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## **CHAPTER 10**

### **TOTAL RECREATIONAL FISHING DAMAGES AND CONCLUSIONS**

#### **10.1 INTRODUCTION**

This chapter provides the computation of the total value of recreational fishing service flow losses (damages) through time from 1981 until the FCAs are removed, and summarizes key conclusions of the assessment. Section 10.2 discusses the detailed computation of total recreational fishing damages through time. Section 10.3 provides conclusions, including a summary of study design features that indicate the estimated damages are likely to understate the value of recreational fishing service flow losses.

#### **10.2 TOTAL RECREATIONAL FISHING DAMAGES THROUGH TIME**

The present value of all interim losses from 1981 until the FCAs are removed is summarized in Table 10-1. These damages, as well as damages for recreation fishing service flow losses from 1976 through 1980, are discussed below. Table 10-1 also includes 1998 annual damages from Chapter 8, which are not discussed again here. To compute damages for service flow losses in each past and future year, estimated fishing activity for the year is multiplied by an estimate of damages per fishing day for the FCAs in that year.

Damages are computed in 1998 dollars and converted to the present value of damages in 2000. A 3% discount rate is used to escalate past damages and to discount future damages to the year 2000. A 3% discount rate is consistent with the average real three-month Treasury bill rates over the last 15 years (Bureau of Economic Analysis, 1998; Federal Reserve, 1998) and is consistent with U.S. DOI implementation guidance (U.S. DOI, 1995) for NRDA's under 43 CFR §11.84(e).

##### **10.2.1 Damages for Past Losses**

Damages for past losses are computed from 1981, commencing after the enactment of SARA, and continuing through 1999 (damages for past losses from 1976 through 1980 are discussed at the end of this section). In the past, the FCAs have varied considerably in both the Wisconsin and Michigan waters of Green Bay. For example, sometimes the FCAs were the same for all anglers, and sometimes the FCAs were different for women who were pregnant, nursing, or who expected to bear children, and for children, than for the rest of the angling population. Further, the FCAs often varied by the size of a species of fish, with the sizes varying through time, and the FCAs

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**Table 10-1**  
**Total Values for Recreational Fishing Service Losses for the Waters of Green Bay**  
**Resulting from Fish Consumption Advisories for PCBs**  
 (\$ millions, \$1998, present value to 2000)<sup>a,b</sup>

Damage Category	(A) Wisconsin Waters of Green Bay		(B) Michigan Waters of Green Bay	(C) All Waters of Green Bay (A + B)
	Open-Water Fishing	Open-Water plus Ice	All Fishing	All Fishing
	Primary Study	Primary + Transfer	Benefits Transfer	Primary + Transfer
1998 Value of 1998 Losses	\$2.673	\$3.127	\$0.438	\$3.566
1. Present Value of Past Losses:				
a. 1981-1999	\$37.8	\$44.3	\$20.2	\$64.5
b. 1976-1980	\$5.4	\$6.3	\$5.8	\$12.1
2. Present Value of Future Losses <sup>c</sup>				
a. Intensive Remediation <sup>d</sup>	\$30.7	\$36.2	\$5.3	\$41.5
b. Intermediate Remediation <sup>e</sup>	\$43.2	\$51.0	\$7.5	\$58.5
c. No Additional Remediation <sup>f</sup>	\$62.3	\$72.9	\$10.2	\$83.2
3. Present Value of Total Damages from 1981 to Baseline (1a+2)				
a. Intensive Remediation	\$68.5	\$80.5	\$25.5	\$106.0
b. Intermediate Remediation	\$81.0	\$95.3	\$27.7	\$123.0
c. No Additional Remediation	\$100.2	\$117.3	\$30.4	\$147.7

a. Rounded to the nearest \$1,000 for 1998 annual values and to the nearest \$100,000 for present value estimates. Totals may not equal sum of elements due to rounding.

b. Values for Wisconsin open-water fishing include reduced quality of current days plus substitution of days to other sites. Values for Wisconsin ice fishing and Michigan fishing include only reduced quality of current days. See text for additional discussion.

c. Present values computed adjusting for changes in FCAs through time, assuming an average fishing activity at 1998 levels, and a 3% discount rate.

d. 20 years of damages = 10 years sediment removal plus 10 years of declining FCAs.

e. 40 years of damages = 10 years sediment removal plus 30 years of declining FCAs.

f. FCAs decline to zero over 100 years due to natural recovery.

varied across years in terms of which species were included. Generally, our nine FCA levels (Table 5-3) do not match the past FCAs, but can be used to understand how per fishing day damages vary with the severity of FCAs. Recognizing the uncertainties in valuing past FCAs, we select per fishing day damage estimates for each year that are expected to be equal to or less than actual values based on comparing the actual past year FCAs to our nine FCA levels (i.e., they are conservative estimates).

### **Wisconsin Open-Water Fishing**

Damages for past losses for anglers active in open-water fishing in Green Bay are computed using the  $WTP^F$  value method, which includes values for changes in the quality of open-water fishing days in Green Bay, as well as values related to substituting open-water fishing days across sites. Damages for past losses are computed as follows.

1. In 1998, open-water fishing damages are computed as discussed in Section 8.4, and escalated to a 2000 present value.
  2. 1999 open-water fishing damages are set equal to 1998 damages and escalated to 2000 values. This assumes that fishing activity in 1999 is the same as in 1998 (because these data are not yet available) and reflects that the FCAs are largely unchanged.
  3. For all other years, we first estimate the open-water fishing days on Green Bay, then multiply these days by a factor to obtain the total open-water fishing days at all sites by anglers who open-water fish in Green Bay. The estimates of open-water fishing activity on Green Bay for 1986 through 1997 are based on the WDNR creel survey estimates because these are the only available estimates (see Table 2-2 for data back to 1990). The creel survey estimates of hours are divided by the creel survey estimate of approximately four hours per fishing day to obtain the number of open-water fishing days. These data are available back to 1986. We use the average of the WDNR 1986 through 1997 fishing levels as the levels for each year from 1981 to 1985 (even though this long-term average is about 25% less than existed in each of the several years immediately after 1985). Next, the total number of open-water fishing days for each year is estimated to equal the Green Bay open-water fishing days for the year multiplied by 2.512, where 2.512 is the 1998 ratio of total open-water fishing days on Green Bay for anglers who are active in open-water fishing in Green Bay (13.19/5.25).
  4. The Wisconsin FCAs for the waters of Green Bay have changed through time (e.g., see Tables 2-8 and 2-9). In summary, the selected per fishing day values for the FCAs range from \$0.81 to \$2.15 for the period 1981 through 1996, and the value is \$4.17 for the period from 1997 to 1999. The values are less in 1981 through 1996 than in 1997 through 1999, reflecting the increased completeness (more species included) and severity of the more recent advisories. The detailed selection of values follows.
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- A. The 1997 and 1999 advisories are very similar to the 1998 advisories, and we select the Level 4  $WTP^F$  of \$4.17 for all three years.
- B. For 1987 through 1996, the Wisconsin advisories were less restrictive. While the advisories show some variations over time, between the Bay and Lower Fox River, and for some specific species within the trout/salmon group, in general they can be summarized as follows. For yellow perch, smallmouth bass, smaller walleye, and smaller trout/salmon, the FCAs advised the removal of fat and suggested methods of cooking, but did not advise limits on consumption. For larger walleye and trout/salmon, the FCAs advised no consumption. For smaller walleye and trout/salmon, the advisories were similar to our Level 1 of unlimited consumption ( $WTP^F = \$0.00$ ) or our Level 2 ( $WTP^F = \$0.81$ ), reflecting some restrictions on walleye and trout/salmon. For larger walleye and trout/salmon, the advisories are most similar to our Level 7 ( $WTP^F = \$5.92$ ), except that Level 7 includes restrictions for smallmouth bass.

This split advisory by size of trout/salmon and walleye implies that advisory Level 0 or 1 damages apply on days an angler catches, or expects to catch, a smaller trout/salmon or walleye; and advisory Level 7 damages are relevant on days an angler catches, or expects to catch, a larger trout/salmon or walleye. Based on WDNR evidence for 1988 through 1998 on the average size of catch (Table F-7), it appears that, generally, the average size of trout/salmon and walleye measured in the creel surveys is of a size similar to or larger than the advisory cut-off sizes (although this varies by year and species). Thus, advisory Level 7 may apply to roughly 50% of fishing days (sometimes more, sometimes less). To be conservative, and to reflect the inclusion of smallmouth bass in our advisory Level 7, we assume Level 1 damages (\$0.00) apply to two-thirds of fishing days and advisory Level 7 damages (\$5.92) apply to one-third of fishing days, for a weighted average of \$1.97.

- C. For 1985 and 1986, the Wisconsin advisories recommend the removal of fat for perch and smaller trout/salmon, limited consumption for smaller walleye and smaller bass, and no consumption for larger trout/salmon, walleye, and bass. These guidelines are a mix of Levels 1, 2, and 9. We select the Level 3 value of \$2.15 to conservatively reflect this more complicated mix.
  - D. For 1984, the advisories differ for women (focusing on women who are pregnant, nursing, or expect to bear children) and children versus the general population. For women and children, the guidelines are most similar to our Level 7 by stressing the removal of fat for perch and “do not eat” for other species. The general population guidelines advise not to eat larger trout/salmon. We select Level 7 to conservatively reflect the advisories for women and children and Level 2 to reflect the advisories for the general population, for a weighted value of \$1.53 (14% times
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\$5.92 plus 86% times \$0.81; see Section 8.4 “All Fishing in Michigan Waters of Green Bay” for a discussion on weights for values for advisories for women and children versus advisories for the rest of the angler population).

- E. For 1980 through 1983, the FCAs focus on trout/salmon only and recommend no more than one meal a week for the general population, and do not eat for children and for women (who are pregnant, nursing, or expect to bear children). These advisories are similar to but less comprehensive than the 1984 advisories. Therefore, we conservatively select the Level 2 value of \$0.81. Level 2 is the same as the general population advisories, except that Level 2 includes a once a week advisory for walleye. However, Level 2 significantly understates the advisories on trout/salmon for women and children.

### Wisconsin Ice Fishing

Because we do not have estimates of total ice-fishing days at all ice-fishing sites for anglers who ice fish the Wisconsin waters of Green Bay, we conservatively apply  $WTP^G$  values to estimates of ice-fishing days in the Wisconsin waters of Green Bay.

1. 1998 ice-fishing damages are computed as discussed in Section 8.4 ( $WTP^G = \$9.75$  times the number of ice-fishing days, which is set equal to 18.24% of open-water fishing days) and escalated to a 2000 present value.<sup>1</sup>!gcfnote!
2. 1999 ice-fishing damages are set equal to 1998 damages and escalated to a 2000 present value. This assumes that ice-fishing activity in 1999 is the same as in 1998, and reflects that the FCAs are largely unchanged.
3. For all past years, ice-fishing days on Green Bay are estimated as 18.24% of the estimated open-water fishing days on Green Bay. Note that this is potentially very conservative as WDNR data (Table 2-3) suggest that historically this percentage is closer to 34%.
4. For all past years, the FCA value selected is the  $WTP^G$  value corresponding to the  $WTP^F$  value selected for Wisconsin open-water fishing days. The corresponding  $WTP^G$  values are \$9.75 for 1997 through 1999, \$5.94 for 1987 through 1996 and for 1981 through 1983, and \$6.09 for 1984 through 1986.

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1. Based on the telephone survey data, the ratio of ice-fishing days by all Green Bay anglers, including those who did not open-water fish, to open-water days is 18.24%.

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### Michigan Fishing

Damages computed for FCAs in the Michigan waters of Green Bay include both open-water and ice-fishing days. Because we do not have estimates of total fishing days at all sites for anglers who fish the Michigan waters of Green Bay, we conservatively use the  $WTP^G$  values, which are multiplied by estimates of fishing days in the Michigan waters of Green Bay. Damages for past losses are computed as follows.

1. 1998 fishing damages are computed as discussed in Section 8.4 [ $WTP^G = \$2.92$  times 150,103 fishing days on the Michigan waters of Green Bay (which in 1998 equals 58.83% of Wisconsin open-water fishing days on the waters of Green Bay)] and escalated to a 2000 present value.
2. 1999 open-water fishing damages are set equal to 1998 damages and escalated to a 2000 present value. This assumes that fishing activity in 1999 is the same as in 1998, and reflects that the FCAs are largely unchanged.
3. The estimates of fishing activity on the Michigan waters of Green Bay for 1981 through 1997 are based on the ratio of WDNR creel survey estimates to Michigan creel survey estimates for each year (e.g., see Table 2-1 for data back to 1990). The ratio before 1990, for which data were not available, is set equal to the average ratio for 1990-1998 of 61.42%.
4. The Michigan FCAs for the waters of Green Bay have varied considerably through time (e.g., see Tables 2-10, 2-11, and 2-12). The upper and lower Green Bay advisories have tended to be similar, although the upper Green Bay advisories have, for some species in some years, been less stringent, often in terms of the size of fish that triggers an advisory level. For example, in 1998, for walleye larger than 18", the advisory in lower Green Bay is "eat no more than one meal a month" and in upper Green Bay the advisory is "eat no more than one meal a week." We summarize the Michigan advisories focusing on lower Green Bay. Because the advisories for upper Green Bay are less stringent for some species in some years, the values selected are likely to be less conservative than for FCAs in the Wisconsin waters of Green Bay.

In summary, the selected per day values for past years range from \$3.56 to \$4.86, which are larger than the \$2.92 selected for 1998. Compared to 1998, past FCAs were generally more restrictive for women and children by recommending no consumption of any listed species, whereas in 1998 the women and children advisories varied by the size of the fish. The selection of values follows.

- A. The 1988 through 1997 FCAs generally advise no consumption of larger trout/salmon and walleye, generally for all members of the population. We weight
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Level 7 by one-third to reflect the advisory for larger fish for a value of \$4.77 (\$14.32/3). Note this is similar to the Level 3 *WTP<sup>G</sup>* of \$4.86.

- B. The advisories before 1988 focused on trout/salmon only and were separate for the general population and for women (generally for women who are pregnant, nursing, or expect to bear children) and children, with the age of children for whom the advisory is applied varying through time. The general population advisories in 1986 and 1987 suggested no consumption of larger trout/salmon, and consumption of smaller trout/salmon no more than once a week (with the sizes varying by trout/salmon species); in 1980 through 1985, the advisories suggested consumption of any trout/salmon no more than once a week. From 1980 to 1987, the advisories for women and children generally recommended no consumption of trout/salmon. We apply the Level 7 value to women and children, and conservatively apply the Level 2 value for the general population for a weighted average of \$3.56 (14% times \$14.32 plus 86% times \$1.81).

### **Total Damages for Past Service Flow Losses**

Total past damages from 1981 to 1999 are \$64.5 million, with Wisconsin open-water fishing accounting for about 59% of the total, all Wisconsin fishing accounting for 69% of the total, and all Michigan fishing accounting for 31% of the total.

FCAs were first issued in response to PCB contamination in the waters of Green Bay in 1976. To include damages for the period from 1976 to 1980, we assume the computed annual 1981 damages are the same for each year from 1976 to 1980, and escalate the damages to a 2000 present value. These 1976 through 1980 past damages amount to \$6.3 million for all Wisconsin fishing, \$5.8 million for all Michigan fishing, and \$12.1 million in total. The annual estimated damages for 1976 through 1981 in Wisconsin are less than for 1981 through 1999 because of the very limited Wisconsin advisories in 1976 through 1980. Including damages from 1976 to 1980 would increase past damages by about 19%, compared to damages for 1981 through 1999.

### **10.2.2 Damages for Future Service Flow Losses**

Damages for future service flow losses are computed starting in 2000. The duration and levels of the FCAs depend on the level of remediation efforts to address PCB contaminated sediments, which have not been selected. Therefore, pending final selection of remediation efforts, we have identified three potential remediation scenarios to illustrate how the magnitude of damage estimates for projected future recreational service losses may vary with the selected remediation. The estimation of damages for future service losses will be revised and incorporated into the Service's compensable values determination after the U.S. EPA has issued a Record of Decision and the Trustees have selected a preferred restoration alternative.

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The three remediation scenarios reflect the range of options considered in the draft Remedial Investigation/Feasibility Study (RI/FS) (ThermoRetec Consulting, 1999a, b), as well as the October 27, 1997 “Fox River Global Meeting” Goal Statement (FRGS-97) by the Fox River Global Meeting Participants (1997).

1. ***Intensive remediation.*** All FCAs are removed in 20 years. This is modeled as a 10-year PCB removal period, during which time the FCA-caused service losses and accompanying damages per fishing day are assumed to decline linearly at a natural recovery rate (see Scenario 3), followed by a 10-year accelerated recovery period during which time the FCA-caused service losses and accompanying damages per fishing day are assumed to decline linearly to zero. This scenario closely reflects the FRGS-97 goal, and is similar to the RI/FS scenario of PCB removal to a 250 µg/kg minimum concentration level throughout the Lower Fox River (however, the draft RI/FS suggests the potential for removal of FCAs in less than 10 years after the above removal is complete, which would reduce damages).
2. ***Intermediate remediation.*** All FCAs are removed in 40 years. This is modeled as a 10-year PCB removal period, during which time the FCA-caused service losses and accompanying damages per fishing day are assumed to decline linearly at a natural recovery rate (see Scenario 3), followed by a 30-year accelerated recovery period during which time the FCA-caused service losses and accompanying damages per fishing day are assumed to decline linearly to zero. This scenario is similar to the RI/FS scenario of PCB removal to a 250 µg/kg average concentration level throughout the Lower Fox River.
3. ***No additional remediation (no action remedy).*** No significant additional PCB removal occurs and the elimination of FCAs occurs due to natural recovery. We model the natural recovery rate to be a linear decline in FCA-caused service flow losses and damages per fishing day to zero at the end of 100 years. This is a conservative assumption as the draft RI/FS suggests that with no additional remediation, the Wisconsin FCAs may continue with little change for 100 years or more.

For all future years we assume that fishing effort remains constant at 1998 levels for all fishing considered, and the levels are based on estimates in this study, as described in Section 8.4. The assumption of current fishing activity levels into the future may or may not be a conservative assumption as fishing effort in the waters of Green Bay was at a decade lowest level in 1997 and 1998. Fishing effort may or may not remain depressed, most likely depending on the future catch rates, changes in FCAs and other water quality measures, and changes in the population of northeast Wisconsin. This assumption can be revisited and revised after the U.S. EPA selection of a Record of Decision and the Trustees have selected a preferred restoration alternative.

As identified in the scenarios, we assume that damages per fishing day due to FCAs decrease over time in a linear fashion. In the no action Scenario 3, damages per day decrease to zero at a natural

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recovery rate assumed to occur over a 100 year period. In Scenarios 1 and 2, damages per day decrease at the assumed natural recovery rate for the first 10 years during remediation, then decrease at an accelerated, but still linear, rate over the next 10 years (Scenario 1) or 30 years (Scenario 2). This process is the same for each category of damages considered (open water and ice fishing in Wisconsin, and all fishing in Michigan). Again, after the U.S. EPA's selection of a record of decision and the trustees' selection of a preferred restoration alternative, the time path of FCAs can be revisited and damages computed based on the projected time path of FCAs and the values for different FCA levels in Table 8-1.

Estimated damages for future service flow losses range from \$41.5 million (under Scenario 1 with intensive remediation) to \$83.2 million (under Scenario 3 with no additional remediation). The Wisconsin share of the damages for future service losses is about 87% reflecting the more significant fishing activity and more restrictive advisories in the Wisconsin waters of Green Bay.

### **10.2.3 Total Recreational Fishing Damages**

Total damages for past and future recreational fishing service losses range from \$106.0 million under Scenario 1 (intensive remediation) to \$147.7 million under Scenario 3 (no additional remediation). The Wisconsin share ranges from 76% to 79% depending on the scenario. Damages for future recreational fishing service flow losses constitute from 39% of the total if intensive remediation is implemented, up to 56% of the total if no additional remediation is undertaken.

The present value of past and future service flow losses varies with the discount rate. For example, increasing the discount rate to 6% increases the value of past service flow losses but decreases the value of future service flow losses. The value of the total of past and future service flow losses would increase by about 15% under Scenario 1, increase by about 7% under Scenario 2, and decrease by about 6% under Scenario 3. Decreasing the discount rate to 2% decreases the value of past and future service flow losses in Scenario 1 by about 3%, increases the value in Scenario 2 by less than 1%, and increases the value in Scenario 3 by about 9%.

## **10.3 CONCLUSIONS**

The value of recreational fishing service losses in the Wisconsin and Michigan waters of Green Bay from PCB releases into the Lower Fox River have been and continue to be substantial, affecting as many as 350,000 fishing days per year in these waters in recent years (and more in past years), and causing anglers to substitute to other fishing sites or to participate less in fishing. The value of losses in the Wisconsin waters of Green Bay is larger than in the Michigan waters of Green Bay, reflecting the increased recreational fishing days and higher PCB concentrations in the Wisconsin waters.

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The value of recreational fishing losses (damages) estimated here is consistent with the literature on recreational fishing impacts and damages from FCAs. About three-quarters of those anglers who continue to fish the Wisconsin waters of Green Bay report behavioral responses to the FCAs, and other anglers report no longer fishing the waters of Green Bay due to FCAs — all of which are comparable to other studies about FCAs on the Great Lakes. The damages per angler per year from the FCAs (about \$55 for anglers active in Green Bay fishing) are comparable to or even less than values found in the literature (especially when accounting for differences in the scenarios for this study compared to those in the literature). The values for changes in catch rates are also comparable to the literature.

The measured damages per fishing day are robust to multiple variations in model specification. In fact, most of the preselected alternative model specifications provided larger damage estimates.

The estimated damages are expected to be a conservative measure of the total value of lost recreational fishing services; e.g., the damages are understated. The principal factors causing the estimated values to be conservative are presented below and are summarized in Table 10-2. The identified potential percentage impacts on the estimates are indicative, rather than precise, based on available evidence and expert opinion. These factors are not accounted for in the estimated damages, either to be conservative or because of uncertainty about how much adjustment to make.

1. ***Uncertainty in estimates of fishing days in the Wisconsin waters of Green Bay.***  
Damages from 1981 through 1997 are computed based on the WDNR estimates of fishing hours in the Wisconsin waters of Green Bay, which are the only estimates available. Future damages are based on estimates from this study. The 1998 estimates in the current study are for anglers who purchased licenses in eight targeted counties and may account for over 90% of fishing days in the Wisconsin waters of Green Bay (Section 3.5.5), but are about 13% larger than in the WDNR data for 1998 (although it is important to note that the two 1998 estimates are not statistically significantly different).<sup>2</sup> Some of this difference may be attributed to sampling procedures in the WDNR open-water creel survey (e.g., the tributaries are sampled March 1 through May 15 and September 1 through December 31, and omit sampling from May 15 through September 1, which may also explain why the WDNR estimate of the percent of effort on the Lower Fox River for 1998 is lower than found in this study; and the open-water creel study in the bay covers the period March 15 through October 31, omitting early and late season fishing days).

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2. The study estimate is 255,200 with a 95% confidence interval of 224,000 to 287,000. The WDNR does not report days, but they can be approximated by dividing the 905,762 hours by 4 hours/day estimated in the creel survey to equal 226,440 days. The confidence interval on the 905,762 hours is  $\pm 70,000$  hours, and thus the confidence interval of the approximation of days exceeds 209,000 to 244,000 (given the unknown variance on the hours/day estimate).

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**Table 10-2  
Key Omissions and Biases in the Estimated Values  
for Recreational Fishing Losses<sup>a,b</sup>**

Item	Potential Impact on Item Estimates	Potential Impact on Total Damages
1. Estimates of fishing days in the Wisconsin waters of Green Bay	0% to -10% for Wisconsin damages for past losses <i>or</i> 0% to +13% for Wisconsin damages for future losses	-4% to +7%
2. Omission of anglers who do not fish Green Bay but would if PCBs and FCAs did not exist	About -5% for all measures	
3. Omission of nonanglers who would fish if PCBs and FCAs did not exist.	Unknown	
4. Omission of losses from reductions in total fishing days	Unknown	
5. Use of $WTP^G$ , rather than $WTP^F$ , for ice fishing and Michigan fishing	About -7% for Wisconsin ice fishing and for Michigan fishing	About -2% to -3%
6. Omitted losses to Oneida tribal waters	Unknown, but likely to be smaller than the measured damages	
7. Limited subsistence fishing losses	Unknown, but likely to be small relative to measured damages	
8. Understated FCA assumptions	-10% for future years, unknown for past years	
9. Understated past losses due to overstated past catch times	About -16% for damages for past losses	About -7% to -10%
10. Conservative estimate of Wisconsin ice-fishing days	About -80% for Wisconsin ice fishing	About -9%
11. Conservative assumption for national recovery	Up to -6% (Scenario 1) to -40% (Scenario 3) for damages for future losses	Up to -2% (Scenario 1) to -20% (Scenario 3)
12. Omitted health and other potential damages	Unknown	
<p>a. The identified percent of impact on the estimates are indicative measures, rather than precise measures, of the potential impacts based on available evidence and professional judgment.</p> <p>b. Negative percentages indicate potentially understated damages; positive percentages indicate potentially overstated damages.</p>		

If the estimates in the current study are preferred to the WDNR estimates, then past damages may be understated, potentially by about 10%, and total damages may be understated by about 4% to 6% (depending on the remediation scenario). If the WDNR estimates are preferred over using fishing days estimates from this study, future damages may be overstated, potentially on the order of 13%, and total damages overstated by about 5% to 7% (depending on the remediation scenario).

2. ***Omitted service losses to anglers who do not fish Green Bay, but would if PCB contamination and FCAs did not exist.*** About 7.4% of Wisconsin license holders in the telephone survey reported that FCAs were a key reason why they do not fish Green Bay in 1998. If these anglers fished Green Bay, the potential increase in Green Bay anglers would be about 24% (Section 2.4). Even if only a share of these anglers became Green Bay anglers and they fished Green Bay less often than other anglers, the potential omission may be on the order of 5% of the quantified damages.<sup>3</sup> This omission is likely to apply equally to fishing in Michigan waters of Green Bay.
3. ***Omitted service losses to nonanglers who do not fish at all, but would fish if PCB contamination and FCAs did not exist.*** Some individuals, particularly those who live nearby and who would likely fish in the waters of Green Bay in any one year, do not fish at all because of the FCAs. Information on the significance of this omission is not available but because of the size of the nonangling population in any year, it could add several percent to the damages.
4. ***Omitted service losses for reduced total fishing days by Green Bay anglers.*** Our lower bound damage estimates include reduced enjoyment of current days plus losses associated with substituting Green Bay fishing days to other fishing sites that, in the absence of FCAs in the waters of Green Bay, would be less preferred. Damages are omitted for the potential reductions in total fishing because of the FCAs. The magnitude of this omission is unknown. By way of comparison, the estimate of damages associated with substituting fishing days to other sites is about 7% larger compared to estimates that do not allow substitution.
5. ***Use of lower value measure for benefits transfer to ice fishing and fishing in Michigan waters of Green Bays.*** These benefits transfers use the lower value measure,  $WTP^G$ , (Section 8.4), which can be expected to produce damage estimates about 5-10% lower than when using the more comprehensive  $WTP^F$  value measure because the  $WTP^G$  measure does not allow anglers to increase Green Bay days by substituting from other fishing sites (this difference was about 7% for open-water fishing and we assume a similar

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3. For example, in the absence of FCAs assume 25% to 50% anglers become active in Green Bay fishing, and they fish half as often as the average. Then, a 24% potential increase in anglers times (0.25-0.50) actual participation rate times 0.5 activity rate = 3% to 6%.

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difference is likely for ice fishing and fishing in Michigan waters). Given that ice fishing in Wisconsin waters of Green Bay plus all fishing in Michigan waters of Green Bay account for about 33% of total damages, this may result in a reduction in total damages on the order of 2% to 3%.

6. ***Omitted damages to Oneida tribal waters.*** Recreational fishing by Oneida Nation tribal members on Oneida tribal waters within the Wisconsin waters of Green Bay (portions of Duck Creek and other tributaries) does not require Wisconsin fishing licenses. These damages have not been fully measured, if measured at all. The magnitude of this omission is unknown. While these omitted service losses and damages are likely to be significant to the Oneida Nation because of the cultural significance of the fishing, they are likely to be smaller than the quantified recreational fishing damages in this report given the relative size of impacted fishable waters on reservation lands compared to the total Wisconsin waters of Green Bay and given the relative size of the angler populations in the general population and in the Oneida Nation.
  
7. ***Limited or omitted subsistence fishing service flow losses.*** While some subsistence anglers may have participated in this study, because of language barriers it is likely that subsistence fishing damages are not well represented in this assessment. Hutchison (1999) addresses the existence and significance of subsistence fishing impacts, but does not quantify damages. While these service flow losses are important to consider, mitigate, and compensate, their omission is likely to be relatively small (in dollars of damage) compared to the quantified recreational fishing damages.
  
8. ***Understated FCA assumptions.*** Throughout the damage assessment, we conservatively selected the FCA levels in the waters of Green Bay. For example, for the damages from 1998 service flow losses, the per fishing day damage in Wisconsin waters of Green Bay of \$9.75 is based on FCA Level 4 in our analysis (Table 5-3), which understates the FCA levels for *every one* of the four focus species.<sup>4</sup>!gcfnote! This omission could understate Wisconsin damages by at least 10% and potentially significantly more.<sup>5</sup>!gcfnote! This understatement is carried forward into the computation of damages for future year losses.

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4. For perch, the assumed “once a week” level understates the advisory level for the Lower Fox River. For trout/salmon, the assumed “once a month” level understates the restrictions for larger salmon and large brown trout. For walleye, the assumed “once a month” only holds for smaller walleye, and understates the restriction for medium and larger walleye (large walleye should not be eaten at all). For smallmouth bass, the assumed “once a month” level understates the advisory for the Lower Fox River.

5. For example, in Table 8-1 comparing Levels 6 and 7, only the walleye advisory becomes more restrictive (from “eat no more than one meal per month” to “do not eat” (as applies to large walleye) and values increase by about 40%. Comparing Levels 8 and 9, perch and smallmouth bass advisories increase from assumed to the actual levels applicable to the Lower Fox River and damages increase by about 8 to 10%.

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For damages for past losses we make similar conservative assumptions about the applicable FCA levels to select damages per fishing day from our available estimates in Table 8-1, but the degree of understatement in past damages is more difficult to assess and remains unknown.

9. ***Understated damages for past losses due to overstated past catch times.*** The value of service losses due to FCAs increases as catch times (how long it takes to catch a fish) decrease.<sup>6</sup> Our per fishing day values are based on 1998 catch time, which were much higher than the average catch times in the past. If the 13-year average catch times were used, damages for past losses would be as much as 16% larger (Section 8.2). Since damages for past losses account for on the order of 44% to 60% of the total damages under the alternative remediation scenarios, this omission could result in total damages understated by as much as 7% to 10%.
  
10. ***Conservative ice-fishing computation.*** The ratio of ice-fishing days to open-water fishing days in the Wisconsin waters of Green Bay is held constant at 18.24% (measured in our survey data), even though the past average is closer to 34%. Thus, actual ice-fishing damages may average up to 86% more than measured ice-fishing damages, and thus total damages may be conservative by about 9%.<sup>7</sup>
  
11. ***Conservative natural recovery for damages for future service flow losses.*** The future scenarios assume natural recovery over a 100-year period. The draft RI/FS suggests that with no additional remediation there may be little or no change in the FCAs. If the assumption of no change in FCAs over a 100-year period were used in the computations, damages for future service flow losses would increase by about 6% to 8% for Scenarios 1 and 2, and by more than 40% for Scenario 3. Total damages would increase by about 3% to 4% for Scenarios 1 and 2, and by more than 20% for Scenario 3.
  
12. ***Omitted health damages.*** The estimated damages do not include the value of health impacts from eating contaminated fish. This may be particularly relevant where past FCAs were less restrictive than in 1998. This is because past PCB levels in the sediments (and thus in fish) were comparable to current PCB levels, and past FCAs, under current scientific standards may have understated the health risks, leading to over consumption of PCB-contaminated fish.

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6. As an angler catches more fish, the advisories can be expected to be more bothersome as the angler may not be able to eat the increased catch of fish as often as he would like. If the angler catches less fish, some advisories become less restrictive because the angler may not catch enough fish to eat meals of fish very often.

7. Even if the WDNR past estimates were used for each past year, and the average from the past used in the future, rather than using our survey estimates for ice-fishing hours, the 1998 and 1999 damages would decrease slightly, but total damages for past ice fishing would still increase by over 80%, and total damages would increase by nearly 9%.

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13. ***Omission of other potential damages.*** Additional potential injuries, for which damages have not been quantified, include impacts of PCBs on fishery populations in the waters of Green Bay, which may reduce recreational fishing catch; and PCBs from the Lower Fox River entering Lake Michigan and contributing to loadings causing FCAs and/or health risks from consuming fish, and potential fishery injuries.