.05	$9.15	$18.08
						Remove all AOCs; FPMNP Model	$3.42	$6.76	$10.75	$21.25
						Remove all AOCs; RPMNP Model	$0.73	$1.44	$19.92	$39.37
(9) Herriges, Kling, & Phaneuf (1999)	Wisconsin Great Lakes	1990	Not specified	1/3 wage	Unknown # of sites or degree of toxins	Reduce toxin levels by 20%; Linear Model	$3.05	$4.79	C	C
			AAA Rate	45 mph travel rate		Reduce toxin levels by 20%; GL Model	$0.47	$0.74	C	C

Table A1. Recreational fishing literature review for fish consumption advisory/contamination (continued)

Study	Location/ Type	Date of Data Collection	Travel Cost		FCA/Toxin Type	Value Estimate	Per-Trip Loss to All Sites in Choice Set		Per-Trip Loss for Trip to FCG Site (α_1/β)	
			Mileage Cost	Cost of Time			Reported	2007$[A]	Reported	2007$[A]
(10) Breffle, Morey, Rowe, Waldman, & Wytinck (1999)	Waters of Green Bay	1997-1999	Stated Preference-Values Per Trip to Affected Site		PCBs-All waters of Green Bay	FCA 9 – FCA 1	$8.52	$10.73	$21.71	$27.35
						FCA 8 – FCA 1	$7.87	$9.91	$19.78	$24.92
						FCA 7 – FCA 1	$5.92	$7.46	$14.32	$18.04
						FCA 6 – FCA 1	$4.23	$5.33	$9.91	$12.48
						FCA 5 – FCA 1	$4.75	$5.98	$11.22	$14.14
						FCA 4 – FCA 1	$4.17	$5.25	$9.75	$12.28
						FCA 3 – FCA 1	$2.15	$2.71	$4.86	$6.12
						FCA 2 – FCA 1	$0.82	$1.03	$1.81	$2.28
(11) Jakus, McGuiness, & Krupnick (2002)	Chesapeake Bay	No primary research	Apply FCA loss of 7% of total CS to CS estimates of McConnell & Strand (1994)		Hypothetical 1 meal/week FCA for Hg in Rockfish	Loss attributable to one FCA	Mean: $2.42	$2.89	[C]	[C]

[A] Welfare estimates are inflated from the year of data collection (most recent year if collection spanned multiple years) to 2007$ using the U.S. Bureau of Labor Statistics' CPI Inflation Calculator at http://data.bls.gov/cgi-bin/cpicalc.pl. Breffle *et al.* study explicitly report values in 1998$. Jakus, McGuiness, and Krupnick explicitly report values in 2000$.

[B] $14.89 loss for consumption anglers and -$6.32 for catch-and-release anglers (net benefit).

[C] Unable to calculate given the information reported.