

1 Article

# 2 Improving the Conscious Consumption of Fish 3 Through an Educational Campaign on the Detroit 4 River (Michigan, USA)

5 Corey A. Krabbenhoff<sup>1</sup>, Susan Manente<sup>2</sup> and Donna R. Kashian<sup>1,\*</sup>

6 <sup>1</sup> Wayne State University; ckrab@wayne.edu

7 <sup>2</sup> Michigan Department of Health and Human Services; ManenteS@michigan.gov

8 \* Correspondence: dkashian@wayne.edu; Tel.: +1-313-577-8052

9

10 **Abstract:** Consumption guidelines are a common way to improve conscious consumption behaviors  
11 in areas where game fish are known to contain contaminants. However, guideline information can  
12 be difficult to distribute, and effectiveness difficult to measure. To increase the distribution and  
13 effectiveness of guideline information for the Detroit River, an educational campaign was launched  
14 in 2010, which included distribution of pamphlets with consumption information, posting of  
15 permanent signs at popular fishing locations, and hiring River Walkers to personally communicate  
16 with anglers. In 2013 and 2015, we conducted in-person surveys of active shoreline anglers to  
17 determine the effectiveness of education and outreach efforts. Results from the survey indicated  
18 that 55% of anglers were aware of the guidelines in 2013, and by 2015 36% had communicated the  
19 information to family or friends. However, anglers were often unwilling to reduce consumption of  
20 popular game species, despite high contaminant levels. Encouragingly, black anglers were most  
21 likely to supplement their diet with species lower in contaminants. Our results suggest that utilizing  
22 multiple educational strategies including reaching out directly to individual anglers may improve  
23 conscious consumption behavior among the targeted population, providing a template for  
24 educational campaigns to successfully target vulnerable populations.

25 **Keywords:** fish consumption; subsistence fishing; Detroit River; surveys; contamination;  
26 consumption advisories; environmental justice; mercury; PCBs; dioxins

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## 28 1. Introduction

29 While fish can be an important source of daily protein, omega-3 fatty acids, and other essential  
30 nutrients, fish may also contain contaminants which are detrimental to human health [1], particularly  
31 in self-caught fish from urban areas with a history of chemical contamination. Considerable effort has  
32 been extended to inform the public of the benefits and risks of fish consumption at local, state and  
33 international (U.S. and Canada) levels. Fish consumption advisories or guidelines are designed to  
34 provide citizens with information on fish from local waters that are lower in chemical contamination  
35 and are therefore safe meal choices relative to those that are high in contamination. However,  
36 advisories typically contain complicated information which is difficult to convey without  
37 indiscriminately discouraging fish consumption. Many populations can benefit from fish as a low-  
38 cost, readily available addition to their diet; avoidance of fish altogether reduces nutritional  
39 opportunities from fish low in contaminants, a problematic potential outcome [2].

40 Research suggests that to achieve a change in behavior, educational approaches need to be  
41 tailored to the particular population and problem and involve direct contact with anglers to be  
42 effective [3-5]. The efficacy of advisory programs has been variable and difficult to measure [6].  
43 Criticisms of advisory campaigns suggest that information does not often reach diverse groups of  
44 people, or even those groups who may be the most impacted by fish contamination. In particular,  
45 previous research has shown that advisory information typically does not effectively reach

46 minorities, women, people with low levels of educational attainment [7], or immigrant communities  
 47 [8]. Further, while progress has been made on assessing the impact of advisories, many of these  
 48 studies primarily include anglers who are white and have moderate income and educational  
 49 backgrounds [9]. This problem is especially significant in distressed urban environments where  
 50 anglers are more likely to engage in subsistence fishing due to high poverty rates. Studies have also  
 51 shown that a higher proportion of those who catch species high in contaminants, keep them, and  
 52 share them with family and friends are people of color [10,11]. Frequent consumption of fish with  
 53 high levels of contaminants can contribute to adverse health conditions especially for fetuses,  
 54 children, and adults with existing chronic health issues such as heart, thyroid or immune diseases  
 55 [12].

56 Residents of Detroit, Michigan commonly supplement their food supply with locally caught fish,  
 57 which are available at low to no cost [13]. These subsistence anglers are primarily low-income,  
 58 minority individuals [10] who regularly fish for white bass (*Morone chrysops*) and walleye (*Sander*  
 59 *vitreus*), which are two of the more contaminated species in this area. As of the 2010 U.S. Census [14],  
 60 a third of Detroit residents live in poverty (more than twice the state average) and the median  
 61 household income (\$29,447) was 60% below the state median. Additionally, Detroit had a 20%  
 62 unemployment rate. Unfortunately, this suggests that the populations with the highest reliance on  
 63 fish from the Detroit River as a food source are also those groups most difficult to target for  
 64 educational and outreach efforts.

**Eat Safe Fish from the Detroit River**

Babies, children, or people with health conditions, such as cancer and diabetes, can be harmed by the chemicals in fish. Look below to choose fish that are better to eat.

**Choose Wisely, Eat Healthy**

Yellow Perch, Crappie, Bullhead, Northern Pike, Largemouth (Green) Bass, Sucker, White (Silver) Bass, Carp

Panfish have less chemicals. Predator and bottom-feeding fish have more chemicals.

Bluegill, Rock Bass, Walleye, Smallmouth (Brown) Bass, White Perch, Freshwater Drum (Sheepshead), Catfish

Check the Eat Safe Fish Guide to find fish that are safe for you and your family to eat.

**The 3Cs to Eating Fish**

- 1. Choose** fish that are lower in chemicals.
- 2. Clean** away the fat, skin, and organs and throw them away.
  - Cut away the fat along the back.
  - Cut away the fatty area along the side.
  - Cut away the belly fat.
- 3. Cook** fish on a grill or rack so fat can drip away. Don't re-use oil used for frying fish.

**Chemicals in the Food Chain**

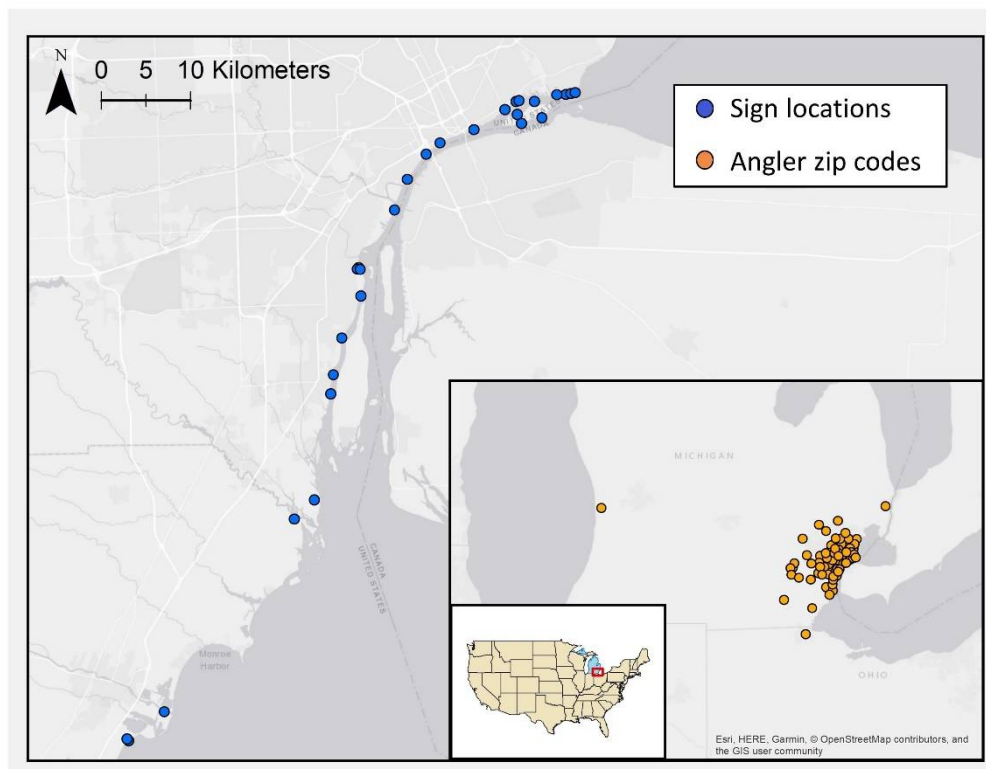
Have questions? Want a free *Eat Safe Fish Guide*? Visit [www.michigan.gov/eatsafe/fish](http://www.michigan.gov/eatsafe/fish) or call the Michigan Department of Health and Human Services at 1-800-648-6942.

MDHHS, DETROIT RIVER RESTORATION, Sea Grant, CIVIL LABS RESTORATION, Wayne County, IPH, WAYNE STATE UNIVERSITY

65

66 **Figure 1.** The Eat Safe Fish advisory sign posted initially in 2010 at 28 popular fishing locations  
 67 along the Detroit River. This updated version was posted in 2015.

68 Due to possible environmental justice concerns associated with fish contaminant levels on the  
 69 Detroit River, an intensive educational campaign was launched in 2010 to provide fish consumption  
 70 guideline information in a targeted way to those individuals who were most susceptible, and thus  
 71 most likely to benefit from the information. As part of this program, multiple outreach methods were  
 72 utilized in an attempt to have the largest impact on the shoreline angler population.



73 **Figure 2.** Map of study location. Blue points indicate locations where 45 signs were posted (some  
 74 locations had multiple signs). Orange points in inset map indicate home zip codes for anglers  
 75 surveyed.

76 The first method was to have a permanent educational presence at fishing locations, through the  
 77 installation of signs containing consumption guideline information (Figure 1) along the Detroit River  
 78 in 2010 (and updated in 2015) at 28 locations known to be popular shore-fishing access points (Figure  
 79 2). Signs were designed in collaboration with the Michigan Department of Health and Human  
 80 Services, community focus groups, and communication experts from Wayne State University, to  
 81 provide information on contaminant levels in the various fish species in the Detroit River and provide  
 82 guidance on the safest consumption practices. Local community focus groups were involved in  
 83 evaluating both the signs and pamphlets during the design phase of these materials.

84 A second outreach method was designed to confront deep cultural preferences and people's own  
 85 interpretation of risk which often hinder behavioral change. Social norms and community practices  
 86 may intercede between effective interventions and adequate uptake into daily life [15]. To overcome  
 87 this challenge in information distribution, two to three Detroit residents were hired as River Walkers,  
 88 beginning in 2012 and continuing through 2016 who assisted outreach efforts. By visiting shore-  
 89 fishing sites and directly communicating with active anglers, River Walkers provided information on  
 90 eating locally caught fish and offered hard copies of educational materials (a third outreach method).  
 91 River Walkers were able to distribute materials including 1) an "Eat Safe Fish in the Detroit Area"  
 92 pamphlet, 2) Eat Safe Fish Guidelines educational pamphlet 3) a "Hooked on Fish from the Great  
 93 Lakes" cookbook, 4) a fishing crossword puzzle and word search for children, and 5) temporary  
 94 tattoos. This personal interaction with an informed, local individual provided an easy way for anglers

95 to express concerns or get answers to their questions. It also provided a face to the consumption  
96 guideline campaign.

97  
98 The overall objective of this study was to assess the progress, strengths, and weaknesses of an  
99 educational outreach program designed to improve conscious consumption practices of fish from the  
100 Detroit River. Specifically, this study evaluated the overall awareness of fish consumption guidelines  
101 among anglers, their knowledge of what the guidelines contained, which methods were most  
102 effective in implementing changes in behavior, and potential environmental justice issues associated  
103 with either contamination exposure or the consumption guideline campaign itself.

## 104 2. Materials and Methods

### 105 2.1 Study Location

106 The Detroit River is a narrow, 45 km long strait connecting Lake St. Clair and Lake Erie and  
107 forms part of the border between Canada and the United States. The cities of Detroit, Michigan and  
108 Windsor, Ontario lie along the flow path of the river. The river is an important shipping route in the  
109 Great Lakes and has long been utilized as a fishing location, particularly for subsistence anglers.  
110 Shore fishing on the Detroit River accounted for nearly a million angler-hours when it was measured  
111 in the 1980s [16]. In a 2002 creel census Thomas and Towns [17] estimated that 40% of all Great Lakes  
112 fishing occurs in only 1% of Michigan's Great Lakes waters, specifically the St. Clair System which  
113 includes the Detroit River, Lake St. Clair and the St. Clair River. The Detroit River was the primary  
114 location for consumption guideline awareness efforts and angler surveys in this study (Figure 2).

115 Contamination of fish in the Detroit River has a long history [18]. A large concern for local  
116 anglers are the levels of polychlorinated biphenyls (PCBs), mercury, and dioxins [19]. Some species  
117 of fish from the Detroit River contain high levels of contaminants and should not be eaten in any  
118 amount (catfish, carp), and others have consumption restrictions but can be eaten occasionally (rock  
119 bass, perch, etc.). Depending on location, fish can sometimes be safely consumed without concern for  
120 contaminants, but no species from the Detroit River fall into this category.

### 121 2.2 Surveys

122 Face-to-face angler surveys were conducted from May to September 2013 and May to August  
123 2015, four and six years after the initial educational programs were implemented. Of the 28 areas  
124 where fish consumption signs had been posted, surveys were conducted at 12 locations in 2013 and  
125 17 locations in 2015 (though most sites were visited multiple times). People who were actively fishing  
126 were approached and asked to participate in a survey about their knowledge of fish consumption  
127 guidelines and their fishing activity. Participants were informed of the purpose of the survey and  
128 provided the opportunity to ask questions prior to consenting to participate; questions were welcome  
129 through the duration of the survey. No compensation was given for participation, but supplemental  
130 guideline materials were provided for those participants who were interested in further information.  
131 The survey was conducted verbally and took approximately ten minutes to complete.

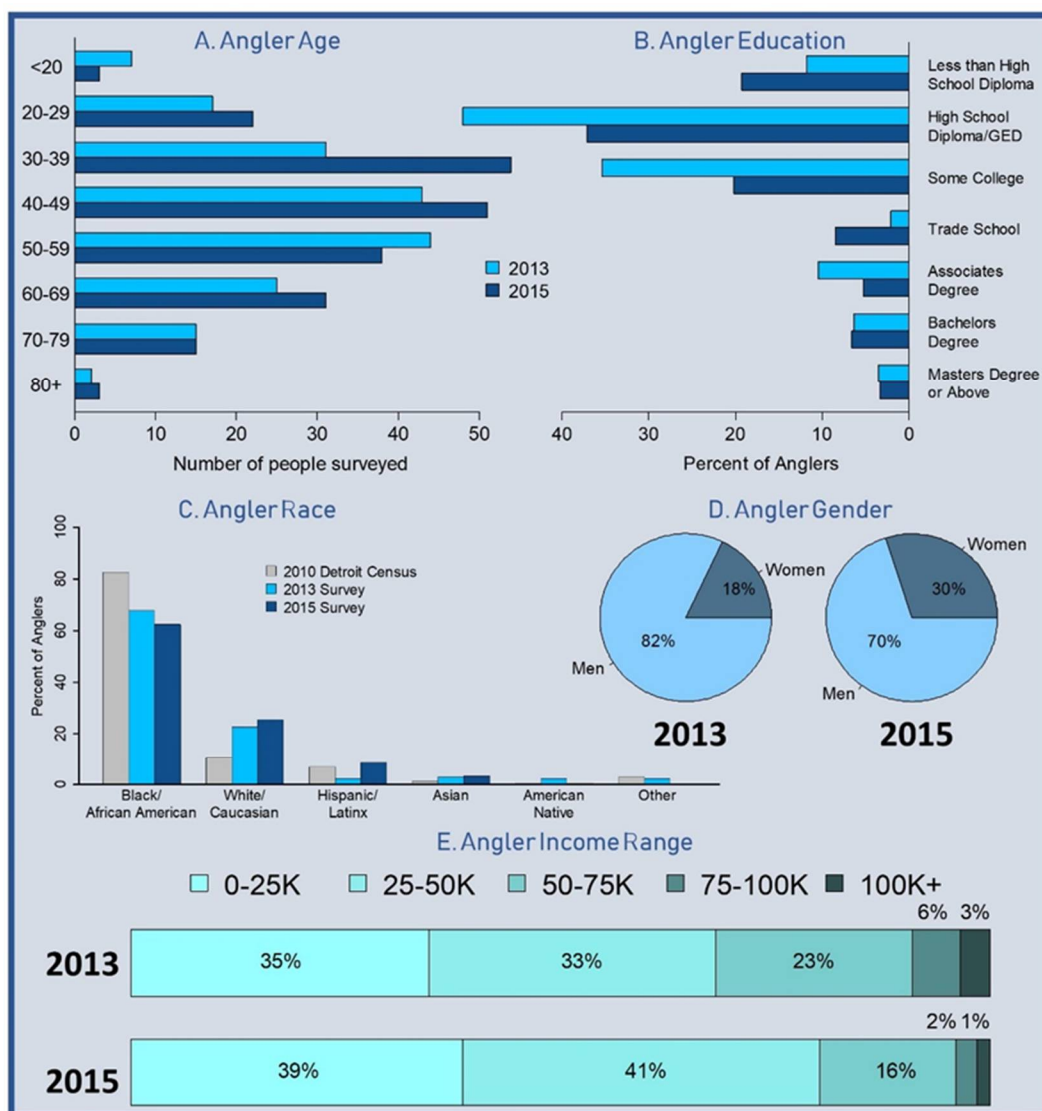
132 Survey questions were designed to evaluate the state of knowledge of the guidelines among  
133 anglers and the effectiveness of the 1) signs produced by the State of Michigan, 2) River Walkers, and  
134 3) the Eat Safe Fish educational pamphlet. Incorporation of multiple educational methods was an  
135 important part of this study because of the diversity of anglers in the study area. Fishing behaviors  
136 of each angler and demographic questions were asked to allow for an evaluation of potential  
137 environmental justice issues surrounding fish consumption advisories on the Detroit River [10].  
138 Specifically, anglers were asked about their awareness of river contaminants and the Eat Safe Fish  
139 Guidelines, how s/he learned of that information, which material/s s/he found to be most helpful, or  
140 whether the information had led to any behavioral change on her/his part (e.g., the fish species  
141 consumed, the cooking methods, etc.). No names or otherwise identifying information were collected  
142 from the angler.

## 143 2.3 Data Analysis

144 Surveys were analyzed for general information and for between year differences. Comparisons  
 145 of answers from 2013 to 2015 were analyzed using Chi-square ( $X^2$ ) goodness of fit tests. Contingency  
 146 tables of survey responses and demographic information were assessed for correlation using Fisher's  
 147 Exact Tests for categorical data that included low numbers for some responses (e.g., income range)  
 148 and Yates' chi-squared tests for those that had more equal distributions among response variables  
 149 (e.g., gender). For continuous data (e.g., number of meals consumed per week), Kruskal-Wallis tests  
 150 were used to determine difference between years and simple logistic regressions were used to  
 151 determine correlation with demographic variables. Diversity of fish species consumed was calculated  
 152 using Shannon's Diversity Index [20]. Difference in the timing of surveys between years was assessed  
 153 using the Mann-Whitney-Wilcoxon test for non-normal distributions with unequal variances on the  
 154 Julian dates for surveys from each year.

155 All data analysis was done using the statistical software R [21]. The add-on package MASS [22]  
 156 was used to complete chi-squared tests.

## 157 3. Results



158 **Figure 3.** Demographics of survey participants in 2013 and 2015. (A) Angler age ranges (by  
 159 decade); (B) angler educational attainment; (C) angler racial identity; (D) angler gender identity; and  
 160 (E) angler household income range (in increments of \$25,000). U.S. census data combines

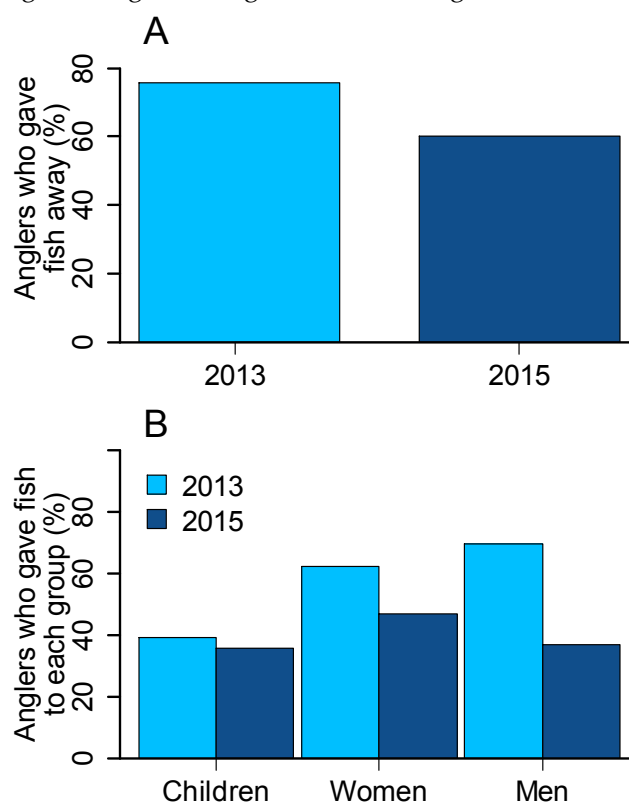
161 'White/Caucasian' and 'Arab/Middle Eastern' into a single category; our data was similarly combined  
162 for comparison. 'Asian' includes the Far East, southeastern Asia, and India. 'American Native'  
163 includes first peoples of North America including Alaska Natives and native Pacific Islanders.

164 A total of 431 shoreline anglers were surveyed (200 in 2013 and 231 in 2015). The anglers  
165 represented 87 of 1160 Michigan zip codes and one Ohio zip code, most of which are located within  
166 25 km of the Detroit River (Figure 2). For each year, the majority of the survey participants self-  
167 identified as African American/Black (68% in 2013; 62% in 2015), with smaller proportions identifying  
168 as White/Caucasian, Asian/Pacific Islander, Arab/Middle Eastern, Hispanic/Latinx, American Indian  
169 or Alaskan native, or other (Figure 3C). Most of the anglers surveyed were male (82% in 2013; 70% in  
170 2015), though an increase in female anglers from 18% in 2013 to 30% in 2015 was observed (Figure  
171 3D). Anglers ranged in age from 18 to 85, with the largest proportion of anglers being in their 50s in  
172 2013, and their 30s in 2015 (Figure 3A). In 2013, 34% of the surveyed anglers reported an annual  
173 household income less than \$25,000 with 34% reporting a household income in the range of \$25,000-  
174 49,999 and 32% reporting a household income higher than \$50,000 (Figure 3E). Income ranges were  
175 similar in 2015 with 39% reporting an income less than \$25,000, 42% reporting a household income  
176 between \$25,000-\$49,000, and 20% reporting an income greater than \$50,000 (Figure 3E). In 2013, 10%  
177 of anglers had less than a high school diploma, while 43% of anglers had received a high school  
178 diploma or GED, and 48% had at least some college or post-high school education (Figure 3B).  
179 Similarly, in 2015, 19% had less than a high school diploma, 37% had a high school diploma or GED,  
180 and 44% of anglers had at least some post-high school education (Figure 3B).

### 181 3.1 Fish Consumption

182 Most anglers surveyed (77% in 2013 and 68% in 2015) reported that fish are at least somewhat  
183 important in their diets. In both survey years, anglers reported consuming the most fish in the  
184 summer and spring seasons, which coincide with typical spawning runs of most species. During this  
185 time, anglers were observed in the greatest numbers along the shoreline. The number of meals per  
186 week consumed was much higher in 2015 than 2013 ( $P < 0.001$ ;  $X^2 = 146.78$ ). However, this difference  
187 may be due to the addition of serving size estimates included in the 2015 survey. Because a 'serving  
188 size' may be different among individuals, the 2015 survey included a definition of 'serving size' as  
189 being approximately the size of one's hand. This would increase the total number of servings  
190 reported if those servings were generally multiple hand-sized portions, which were reported as a  
191 single serving in the 2013 survey. Our data shows that the mean number of servings, as defined by a  
192 'hand-sized' serving of fish, consumed per week by the anglers in 2015 was  $7.5 \pm 0.25$  in spring and  
193  $6.2 \pm 0.25$  in summer, or roughly one serving per day. Consumption fell to  $0.99 \pm 0.25$  servings per  
194 week in the fall and  $0.11 \pm 0.26$  in the winter, or less than one serving per week.  
195

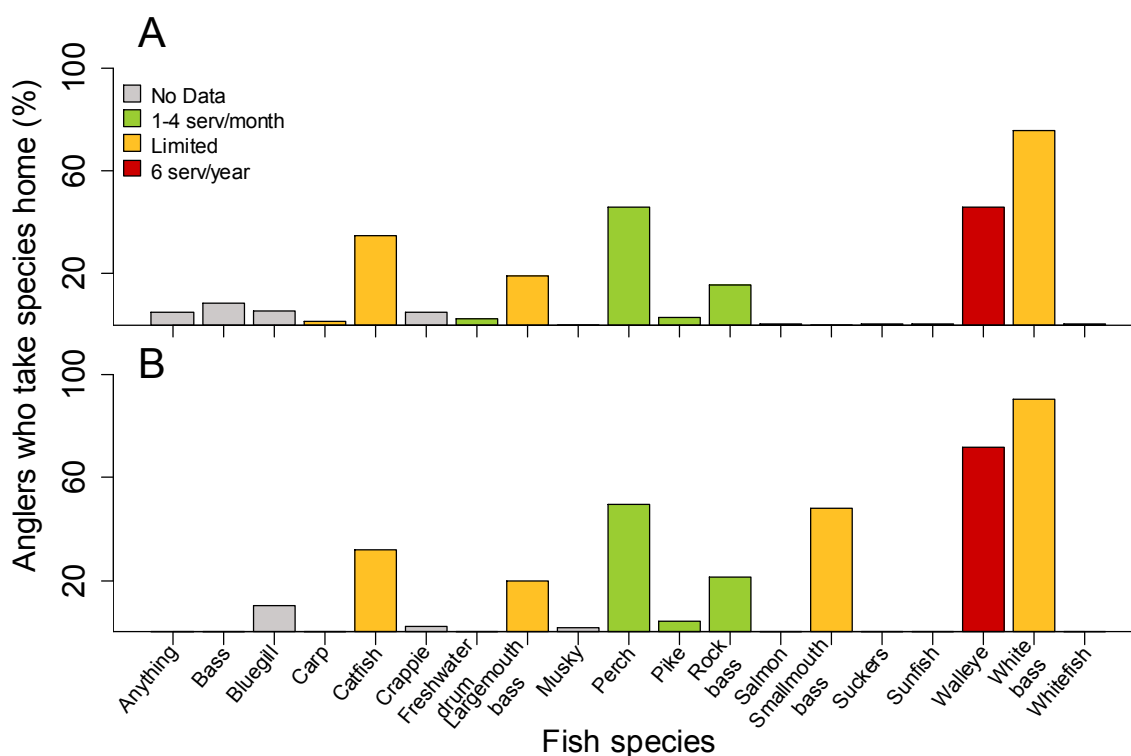
196 Anglers reported frequently providing fish to family and friends with 76% in 2013 and 69% in  
 197 2015 reporting giving fish away (Figure 4A). Of that which is given away, 52-59% of anglers reported  
 198 providing fish to children, 78-83% to women, and 61-92% to men (depending on survey year- Figure  
 199 4B). Encouragingly, almost all anglers (94-98%) reported removing the head, skin, fat, and/or organs  
 200 prior to cooking. In 2013, typical cooking methods were also addressed. Ninety percent of anglers  
 201 regularly fried their fish (a cooking method not recommended due to its inability to eliminate fats  
 202 containing PCBs and dioxins). Baking and grilling (more preferred methods) were less common with  
 203 only 34% and 21% of anglers, respectively, cooking their fish this way. Finally, fewer than 5% of  
 204 anglers reported boiling, broiling, smoking, and/or steaming their catch.



205 **Figure 4.** (A) Percent of surveyed anglers who reported giving away some of their catch in 2013  
 206 and 2015. (B) Of those anglers who gave fish away, the percent who gave their fish to Children,  
 207 Women, and/or Men (total number of anglers who answered questions differed between years).

208 White bass (*Morone chrysops*; also locally referred to as silver bass or occasionally stripe bass)  
 209 was the most common species taken home by anglers. Walleye (*Sander vitreus*) was the next most  
 210 common species followed by yellow perch (*Perca flavescens*), smallmouth bass (*Micropterus dolomieu*;  
 211 locally brown bass) and catfish (typically channel catfish, *Ictalurus punctatus*). Some differences were  
 212 identified in the species anglers commonly took home between 2013 and 2015 (Figure 5). Specifically,  
 213 white bass, walleye, and smallmouth bass were all more commonly kept in 2015 than 2013 ( $P = 0.003$ ;  
 214  $X^2 = 39.28$ ). Additionally, a larger diversity of species was kept in 2013 than 2015 ( $H' = 3.00$  in 2013,  
 215  $H' = 2.33$  in 2015). Species with higher restrictions (as indicated by the Eat Safe Fish program) were  
 216 more commonly kept in 2015 than 2013 ( $P = 0.021$ ;  $X^2 = 9.70$ ; Figure 7). However, this trend was driven  
 217 by an increase in walleye (46% to 72%) and white bass (75% to 90%), while consumption of catfish  
 218 decreased (35% to 32%). Additionally, the mean timing of surveys was later in 2015 than in 2013 ( $P <$   
 219  $0.001$ ) by a mean of 6.21 Julian days (median difference of 16 Julian days), which may account for  
 220 skewing of data toward a particular subset of species (as spawning runs for specific species are  
 221 typically distinct events and attract a large number of anglers, particularly for white bass).

222



223 **Figure 5.** Fish species taken home by anglers in 2013 (A) and 2015 (B) with their relative  
 224 suggested serving frequencies indicated.

### 225 3.2 Consumption Guideline Awareness

226 During the two-year period between surveys, general awareness of the fish consumption  
 227 guidelines did not change (55% in 2013, 57% in 2015;  $P = 0.766$ ,  $X^2 = 0.088$ ). A larger proportion of  
 228 anglers saw the signs and/or encountered the River Walkers in 2015 than 2013 ( $P = 0.005$ ,  $X^2 = 7.76$ ;  $P$   
 229  $< 0.001$ ,  $X^2 = 54.26$ ). However, fewer people who saw the sign in 2015 actually read it ( $P = 0.011$ ,  $X^2 =$   
 230  $6.45$ ), perhaps suggesting some decline in interest over time as people become accustomed to the  
 231 signs the longer they are present. Demographic factors had little impact on anglers' awareness of the  
 232 guidelines, with race, income, and gender having insignificant correlation with angler awareness of the  
 233 guidelines ( $P = 0.814$ ,  $0.198$ ,  $0.149$ , respectively). However, education was correlated with  
 234 awareness ( $P = 0.007$ ); individuals with higher educational achievement (some college, trade school,  
 235 or more) were more commonly aware of the guidelines (69%) than individuals with lower  
 236 educational achievement (high school degree, GED, or less; 46%). Encouragingly, anglers who were  
 237 aware of the guidelines were 5% more likely to supplement their diet with species lower in  
 238 contaminants. Additionally, 36% of anglers shared information about the guidelines with friends or  
 239 family.

240 The different methods utilized in the study were differentially effective between years. The River  
 241 Walkers, signs, and educational pamphlets were all reportedly more effective in 2013 than in 2015  
 242 (Table 1). In 2013, all methods were reported as helpful to the anglers, with no significant differences  
 243 for any pairwise comparison. Pamphlets had an influence on 51% of anglers in 2013, but this number  
 244 fell to 13% in 2015. In 2015, the signs were reportedly more helpful to anglers than were the River  
 245 Walkers. However, a higher percentage of anglers reported that the sign was confusing in 2015 than  
 246 in 2013 (up from 15% to 23%). No correlation with race, education, or income was found with a  
 247 positive response to any particular outreach method ( $P = 0.119 - 0.955$ ).

248 **Table 1.** Statistical summary of outreach methods. Data was derived from "Yes" or "No"  
 249 answers regarding whether anglers found each method to be helpful to them. Percent of angler

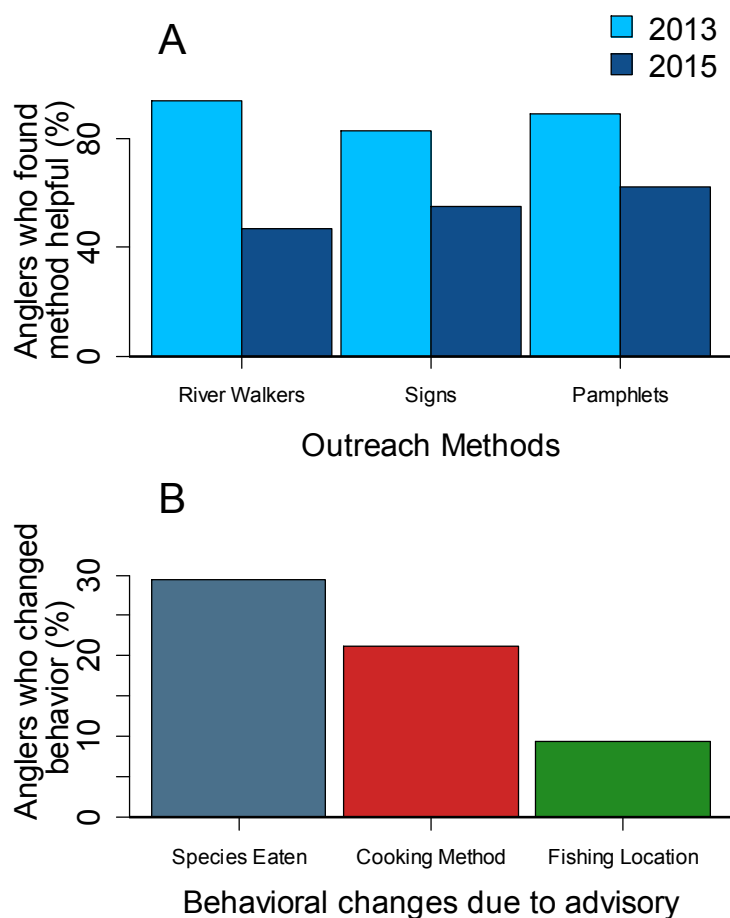


250 responses indicating a method was helpful are indicated and comparisons between methods and  
 251 years are included. *P* indicates p-value from chi-squared or Fisher's Exact Test comparisons.  
 252 Significant comparisons appear in bold.

253

Method	% anglers who reported method as helpful		<i>P</i>
	2013	2015	2013 vs. 2015
River Walkers	94	47	<b>&lt;0.001</b>
Signs	93	65	<b>&lt;0.001</b>
Pamphlets	89	52	<b>&lt;0.001</b>
	<i>P</i>	<i>P</i>	<i>P</i>
Pairwise Comparisons	2013	2015	2013 vs. 2015
RW vs. Signs	0.999	<b>0.006</b>	-
RW vs. Pamphlets	0.531	0.460	-
Signs vs. Pamphlets	0.462	0.052	-
RW 2013 vs. 2015	-	-	<b>&lt;0.001</b>
Signs 2013 vs. 2015	-	-	<b>&lt;0.001</b>
Pamphlets 2013 vs. 2015	-	-	<b>&lt;0.001</b>

254



255 **Figure 6.** The percentage of anglers who reported various outreach methods as helpful (A), and  
 256 the behavioral changes implemented by anglers in 2015 (B).

257 Anglers did report having implemented some behavioral changes due to consumption  
258 suggestions. The largest reported change was in the species consumed by anglers (29%). Cooking  
259 method (21%) and fishing method or location (9%) were also impacted by the consumption campaign  
260 (Figure 6). Walleye and white bass were the most popular species consumed by all anglers, but those  
261 who reported having made changes to the species they consume were 40% more likely to supplement  
262 their diet with species with lower contamination levels in 2015. Education, income, and gender had  
263 no significant impact on changes in behavior. However, race was significantly correlated with reports  
264 of changes in species anglers chose to consume ( $P = 0.002$ ). Specifically, participants who self-  
265 identified as White/Caucasian were less likely to have changed the species they consumed than those  
266 who were Hispanic/Latinx ( $P = 0.008$ ), though the small sample sizes for all races other than African  
267 American/Black may have influenced this outcome. This trend was thus driven by African  
268 American/Black participants who reported changing the species they consume at a higher rate than  
269 other participants (34% as opposed to a combined 16% for all other participants).

#### 270 4. Discussion

271 The history of contamination in Detroit and the surrounding area make understanding the  
272 relative benefits and risks of fish consumption difficult to grasp [18]. Despite challenges in designing  
273 effective educational campaigns, methods tailored to the specific population of anglers as described  
274 in this study have demonstrated gains in general knowledge among Detroit anglers. Following a  
275 multifaceted educational campaign that began in 2010, and included one-on-one interactions with  
276 anglers beginning in 2012, we were able to document awareness of fish consumption advisories by  
277 2013, a period just three years after the start of the program. Anglers reported significant behavioral  
278 changes in the fish species they consumed by 2015. Despite awareness of the consumption guidelines  
279 not having changed over our two-year survey period, there have been significant improvements in  
280 the conscious consumption of fish among Detroit anglers.

281 Contrary to previous findings [23], African American/black anglers were more likely to  
282 supplement their diet with lower-risk species than anglers of other races. This finding is encouraging  
283 given that minorities are disproportionately affected by contaminants through fish consumption  
284 [23,24,9]. The survey results also indicated areas where educational efforts may be improved; for  
285 example, all outreach methods were reported as highly effective in the 2013 survey but were less  
286 helpful in 2015. Specifically, the educational pamphlet influenced anglers at the highest rate initially,  
287 but significantly decreased in influence by 2015. Further, fewer anglers in 2015 read the signs, and  
288 we suspect they may have become part of the 'background' of the landscape. This may indicate some  
289 level of saturation of knowledge following initial efforts, which corresponds to a drop in new interest  
290 in subsequent years. Overall, these trends demonstrate that outreach efforts need to vary over time  
291 to reach a broad audience and be maximally effective.

292 In terms of angler behavior, fish species of greater concern were still some of the most consumed  
293 in the later year of the surveys. Overall, this may indicate relative willingness to adjust behaviors  
294 with respect to specific species, particularly those like walleye which have deep cultural importance  
295 for recreational fishing in this region [25,26]. Indeed, walleye and white bass were still the most  
296 commonly consumed species among anglers who reported having made changes to the species they  
297 consume; however, anglers who were aware of the guidelines or reported making behavioral changes  
298 were also willing to supplement their diets with species reported to have lower contaminant levels.  
299 This suggests that fish species which are not specifically sought after (due to local importance or  
300 lower abundance) may provide greater opportunity for angler behavior change. For example, anglers  
301 may be unwilling to remove walleye from their diet but might consume yellow perch instead of  
302 catfish. Species like catfish, which have relatively high contaminant loads but are not favorites among  
303 anglers may thus provide the greatest opportunity for overall improvement in consumption trends,  
304 as resistance to decreasing consumption of those species will be lower.

305 Race and education were both correlated with overall consumption guideline awareness and the  
306 implementation of behavioral change. This may indicate some cultural implications in the perception  
307 of messages [15]. In some cases, despite being aware of guideline suggestions, anglers were not

308 amenable to the overall message, potentially indicating a mistrust of the information [27]. The  
309 suggestions provided may confront generational or cultural tradition, which can make receipt of the  
310 information difficult and can hinder implementation of behavioral suggestions [28]. Incorporation of  
311 outreach methods which address familial and cultural concerns over the guideline suggestions need  
312 to be considered in designing outreach efforts in this and other systems. Importantly, anglers did  
313 report relaying consumption guidelines to friends and family members. Encouraging dissemination  
314 of information to friends and family may be a way to improve overall awareness as it allows  
315 information to flow through inherently trustworthy sources. Further, utilizing relationships with  
316 stakeholder groups in the area could also improve translation of research to active anglers as well as  
317 provide educational campaigns with appropriate techniques to effectively engage the public [29].

318 In this study, several techniques were assessed for their value in informing local anglers. Signs  
319 were posted, River Walkers were hired to engage anglers, and pamphlets were provided with  
320 information on consumption guidelines. The assessment using surveys allowed direct feedback on  
321 guideline efforts from the target population. Of the outreach efforts utilized, the highest percentage  
322 of anglers reported that the signs were most helpful in the later survey year. This suggests that  
323 location-specific visual aids which anglers can engage on their own time are important in reaching  
324 anglers and that efforts including such resources may be more effective [30]. However, the percent of  
325 anglers who found each method to be helpful changed between years which may indicate anglers are  
326 not always amenable to the guideline message or perhaps a decline in the number of anglers who  
327 were amenable to the message were encountered due to survey efforts that took place later in the  
328 fishing season. Over the course of this study, we identified an increase in the proportion of female  
329 anglers as well as a decrease in the mean age of the angler population. This is consistent with general  
330 trends observed in angling communities [31] and will be important in the design of future advisories,  
331 particularly as women of child-bearing age are increasingly engaging in sport fishing, especially in  
332 the Great Lakes [32]. As seen in this study, outreach methods are not equally effective, and better  
333 understanding the changing demographics of the audience will aid in designing more effective  
334 educational programs.

335 Importantly, this study surveyed the same geographic population of anglers (though  
336 individuals varied) over multiple years to assess changes in behavior associated with educational  
337 outreach efforts. Although consumption studies are relatively common, and those which survey  
338 anglers have produced similar data [e.g., 33], few occur over multiple years to assess longer term  
339 changes and retention of guideline information within a population [34]. This type of repeated  
340 sampling is necessary to ensure ongoing impact of consumption guidelines, particularly as  
341 information is updated and the angler demographics change. In the case of the Detroit River,  
342 consumption guidelines are updated annually so it is imperative that anglers are made aware of  
343 recommendations on a continual basis.

344 This study adopted a unique approach to evaluating the progress of fish consumption guidelines  
345 awareness. The face-to-face interaction with individuals who were actively fishing ensured that the  
346 target group was reached [35]. This strategy differs from a majority of previous efforts which relied  
347 on phone surveys [36,7], online questionnaires, or face-to-face surveys occurring in general public  
348 areas not specific to fishing activities [37]. Further, the anglers who participated in the surveys  
349 occupied demographic groups (low income and education, racial minorities) traditionally missed in  
350 these types of studies despite being at high risk. This unique design is particularly important for areas  
351 with high rates of poverty, such as Detroit, where literacy and access to communication services may  
352 be low. Further, this study focused on a specific body of water rather than obtaining data on a larger,  
353 regional scale [e.g., 36]. Data collected from surveys at a regional scale may be difficult to extrapolate  
354 to local water bodies and fishing activities [e.g., 7]. Providing consumption materials and conducting  
355 surveys in person at locations where anglers are most likely to be affected by contamination ensures  
356 that those individuals who are most likely to be impacted are receiving the information, in addition  
357 to providing the greatest possible accuracy in measuring the impact of consumption guideline efforts.  
358 This practice also allows for the ability to regularly adapt education and outreach strategies based on  
359 feedback directly provided by anglers.

360 Data from anglers fishing the Detroit River is invaluable in setting priorities in fish consumption  
361 education and outreach that are meaningful and appropriate for this population and in designing  
362 future activities. Specifically, identifying the most successful methods of outreach for particular  
363 groups and over time is an important contribution of this study. Educating anglers and their families  
364 about the benefits of eating safer fish and the risks of eating the most contaminated fish can affect  
365 behavior change and will help protect the health of urban anglers who depend upon local fish as a  
366 food source. Educating anglers about choosing the safest fish to eat and the appropriate cooking and  
367 cleaning methods has the potential to improve conscious consumption behaviors among Detroit  
368 residents and create a more informed public over time. This study can be used as a template going  
369 forward to continue the efforts to improve educational campaigns in Detroit, as well as a guideline  
370 for evaluating fish consumption advisories elsewhere.

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