CHAPTER 2
BACKGROUND

This chapter provides background data on fishing activity in the assessment area (Section 2.1), an overview of FCAs for the assessment area (Section 2.2), and a summary of literature about how anglers respond to FCAs (Section 2.3) and how much anglers value changes in FCAs and catch rates (Section 2.4).

2.1 RECREATIONAL FISHING IN THE WATERS OF GREEN BAY

The waters of Green Bay are located in northeastern Wisconsin and in the Upper Peninsula of Michigan. The Bay of Green Bay is the largest bay on Lake Michigan and is approximately 190 miles in length extending from the City of Green Bay at the southern tip to the Bays de Noc at the north. Additionally, the waters of Green Bay include all the tributaries leading into the Bay of Green Bay up to their first dam or barrier. Thus, the waters of Green Bay are extensive and support a substantial recreational fishery.

Because of its size, the weather, and the fish available (discussed below), fishing the waters of Green Bay (especially in the Bay of Green Bay) is substantially different from fishing in most inland waters. Further, because the Bay of Green Bay is smaller than and sheltered from Lake Michigan, it also offers a fishing experience that is generally different from fishing in Lake Michigan: fishing the waters of Green Bay is unique.

The Wisconsin Department of Natural Resources (WDNR) conducts a yearly creel survey for open-water fishing in the Wisconsin waters of Green Bay.[1] These data include catch by species, overall effort, and effort by targeted species. The primary purpose of this creel survey is to collect information such as the number of fish caught, the weight and length of the fish, and if the fish was tagged. Information is also collected on what type of fishing (pier, ramp, shore, stream, or ice) occurs; and estimates on how many hours were spent fishing and targeting specific species. The creel survey is supplemented by a mail survey of moored boat owners and a charter boat survey, which provide estimates of fishing hours for these fishing modes. Combined, the creel survey plus the moored and charter boat surveys estimate total fishing effort in hours fished.

1. The open-water creel survey on the bay generally runs from March 15 to October 31, and on the tributaries generally runs from March 1 to May 15 and from September 1 to December 31. All Wisconsin survey data in this chapter were received from Brad Eggold, WDNR Senior Fisheries Biologist, Plymouth Field Station.

The fishing effort data from the WDNR surveys for 1990 through 1998 are shown in Table 2-1, along with fishing effort data from the Michigan Department of Natural Resources (MDNR) creel survey.[2] The Wisconsin data are for the March to December season; the MDNR data are for overall fishing efforts in the Michigan waters of Green Bay for the entire year. The number of hours fishing on both the Wisconsin and Michigan waters of Green Bay has been decreasing in the last few years, but both remain large and important fisheries. The Michigan Green Bay fishery for the entire year averages about 60% the size of the Wisconsin Green Bay open-water fishery from March to December.

The Fox River portion of the Wisconsin waters of Green Bay passes through the City of Green Bay, the region's major city. The WDNR surveys estimate that fishing effort on the Lower Fox River has accounted for about 3% of the open-water fishing in the Wisconsin waters of Green Bay over the last nine years (Table 2-2).

Ice fishing is a significant part of the Wisconsin Green Bay fishery. Table 2-3 shows the ratio of ice-fishing to open-water fishing in the Wisconsin waters of Green Bay from the WDNR surveys, which varies year-to-year depending on the length of the ice-fishing season.

The waters of Green Bay provide a unique mix of target species for recreational fishing. Table 2-4 compares the different fish species as a proportion of total catch for the Wisconsin waters of Green Bay and for Lake Michigan from the 1998 Wisconsin creel survey. Trout and salmon fishing[3] dominates the remainder of the Wisconsin waters of the Lake Michigan fishery, whereas anglers most frequently catch yellow perch on Green Bay and infrequently target and catch perch in Lake Michigan. Walleye and smallmouth bass are important and growing fisheries in Green Bay, while walleye accounted for only 0.1% of the 1998 Lake Michigan catch, and smallmouth bass accounted for 3.1%. Note that these catch statistics do not include the approximately 15% of fishing activity that is from charter boats and moored boats (creel data are not collected for these fishing modes). Therefore, these statistics are viewed as indicative of the percentage of catch and of changes in catch through time.

Historically the yellow perch fishery made up an even greater portion of the catch on Green Bay, but declining fish stocks have both decreased the overall catch in the bay and led to changes in the species that are targeted. Tables 2-5 and 2-6 compare catch and effort breakdowns by species for the 1986 to 1998 angling years. In 1998, only 16% of the hours spent on Green Bay were in the perch fishery, the result of a steady drop in effort starting in 1992. Perch also decreased in its share of the overall total number of fish caught in Green Bay from 94% in 1992 to 73% in

2. All Michigan Creel data in this chapter were received from Gerald Rakoczy, MDNR Fisheries Research Biologist.

3. Throughout this report, we refer to trout and salmon as a group, which includes coho, chinook, and atlantic salmon, as well as rainbow, brown, brook, and lake trout.

Table 2-1
Hours of Fishing Effort on the Michigan and Wisconsin Waters of Green Bay: 1990-1998

	1990	1991	1992	1993	1994	1995	1996	1997[a]	1998	Average 1990-1998[b]
Hours of all fishing effort on the Michigan waters of Green Bay (*all year*)	736,599	948,456	692,284	734,400	609,360	666,976	627,900	452,044	532,829	693,601
Hours of open-water fishing effort on the Wisconsin waters of Green Bay (*March to December*)	1,245,291	1,324,911	1,188,588	1,112,877	1,191,252	1,078,522	972,938	886,873	905,762	1,100,779
Michigan effort as a percentage of Wisconsin open-water fishing effort	59%	72%	58%	66%	51%	62%	65%	51%	59%	61%

a. In 1997 there was no winter (January-March) creel survey conducted in Michigan Green Bay and therefore, the harvest and effort estimates for 1997 are not comparable to prior years that included the winter data. Insufficient data were collected at South Haven and Saugatuck during some months and therefore the estimates may not be reliable or comparable to prior years.
b. Excluding 1997 for the Michigan data.

Source: WDNR creel, and moored and charter boat surveys, 1990-1998. Data provided by Brad Eggold, Senior Fisheries Biologist, Plymouth Station. MDNR, 1985-1998. Data provided by Gerald Rakoczy, MDNR Fisheries Research Biologist.

Table 2-2
Open-Water Fishing Hours on the Fox River from Its Mouth to the Dam at DePere: 1990-1998

Angling Hours	1990	1991	1992	1993	1994	1995	1996	1997	1998	Average 1990-1998
Fox River[a]	23,965	21,870	22,131	34,645	27,412	28,186	50,921	46,291	37,404	32,536
All waters of Green Bay[b]	1,245,291	1,324,911	1,188,588	1,112,877	1,191,252	1,078,522	972,938	886,873	905,762	1,100,779
Fox River as a percent of Green Bay	1.9%	1.7%	1.9%	3.1%	2.3%	2.6%	5.2%	5.2%	4.1%	3.1%

a. These data are available only for the ramp, pier, shore, and stream fisheries, omitting the moored and charter fisheries. Charter fishing is limited to the Marinette and Door county regions of Green Bay and therefore is not part of the Fox River effort, but to the extent that the anglers who moor their boats fish on the Fox River, the Fox River as a percent of Green Bay will be underestimated.
b. These data are for ramp, pier, shore, stream, moored, and charter fisheries.

Source: WDNR creel surveys 1990-1998. Data provided by Brad Eggold, Senior Fisheries Biologist, Plymouth Station.

Table 2-3
Ice-Fishing Hours on the Wisconsin Waters of Green Bay: 1990-1998

	1990	1991	1992	1993	1994	1995	1996	1997	1998	Average 1990-1998
Ice fishing	878,269	834,219	448,610	370,664	278,258	316,660	234,617	169,973	29,108	395,598
Open water	1,245,291	1,324,911	1,188,588	1,112,877	1,191,252	1,078,522	972,938	886,873	905,762	1,100,779
All fishing	2,123,560	2,159,130	1,637,198	1,483,541	1,469,510	1,395,182	1,207,555	1,056,846	934,870	1,496,377
Ice fishing as a percent of all fishing	41%	39%	27%	25%	19%	23%	19%	16%	3%	24%
Ice fishing as a percent of open-water fishing	71%	63%	38%	33%	23%	29%	24%	19%	3%	34%

Source: WDNR creel, charter boat, and moored boat surveys, 1990-1998. Data provided by Brad Eggold, Senior Fisheries Biologist, Plymouth Station.

Table 2-4
Percent of Total Catch by Species for the Wisconsin Waters of Green Bay and Lake Michigan: 1990-1998[a]

	Green Bay	Lake Michigan (excluding Green Bay)
Yellow perch	73.3%	18.5%
Trout/salmon	6.0%	78.1%
Walleye	10.3%	0.1%
Smallmouth bass	4.7%	3.1%
All other species	5.8%	0.2%

a. Measured by number of fish. These data are available only for the ramp, pier, shore, and stream fishing hours. The moored and charter fishing is omitted. Percentages are rounded and may not total 100%.

Source: WDNR creel surveys 1990-1998. Data provided by Brad Eggold, Senior Fisheries Biologist, Plymouth Station.

1998. This drop was not as large as the decrease in effort as perch have much higher catch rates than other species, and while the proportion of effort has increased for other species their catch rates and overall effort have also declined. Again, note that the WDNR statistics provided did not include catch data for the approximately 15% of fishing activity that is from charter boats and moored boats. Estimates of time spent per fish caught, by species, are reported in Section 5.2 under the discussion of "catch times."

Table 2-7 shows the percentage of catch by species for the Michigan waters of Green Bay. In its creel survey the MDNR reports catch only for the four species that dominate the fishery: chinook salmon, brown trout, yellow perch, and walleye.[4] Perch are by far the most frequently caught species in the Michigan waters of Green Bay, but have been declining in both their levels of catch and proportion of overall catch. This trend parallels what has happened in the Wisconsin waters of Green Bay. The MDNR does not collect data on the effort spent targeting specific species, so that comparison cannot be made.

4. From conversations with Gerald Rakoczy, these species account for at least 95% of the catch in the Michigan waters of Green Bay.

Table 2-5
Percent of Open-Water Catch on Wisconsin Waters of Green Bay by Species: 1986-1998[a]

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	Mean 1986-1998
Yellow perch	94%	95%	96%	97%	95%	95%	94%	89%	91%	89%	78%	65%	73%	93%
Trout/salmon	3%	3%	2%	2%	3%	2%	2%	3%	2%	4%	4%	7%	6%	3%
Walleye	2%	1%	2%	0.3%	0.3%	0.3%	1%	3%	3%	2%	3%	11%	10%	2%
Smallmouth bass	0.5%	0.5%	0.6%	0.7%	1%	2%	4%	4%	3%	4%	8%	7%	5%	2%
All other species	0.4%	0.2%	0.1%	0.1%	0.4%	0.4%	0.2%	1%	1%	2%	6%	10%	6%	1%

a. These data are available only for the ramp, pier, shore, and stream fisheries. The moored and charter fishing is omitted. Percentages are rounded and may not total 100%.

Source: WDNR creel surveys 1986-1998. Data provided by Brad Eggold, Senior Fisheries Biologist, Plymouth Station.

Table 2-6
Percent of Targeted Open-Water Angling Hours on Wisconsin Waters of Green Bay by Species: 1986-1998[a]

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	Mean 1986-1998
Yellow perch	55%	63%	55%	58%	64%	66%	61%	48%	49%	49%	35%	19%	16%	49%
Trout/salmon	31%	25%	28%	25%	15%	15%	18%	20%	18%	18%	17%	27%	33%	22%
Walleye	11%	10%	11%	5%	5%	5%	8%	11%	13%	12%	21%	26%	22%	12%
Smallmouth bass	1%	2%	5%	10%	11%	7%	8%	12%	12%	13%	17%	21%	20%	11%
All other species	2%	1%	2%	2%	6%	6%	5%	8%	9%	9%	11%	6%	9%	6%

a. These data are available only for the ramp, pier, shore, and stream fishing hours. The moored and charter fishing is omitted. Percentages are rounded and may not total 100%.

Source: WDNR creel surveys 1986-1998. Data provided by Brad Eggold, Senior Fisheries Biologist, Plymouth Station.

Table 2-7
Percent of Catch on Michigan Waters of Green Bay by Species: 1985-1998

% of Catch	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997[a]	1998	Mean 1985-1998
Yellow perch	95%	94%	91%	90%	85%	89%	92%	94%	69%	75%	62%	82%	48%	80%	82%
Trout/salmon	1%	1%	4%	3%	3%	0%	0%	0%	14%	7%	7%	3%	20%	6%	5%
Walleye	4%	5%	5%	7%	12%	10%	8%	6%	17%	18%	32%	16%	33%	15%	13%

a. In 1997 there was no winter (January-March) creel survey conducted in Michigan Green Bay and therefore, the harvest and effort estimates for 1997 are not comparable to prior years that included the winter data. Insufficient data were collected at South Haven and Saugatuck during some months and therefore the estimates may not be reliable or comparable to prior years. Percentages are rounded and may not total 100%.

Source: MDNR, 1985-1998. Data provided by Gerald Rakoczy, MDNR Fisheries Research Biologist.

2.2 OVERVIEW OF FCAS IN THE ASSESSMENT AREA

PCBs are synthetic substances that were used by the NCR Corporation until 1971 when they were replaced by other emulsion constituents. PCBs continued to be released into the Fox River and accumulated in its sediments for several years until the majority of NCR broke and post-consumer NCR paper had been recycled, some of which migrated downstream and into Green Bay. Fish absorb these PCBs though sediments suspended in the water and through the food they eat. PCBs accumulate in the fat of a fish and are extremely persistent and easily passed through the food chain. As a result, larger, older, or predatory fish, and bottom fish, accumulate higher levels of PCBs in their bodies (Stratus Consulting, 1998).

As a result of PCBs, FCAs for recreational fishing have been in place since 1976 for the Wisconsin waters of Green Bay and Lake Michigan.[5] In this section we summarize the history of FCAs in the waters of Green Bay; for a more extensive discussion, see Stratus Consulting (1998).

Wisconsin

Wisconsin's FCAs for 1997 to 1999 (WDNR, 1997a, 1998b, 1999) explain the health risks from PCB contamination of fish as follows:

> High consumption of PCB-contaminated fish has been linked to slower development and learning disabilities in infants and children born to women who regularly have eaten highly contaminated fish for many years before becoming pregnant. Once eaten, PCBs are stored in body fat for many years. This is true for animals, such as game fish, and humans. Because PCBs are stored in the body for so long, each time you ingest PCBs the total amount of PCB in your body increases. Following the consumption guidelines in this publication can minimize your lifetime build-up of PCBs regardless of your age, sex or physical status.

Further anglers are told:

> Although this advisory is based on reproductive risks rather than cancer, some contaminants do cause cancer in animals. Your risk of cancer from eating contaminated fish cannot be predicted with certainty . . . If you follow this advisory over your lifetime, you will minimize your exposure and reduce whatever cancer risk is associated with those contaminants.

5. Further, because of PCB contamination, the large-scale commercial carp fishery in Green Bay was suspended to interstate commerce in 1975 and closed entirely in 1984 (Kleinert, 1976; Allen et al., 1987).

The Wisconsin FCAs for fish contaminated with PCBs and pesticides are accompanied by advice regarding the preparation of these fish. The preparation advice includes removal of skin and fat, cooking by baking or broiling, and discarding any drippings.

Over time, advice offered in the Wisconsin FCAs has become increasingly specific (Tables 2-8 and 2-9). The initial FCAs were relatively general. Early advisories typically focused on species and simply advised anglers to limit consumption of fish mentioned. As more information about the contamination of sportfish species became available, FCAs were increasingly refined to focus on location, species, and size. Through time the overall level of severity of the advisories have remained generally similar for some species and become more restrictive for other species.

From 1985 through 1996, the Wisconsin FCAs reflected two levels of consumption restrictions. At the more restrictive level, the Wisconsin FCAs advised that some fish, primarily larger fish, as well as fish from locations with higher PCB levels, should not be eaten at all. At the less restrictive level, the Wisconsin FCAs advised that women of childbearing years and children should not eat the fish, and all others should restrict consumption of these fish to one meal a week. Beginning in 1997, the Wisconsin FCAs reflected five levels of consumption advice: (1) unlimited consumption, (2) eat no more than one meal a week, (3) eat no more than one meal a month, (4) eat no more than one meal every two months, and (5) do not eat. While the level of advisory varies for each fish species, overall future changes in FCAs can be expected to generally move in the same direction for all species (e.g., all advisories will remain the same or become less restrictive with changes in PCB contamination and changes in advisory standards).

The 1998 Wisconsin advisories are listed in Table 2-10 (they have remained the same for Green Bay in 1999). Table 2-10 also lists the 1998 Michigan advisories that are discussed below. It is relevant to note that effectively all sport-caught fish in the Wisconsin waters of Green Bay have a PCB advisory. The Lower Fox River advisory levels are more restrictive than those for the remaining waters of Green Bay, reflecting higher concentrations of PCBs in the sediments, water column, and fish.

Michigan

Similar FCAs apply to the Michigan waters of Green Bay. The Michigan FCAs separate the Green Bay waters into three sections: the waters south of Cedar River, the waters in Little Bay de Noc, and the waters between Cedar River and Little Bay de Noc (in this middle region the FCA for Lake Michigan north of Franklin applies; this area includes Big Bay de Noc). The 1988-1997 Michigan advisories for Green Bay south of the Cedar River are shown in Table 2-11 and those for Little Bay de Noc are shown in Table 2-12; they have generally been less restrictive than those issued for PCBs in the Wisconsin waters of Green Bay and more restrictive than the Michigan advisories for Lake Michigan north of Franklin.

Table 2-8
Fish Consumption Advisories for the Wisconsin Waters of Green Bay: 1976-1999

Species	‘76	‘77	‘78	‘79	‘80	‘81	‘82	‘83	‘84	‘84+	‘85	‘85+	‘86	‘87	‘88	‘89	‘90	‘91	‘92	‘93	‘94	‘95*	‘96*	‘97	‘98	‘99
Yellow Perch All										⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	◊	◊	◊
Trout > 20"	⊖	⊖	⊗[a]	⊗[a]	⊗[a]	⊗[a]	⊗[a]	⊗[a]	⊗[a]																	
Lake Trout All											M															
Lake Trout < 20"												⊙	⊙													
Lake Trout <25										⨸																
Lake Trout 20-25"												⊗	⊗													
Lake Trout > 25"										M		M	M													
Brown Trout All										⨸	M	M	M													
Brown Trout < 12"														⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙			
Brown Trout > 12"														M	M	M	M	M	M	M	M	M	M			
Brown Trout < 14"																								❖		
Brown Trout 14"-21"																								◆		
Brown Trout > 21"																								M		
Brown Trout < 17"																									❖	❖
Brown Trout 17-28"																									◆	◆
Brown Trout > 28"																									M	M
Rainbow Trout All										⨸	⨸	⊙	⊙											❖	❖	❖
Rainbow < 22"														⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙			
Rainbow > 22"														M	M	M	M	M	M	M	M	M	M			
Brook Trout All										⨸	⨸															
Brook Trout < 15"														⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙			
Brook Trout > 15"														M	M	M	M	M	M	M	M	M	M			
Salmon > 20"	⊖	⊖	⊗[a]	⊗[a]	⊗[a]	⊗[a]	⊗[a]		⊗[a]																	
Chinook Salmon All										⨸																

Table 2-8 (cont.)
Fish Consumption Advisories for the Wisconsin Waters of Green Bay: 1976-1999

Species	'76	'77	'78	'79	'80	'81	'82	'83	'84	'84+	'85	'85+	'86	'87	'88	'89	'90	'91	'92	'93	'94	'95*	'96*	'97	'98	'99
Chinook Salmon < 25"											⨸			⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙			
Chinook Salmon > 25"											M	⊗	⊗	M	M	M	M	M	M	M	M	M	M			
Chinook Salmon < 29"																								◊		
Chinook Salmon > 29"																								❖		
Chinook Salmon < 30"																									❖	❖
Chinook Salmon > 30"																									◆	◆
Coho Salmon All										⨸		⊙	⊙													
Coho Salmon < 28"											M															
Coho Salmon >28"											⨸															
Smallmouth Bass All										⨸[c]	M	⊗	⊗	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	❖	❖	❖
Walleye All										⨸	⨸															
Walleye < 20"												⊗	⊗	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙			
Walleye > 20"												M	M	M	M	M	M	M	M	M	M	M	M			
Walleye < 17"																								❖	❖	❖
Walleye 17"-26"																								◆	◆	◆
Walleye > 26"																								M	M	M
Bullheads All			⊗[a,b]	⊗[a,c]	⊗[a,c]	⊗[a,d]	⊗[a,d]	⊗[a,d]	⊗[a,d]	⊙	⨸	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙			
Whitefish All				⊗[a,b]	⊗[a,c]	⊗[a,c]	⊗[a,d]	⊗[a,d]	⊗[a,d]															◆	◆	◆
Carp All	⊖	⊖	⊗[a]	⊗[a]	⊗[a]	⊗[a]	⊗[a]	⊗[a]	⊗[a]	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Catfish All			⊗[a,b]	⊗[a,c]	⊗[a,c]							M	M											◆	◆	◆
White Sucker All										⨸		M	M	M	M	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	❖	❖	❖
White Bass All												M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Splake < 16"														⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	❖	❖	❖
Splake > 16"														M	M	M	M	M	M	M	M	M	M			
Splake 16"-20"																								◆	◆	◆
Splake > 20"																								M	M	M
Northern Pike All										⨸	⨸	⊗	⊗													
Northern Pike < 28"														⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙			

Table 2-8 (cont.)
Fish Consumption Advisories for the Wisconsin Waters of Green Bay: 1976-1999

Species	'76	'77	'78	'79	'80	'81	'82	'83	'84	'84+	'85	'85+	'86	'87	'88	'89	'90	'91	'92	'93	'94	'95*	'96*	'97	'98	'99
Northern Pike > 28"														**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**			
Northern Pike < 22"																								◊	◊	◊
Northern Pike > 22"																								❖	❖	❖
Sturgeon All																				**M**	**M**	**M**	**M**	**M**	**M**	**M**
White Perch All																								**M**	◆	◆

⊗ = Limit consumption for general population, no consumption by children aged 6 or under, or by women who are pregnant, nursing, or expect to bear children.
⨸ = No consumption by infants, children, or by women who are pregnant, nursing, or expect to bear children.
⊖ = Limit consumption to 1 meal per week for general population, limit consumption to 1 average size serving per week for pregnant women and children.
⊙ = Remove all fat and skin before cooking, follow cooking and cleaning tips for reducing PCB levels.
◊ = Limit consumption to one meal every week.
❖ = Limit consumption to one meal every month.
◆ = Limit consumption to one meal every two months.
M = No consumption.
+ = This advisory was published in a health guide separate from the fishing regulations pamphlet.
* = Advisories were not reprinted in 1995 and 1996. The 1994 advisory remained in force during these years.
a. Consumption limit for general population is 1 meal (½ pound) per week.
b. Advisory limited to southern Green Bay (south of a line between Pensaukee and Little Sturgeon).
c. Advisory limited to southern Green Bay (south of Peshtigo).
d. Advisory limited to southern Green Bay (south of a line from Pensaukee to Little Sturgeon Bay).

Sources: Stratus Consulting, 1998; WDNR, 1998b, 1999.

Table 2-9
Fish Consumption Advisories for the Lower Fox River between Green Bay and the Dam at DePere

Species	‘76	‘77	‘78	‘79	‘80	‘81	‘82	‘83	‘84	‘84+	‘85	‘85+	‘86	‘87	‘88	‘89	‘90	‘91	‘92	‘93	‘94	‘95	‘96	‘97	‘98	‘99
Yellow Perch All																								❖	❖	❖
Walleye All														**M**	**M**	**M**										
Walleye < 15"																	⊙	⊙	⊙	⊙	⊙	⊙	⊙			
Walleye 15-18"																	⊗	⊗	⊗	⊗	⊗	⊗	⊗			
Walleye > 18"																	**M**	**M**	**M**	**M**	**M**	**M**	**M**			
Walleye < 16"																								❖	❖	❖
Walleye 16"-22"																								◆	◆	◆
Walleye > 22"																								**M**	**M**	**M**
Smallmouth Bass All																								◆	◆	◆
White Sucker All														**M**	**M**	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	◆	◆	◆
Northern Pike All															⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗			
Northern Pike < 25"																								❖	❖	❖
Northern Pike > 25"																								◆	◆	◆
Black Crappie < 9"																								❖	❖	❖
Black Crappie > 9"																								◆	◆	◆
Bluegill All																								❖	❖	❖
Rock Bass All																								❖	❖	❖
White Perch All																										◆
White Bass All														**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**
Carp All														**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**
Catfish All															**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**
Drum All															**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**			

⊗ = Limit consumption for general population, no consumption by children aged 6 or under, or by women who are pregnant, nursing, or expect to bear children.
⊙ = Remove all fat and skin before cooking, follow cooking and cleaning tips for reducing PCB levels.
♢ = Limit consumption to one meal every week. ◆ = Limit consumption to one meal every two months.
❖ = Limit consumption to one meal every month. **M** = No consumption.
+ = This advisory was published in a health guide separate from the fishing regulations pamphlet.

Sources: Stratus Consulting, 1998; WDNR, 1998b, 1999.

Table 2-10
1998 Wisconsin FCAs for Green Bay[a] and Fox River,[b] and Michigan FCAs for Lower Green Bay,[c] Upper Green Bay,[d] and Little Bay de Noc[e]

		Unlimited	One Meal a Week	One Meal a Month	One Meal Every 2 Months	Do Not Eat
Bluegill	WI Fox River			all sizes		
Brown trout	WI Green Bay			< 17"	17-28"	> 28"
	MI Lower Green Bay		GP<18"	WC<14"	WC14-18"	GP WC>18"
	MI Upper Green Bay	GP<22"		WC<22"		GP WC>22"
Burbot	MI Little Bay de Noc	GP	WC<26"	WC>26"		
	MI Lower Green Bay	GP = unlimited	WC<26"	WC>26"		
Carp	WI Fox River					all sizes
	WI Green Bay					all sizes
	MI Lower Green Bay					GP WC
	MI Upper Green Bay					GP WC
Channel catfish	WI Fox River					all sizes
	WI Green Bay					all sizes
	MI Lower Green Bay		GP		WC	
	MI Upper Green Bay					GP WC
Chinook salmon	WI Green Bay			< 30"	> 30"	
	MI Lower Green Bay	GP		WC		
	MI Upper Green Bay	GP		WC		
Lake trout	MI Lower Green Bay	GP<22"	GP>22"	WC<26"	WC>26"	
	MI Upper Green Bay	GP<22"	GP>22"	WC<26"	WC>26"	
Longnose sucker	MI Little Bay de Noc	GP<14"	GP>14"	WC<14"	WC14-18"	WC>18"
Northern pike	WI Fox River			< 25"	> 25"	
	WI Green Bay		< 22"	> 22"		
	MI Lower Green Bay	WC<22"		WC>22"		
Rainbow trout	WI Green Bay			all sizes		
	MI Lower Green Bay	GP		WC		
	MI Upper Green Bay	GP	WC<18"	WC>18"		

Table 2-10 (cont.)
1998 Wisconsin FCAs for Green Bay[a] and Fox River,[b] Michigan FCAs for Lower Green Bay,[c] Upper Green Bay,[d] and Little Bay de Noc[e]

		Unlimited	One Meal a Week	One Meal a Month	One Meal Every 2 Months	Do Not Eat
Smallmouth bass	WI Fox River				all sizes	
	WI Green Bay			all sizes		
	MI Little Bay de Noc	GP		WC		
Walleye	WI Fox River			< 16"	16-22"	> 22"
	WI Green Bay			< 17"	17-26"	> 26"
	MI Lower Green Bay	GP<18"	GP18-26"	WC<18"	WC18-26"	GP >26" WC >26"
	MI Upper Green Bay	GP<22"	GP>22" WC<18"	WC18-26"	WC>26"	
White bass	WI Fox River					all sizes
	WI Green Bay					all sizes
	MI Lower Green Bay					GP WC
Whitefish	WI Green Bay				all sizes	
	MI Lower Green Bay	GP			WC	
	MI Upper Green Bay	GP	WC<18"	WC18-26"	WC>26"	
White sucker	WI Fox River				all sizes	
	Green Bay			all sizes		
	MI Lower Green Bay	GP		WC		
Yellow perch	WI Fox River			all sizes		
	WI Green Bay		all sizes			
	MI Lower Green Bay	GP	WC			
	MI Upper Green Bay	GP	WC			

GP = general population, WC = women and children.
a. Including tributaries up to the first dam or barrier.
b. From mouth up to the dam at DePere.
c. Michigan waters of Green Bay south of the Cedar River.
d. Michigan waters of Green Bay north of the Cedar River (excluding Little Bay de Noc), same advisories as Lake Michigan north of Franklin.
e. Apply to smallmouth bass, burbot, and longnose sucker.

Source: MDNR, 1998.

Table 2-11
State of Michigan Fish Consumption Advisories for Green Bay South of Cedar River (advisory applies to Michigan and Wisconsin waters, including the Menominee River from mouth to first dam): 1988-1997

Species	Size	‘88	‘89	‘90	‘91	‘92	‘93	‘94	‘95	‘96	‘97
Rainbow trout	>22"	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**
Chinook salmon	>25"	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**		
Brown trout	>12"	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**		
	>21"									**M**	
	≤21"									**F**[a]	
	>18"										**M**
	≤18"										**F**[a]
Brook trout	>15"	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	
	14-30"										**M**
Splake	>16"	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**		
	≤16"	**F**[a]	**F**[a]	**F**[a]	**F**[a]	**F**[a]	**F**[a]	**F**[a]	**F**[a]		
	>20"									**M**	
	≤20"									**F**[a]	
	>18"										**M**
	≤18"										**F**[a]
Northern pike	>28"	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	
	≥26"										**M**
Walleye	>20"	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	
Walleye (advisory issued for PCBs and mercury)	≥18"										**M**
White bass	All	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	
	≤22"										**M**
Carp	All	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**
White sucker	All	**M**									
Sturgeon	All						**M**	**M**	**M**	**M**	
	≥30"										**M**
Lake trout	≥22"										**F**[A]
Catfish	All										**M**

M = No consumption.
F = Limit consumption to 1 meal (½ pound) per week.
a. No consumption of listed fish by children aged 15 and under or by women who are pregnant, nursing, or expect to bear children.

Source: Stratus Consulting, 1998.

Table 2-12
State of Michigan Fish Consumption Advisories for Little Bay de Noc (Lake Michigan): 1989-1997

Species	Size	'89	'90	'91	'92	'93	'94	'95	'96	'97
Longnose suckers	>16"		F [a]	F [a]	F [a]	F [a]	F [a]	F [a]	F [a]	
	≥14"									F [a]
Walleye	>22"	F [b,c]	F [b,c]	F [b]	F [b]	F [b,c]	F [b,c]	F [b,c]		

F = Limit consumption to 1 meal (½ pound) per week.
a. No consumption of listed fish by children aged 15 and under or by women who are pregnant, nursing, or expect to bear children.
b. No more than one meal a month of listed fish by children aged 15 and under or by women who are pregnant, nursing, or expect to bear children.
c. Advisory listed for mercury only.

Source: Stratus Consulting, 1998.

Michigan FCAs changed significantly in structure and content in 1998. Different advisories are now given for (1) women who are pregnant, nursing, or expect to bear children and for children, and (2) for the general population; and more restriction levels have been added. The 1998 levels for Michigan are shown in Table 2-11, along with the 1998 Wisconsin advisories for Green Bay for comparison. Generally the advisories issued in 1998 in Michigan are less restrictive than former Michigan advisories and current Wisconsin advisories as they have the same or similar advisories for women and children, but less restrictive advisories for the remainder of the population.

2.3 IMPACTS FROM FCAS

One intent of FCAs is to educate and warn anglers of potential health risks and to encourage changes in behavior, if and as necessary, to reduce potential health risks. The literature on anglers' behavioral response to FCAs repeatedly shows that anglers change their behavior in response to FCAs. Table 2-13 provides a sample of this literature. These behavioral responses range from reductions in trip taking to changes in how fish are prepared and cooked. These behavioral changes represent recreational fishing services that have been lost (damages) to anglers. Even anglers who do not change their behavior may experience a reduction in enjoyment of their fishing experience and thus experience a loss of services (damages).

Table 2-13
Studies of Behavioral Responses by Anglers to Fish Consumption Advisories

Author	Location and Date of Study	Type of Advisory Considered	Reported Behavioral Response
Hutchinson, 1999	Lower Fox River, Wisconsin, 1997	Lower Fox River -Varies by species, levels include no consumption and limited consumption	64% Had made a change, of these: 71% Travel to other locations to fish 65.9% Do not eat the fish they catch 17.7% Change frequency of fish consumption 9.8% Target and catch different species 7.3% Change the size of fish they keep 2.4% Clean or prepare fish in different ways
West et al., 1989	Michigan, 1988	Michigan Great Lakes and inland waters -Varies by species, levels include no consumption and limited consumption	76% Change cleaning methods 73% Change cooking methods 6% Eat less fish from the site 66% Eat different species
West et al., 1993	Michigan, 1991-1992	Michigan Great Lakes and inland waters -Varies by species, levels include no consumption and limited consumption	75% Change cleaning methods 86% Change cooking methods (Great Lakes anglers) 80% Eat different species (Great Lakes anglers) 46% Eat less fish from the site (overall) 27% Change cooking methods (overall)
Fiore et al., 1989	Lake Michigan, Wisconsin, 1985	Fish caught in Lake Michigan and Green Bay -Varies by species, levels include limited consumption and no consumption	57% Report changing fishing habits and/or fish consumption habits
Silverman, 1990	Lake St. Clair, Detroit River, Lake Erie, 1990	All waters of Michigan, including Great Lakes and inland waters -Varies by species, levels include no consumption and limited consumption	10% Take fewer trips 31% Change fishing locations 21% Change targeted species 56% Change cleaning methods 41% Change the size of fish consumed 28% Change cooking methods 56% Eat less fish from the site 31% Eat different species
Knuth et al., 1996	New York portion of Lake Ontario, 1993	Fish caught in Lake Ontario -Varies by species, levels include no consumption and limited consumption	83% Use risk-reducing cleaning methods 42% Use risk-reducing cooking methods 32% Said they would eat more fish in the absence of advisories

Table 2-13 (cont.)
Studies of Behavioral Responses by Anglers to Fish Consumption Advisories

Author	Location and Date of Study	Type of Advisory Considered	Reported Behavioral Response
Knuth et al., 1993	Ohio River, Illinois, Indiana, Ohio, Kentucky, Pennsylvania, West Virginia, 1992	Fish caught in the Ohio River -Advisories vary throughout the different states and species, levels include no consumption and limited consumption	37% Take fewer trips 26% Change fishing locations 26% Change targeted species 22% Change cleaning methods 17% Change the size of fish consumed 13% Change cooking methods 42% Eat less fish from the site 13% No longer eat fish from the site
Connelly et al., 1992	New York, 1992	All waters of New York -Varies by species, levels include no consumption and limited consumption	18% Take fewer trips 45% Change cleaning methods 25% Change the size of fish consumed 21% Change cooking methods 70% Eat less fish from the site 27% Eat different species 17% No longer eat fish from the site
Connelly et al., 1990	New York, 1987-1988	New York inland waters and Lake Ontario -Varies by species, levels include no consumption and limited consumption	17% Take fewer trips 31% Change fishing locations 46% Change cleaning/cooking methods 51% Eat less fish from the site 17% Eat different species 11% No longer eat fish from the site
Vena, 1992	Lake Ontario, New York, 1990-1991	Fish caught on Lake Ontario -Varies by species, levels include limited consumption and no consumption	16% Take fewer trips 30% Change fishing locations 20% Change targeted species 31% Change cleaning methods 53% Eat less fish from the site 16% No longer eat fish from the site

The study results listed in Table 2-13 show that the responses to FCAs vary by location, FCA severity, and species. The literature cited suggests that the presence of FCAs has resulted in changes in the number and/or quality of recreational fishing days taken. These studies show a range of 10% to 71% of the anglers taking fewer trips to the contaminated sites. These trips may be substituted to other sites that would be considered inferior if the site were not contaminated or substituted from fishing to other, less preferred activities. Anglers may be incurring higher travel costs and/or inferior conditions because of the substitution.

Anglers who remain in the fishery are also impacted. The studies cited in Table 2-13 also found that 6% to 70% of anglers eat fewer fish from the site, 27% to 80% changed the species that they eat, 11% to 66% no longer eat any fish from the site, 2% to 83% changed the way they clean the fish, and 13% to 86% changed the way they cook the fish.

Evidence that anglers have substituted fishing days to other fishing sites is also found in a Wisconsin study, which did not ask about behavioral responses to FCAs (Bishop et al., 1994). Anglers who fished inland waters were asked about the relative importance of various factors that played a part in choosing not to fish in the Great Lakes. "PCB and other contamination in the fish" was identified as a "somewhat important" or "very important" factor by 55% of the respondents. No other single factor was cited by a higher proportion of respondents.

The presence of FCAs may also keep potential anglers from fishing at all. For some individuals, Green Bay may be the only site that they would like to fish because of the convenience of its location or other unique attributes. These individuals may return to fishing in the absence of contamination and the resultant FCAs, and therefore have experienced service flow losses.

The Hutchinson (1999) study cited in Table 2-13 looked at the impacts of PCB contamination on subsistence fishing in the Lower Fox River. Personal interviews were conducted with 70 Hmong or Laotion anglers, 25 Anglo-American anglers, and 7 other minority anglers. This study found that anglers from Hmong/Laotion and other minority groups were more likely than Anglo anglers to eat fish from the Lower Fox River (80%, 72%, and 12%, respectively). About 62% of the non-Anglo anglers ate fish from the Lower Fox River once a month or more. At the time of the study all fish had a minimum restriction of "eat no more than once a month" in the Wisconsin FCAs for the Lower Fox River. When asked about how they reacted to FCAs, 79% of Anglo anglers, 64% of Hmong/Laotion anglers, and 17% of other minorities said they had changed their fishing activity in response to the FCAs.

The identified studies indicate that FCAs impact anglers and their fishing enjoyment. Several of the studies include Green Bay in their study area, but most of the studies that include Green Bay do so as part of a larger area. The Hutchinson (1999) study focuses specifically on the Lower Fox River and the mouth of the Bay around the City of Green Bay, but also focuses on a subset of anglers rather than all recreational anglers.

2.4 ECONOMIC VALUES

In 1996 anglers spent over $900 million on recreational fishing in Wisconsin (U.S. DOI, 1998). Anglers clearly value their fishing experiences, but figures about total expenditures do not tell us what they value about specific sites or fishing days. Models of recreational fishing demand are used to determine the values that anglers place on the different characteristics of fishing sites. In this section we summarize results of the recreation demand literature to value changes in catch rates and for the removal of FCAs. We find the existing literature provides a useful perspective on expected values for the waters of Green Bay, but the literature is not adequate to be relied on solely for this damage assessment.

Values for Changes in Catch Rates

Demand for a fishing day is an increasing function of catch rates. All else being equal, an angler would rather catch more fish. Because catch rates are such an important part of the angling experience, many studies have been done that value catch increases and reductions. Table 2-14 lists a sample of studies that value changes in catch rates in Lake Michigan and Green Bay. These studies indicate that values for changes in catch rates are not inconsequential, but there is large variation in the values these studies produce as there is variation in the location of the studies, the population included, and the species studied. Milliman et al. (1992) surveyed Green Bay anglers in a contingent valuation study that valued additional catch and size of sportfish, but did so when the fishery was at its recent best, and the marginal value of another fish would be low compared to current conditions. The values for the Great Lakes trout/salmon fishery from Lyke's (1993) study were derived from a population of Great Lakes trout/salmon anglers, as well as anglers who did not fish the Great Lakes and would be less concerned with its catch rates. Chen et al. (1999) and Samples and Bishop (1985) both valued increases in trout/salmon species outside of our assessment site.

Chen et al. (1999) modeled fishing choices of Michigan anglers for trips targeting Great Lakes trout and salmon. Each site is a Michigan county, and there are 41 counties that support the fishery. Data on 325 trips from 90 individuals are from their 1994 survey. Value estimates for changing the catch rates in Muskegon County by different amounts are reported in Table 2-14. For doubling the catch rate, the value per user day estimates range from $3.42 to $14.23, depending on the model. For tripling the catch rate, values range from $12.62 to $56.03.

No single previous study values the specific assessment area and specifically addresses anglers' values for changes in catch rates for the species of most interest in this fishery. Thus, the current study provides the basis for measuring accurately values for changes in catch rates for the key species of interest, for addressing potential damages from PCB-induced reductions in catch rates, and for addressing restoration benefits of increased catch rates.

Values for FCAs

While there is relatively extensive literature on the valuation of changes in catch rates, there are fewer studies that value changes in the levels of toxins and the resulting FCAs. Some of these studies are summarized in Table 2-15. The values anglers place on cleaner waters and fish are substantial, but vary across site, type of contamination, levels of contamination, shares of trips affected by the FCAs, substitute sites available, and other factors.

Table 2-14
Selected Valuation Studies for Changes on Catch Rates

Authors	Study Location and Year	Modeled Population	Model	Item Valued	Value Estimates[a] (1998 dollars)
Samples and Bishop, 1985	Lake Michigan, 1979	592 residents of 11 Wisconsin counties adjacent to Lake Michigan	Multiple site travel cost model	10% increase in trout and salmon catch rates	$0.67 per trip $15.15 per additional trout/salmon
Milliman et al., 1992	Green Bay, 1983	250 sport anglers who had been contacted on-site	Dichotomous choice contingent valuation model	Hicksian surplus for yellow perch (catch per trip was at historically high level at time of survey, 1983)	$38.38 per trip $0.29 per additional fish $0.44 per additional inch in length of fish
Lyke, 1993	Wisconsin Great Lakes, 1990	274 Great Lakes trout and salmon anglers 239 inland anglers	Nested logit travel cost model	Avoid a 50% reduction Lake Michigan lake trout catch Avoid a 33% reduction Lake Michigan salmon catch Value of trip to Lake Michigan	$0.07 per trip $0.12 per trip $21.80 per trip
Chen et al., 1999	Michigan waters of Great Lakes, 1994	325 trips from 90 Michigan resident anglers	Multinomial logit and probit repeated random utility models	Increase in trout and salmon catch rates	$3.42 to $14.23 per day for doubling the catch rate, $12.62 to $56.03 per day for tripling the catch rate

a. Per trip (per day) values apply to trips to the impacted fishing site.

Table 2-15
Selected Valuation Studies for the Reduction of Toxins at Fishing Sites

Authors	Study Location	Sample Information	Model	Resource Change	Value Estimates (1998 dollars)[a]
Herriges et al., 1999	Wisconsin waters of Great Lakes	240 Great Lakes trout and salmon anglers, and 247 non-Great Lakes anglers (data from Lyke, 1993)	Kuhn Tucker models	20% reduction in contaminant levels in fish	$66.41 to $81.99 per angler per season $9.08 to $11.22 per Great Lakes fishing day
Chen and Cosslett, 1998	Michigan Great Lakes sites	338 one-day salmon fishing trips	Simulated maximum likelihood is used to estimate a random parameter probit model	Remove area of concern designation at all Michigan Great Lakes sites (total of 14)	$1.19 to $5.61 per trip
Lyke, 1993	Wisconsin Great Lakes	274 Great Lakes trout and salmon anglers, and 239 inland anglers	Contingent valuation -Linear logit (LL) -Constant elasticity of substitution (CES)	Eliminate all contaminants that threaten human health in Wisconsin Great Lakes	$47.08 (LL) to $165.54 (CES) per angler per year $3.88 (LL) to $13.61 (CES) per Great Lakes fishing day
Montgomery and Needelman, 1997	New York	266 anglers and 3,013 nonanglers	Repeated discrete choice RUM	Remove toxic contamination at 23 of 2,586 lakes	$1.98 per trip $0.59 per angler day $83.14 per angler season

Table 2-15 (cont.)
Selected Valuation Studies for the Reduction in of Toxins at Fishing Sites

Authors	Study Location	Sample Information	Model	Resource Change	Value Estimates (1998 dollars)[a]
Hauber and Parsons, 1998	Maine lakes and rivers	143 Maine anglers 2,425 freshwater fishing day trips	Nested logit RUM	Clean up all Maine rivers having FCAs	$1.46 to $1.70 per trip
Jakus et al., 1997	Reservoirs in middle and eastern Tennessee	368 anglers fishing Tennessee reservoirs	Repeated discrete choice RUM (for annual), multinomial logit site-choice model (for per-trip)	Remove FCAs from 6 of 14 eastern Tennessee reservoirs — Remove FCAs from 2 of 14 middle Tennessee reservoirs	$3.15 per trip $52.13 per angler per season — $2.03 per trip $24.15 per angler per season
Jakus et al., 1998	Reservoirs in Tennessee	222 anglers fishing Tennessee reservoirs	Multinomial logit site choice model -Valuation considers whether angler knows about advisories	Remove FCAs from 6 of 14 total Tennessee reservoirs	$7.40 per trip (assumes all anglers know about FCA) $1.51 per trip (across all anglers, but assuming those who do not know have zero loss)
Parsons et al., 1999	Reservoirs in middle Tennessee	143 anglers fishing in middle Tennessee reservoirs	Various RUMs	Remove FCAs from 2 of 14 middle Tennessee reservoirs	$1.95 to $2.05 per trip

a. Per trip (and per day) values in this column apply to all trips taken in the modeled region, not just the trips to the contaminated sites. A lower-bound estimate of annual value could be computed by multiplying the per-trip values by the number of trips to all sites modeled, not just the contaminated sites. The values per trip to contaminated sites only would be greater than the per-trip values reported in this table.

Herriges et al. (1999) developed utility-theoretic Kuhn-Tucker recreation demand models and estimated them using Lake Michigan and Green Bay angling data from 487 anglers collected by Lyke (1993).[6] The models are used to value a 20% reduction in toxins at four aggregate Wisconsin sites, which include Green Bay. The models indicate toxins in Lake Michigan significantly reduce the well-being of Wisconsin anglers. Site-specific values are not presented, but the range of values for a 20% reduction in toxins at all four sites is $66.41 to $81.99 per angler per year ($1998). For comparison to the other studies, we divide the annual values in Herriges et al. by the sample average number of Great Lakes fishing days (7.31) to obtain values per Great Lakes fishing day of $9.08 to $11.22. Similarly for Lyke, using her sample average of 12.16 Great Lakes fishing days, the values per Great Lakes fishing days range from $3.88 to $13.61.

Montgomery and Needelman (1997) estimated a repeated discrete choice model of trips to 2,586 possible fishing sites, 23 of which had toxic contamination. These 23 sites include smaller lakes, as well as portions of larger lakes such as Lake Ontario and Lake Champlain. The population used in this study included 266 New York residents who had fished, and 3,013 who had not fished, between mid-April and October 1989. With 2,586 possible fishing sites, but only 23 contaminated, few angler trips were affected; the impact should be less significant than that of Green Bay FCAs on Green Bay anglers. However, even with a small proportion of sites affected (about 1%) and a population sample that was made mostly of nonanglers, Montgomery and Needelman estimated the value of eliminating toxic contamination at all the toxic sites would be $1.98 per trip ($1998), estimated using only data from anglers. Note that these values applied to all fishing trips taken to all sites, not just trips to the affected sites.

Three studies listed in Table 2-15 (Jakus et al., 1997, 1998; Parsons et al., 1999) estimated the value of reducing toxic contamination to the degree that FCAs could be removed from contaminated reservoirs in Tennessee. These studies concentrated on different geographic regions and included both toxic and nontoxic sites. The models developed were all random utility models, and the population was limited to anglers who used the sites. It should be emphasized that the per-trip values from all of these studies were for trips to all sites modeled, including nontoxic sites. These values did not apply only to the trips taken to the toxic sites.

The values estimated for removing FCAs from two toxic sites within a 14-site region were about $2 per trip. As two sites constituted 14% of 14 sites, a rough first approximation of the per-trip value of cleanup for only the affected sites was approximately $14 ($2/0.14). The values for removing FCAs from 6 toxic sites within a 14-site region were $3.15 per trip from a multinomial logit site-choice model, $1.51 in the same type of model but with the assumption that anglers who did not know about FCAs had zero loss, and $7.40 in the same model with the assumption that all

6. Other types of models are also estimated, but those models are not utility theoretic and often give implausible results that are not consistent with expectations. However, all estimated models indicate that toxins reduce the amount and quality of fishing services.

anglers knew about FCAs. The 6-site subset represented 43% of the total number of sites, so a rough first approximation of the losses per trip to the contaminated sites ranged from about $3 to $17 [($1.51 to $7.40)/$0.43]. This study showed significant values for removing FCAs but looked at a fishery that was markedly different from Green Bay. The system of reservoirs offered smaller waters with similar nontoxic substitutes to the few reservoirs that were contaminated.

Chen and Cosslett (1998) used data collected on 338 single-day fishing trips targeting trout or salmon. The choice set included 41 possible sites in the Michigan waters of the Great Lakes. They estimated three models of fishing demand: a varying parameter multinomial probit model, an independent multinomial logit model, and an independent multinomial probit model. They valued the cleanup of toxic contamination at 14 sites in the Great Lakes waters of Michigan sufficient to remove the designation of Area of Concern by the International Joint Commission. The values for this cleanup ranged from $1.19 to $5.61 per trip. Again these values are not directly applicable to Green Bay because it was a multisite study limited to trout and salmon anglers in Michigan, and values applied to all trips taken in the 41-site region. These 41 affected sites accounted for 34% of the sites, implying an approximate value per trip to an affected site of about $3.50 to $16.50 [($1.19 to $5.61)/0.34].

None of these studies provided site-specific estimates for the assessment area, or adequately showed how the value of recreational fishing services vary with the levels of FCAs of relevance to this damage assessment. Most were for multiple sites with similar substitutes and/or limited fish species. These studies all indicated the significance of damages from contamination, but did not provide specific values sufficiently useful to transfer to the damage assessment of Green Bay.