

Use of Angler Diaries to Examine Biases Associated with 12-Month Recall on Mail Questionnaires

NANCY A. CONNELLY AND TOMMY L. BROWN

*Human Dimensions Research Unit, Department of Natural Resources
 Cornell University, Fernow Hall, Ithaca, New York 14853, USA*

Abstract.—A comparison of diary and mail methodologies for a cohort of anglers who fished Lake Ontario was used to examine biases associated with 12-month recall from mail questionnaires. Significant differences in estimates were found between estimates reported by respondents in diaries (1992) versus mail questionnaires (1991) for number of days fished and fish consumption, but not for fishing expenditures and catch. After the data were adjusted for a decline in fishing on Lake Ontario between 1991 and 1992, it was found that angler-days were overestimated by 44–45% on the 12-month recall mail questionnaire. This percentage can serve as an initial estimate of a correction factor for future studies. Lower average annual fish consumption rates were reported in the diary year compared with the mail questionnaire year. However, because of the lower percentage of meals of sport-caught fish during the diary year and the knowledge that sportfishing declined in 1992 for Lake Ontario anglers, it is not clear what portion of the decline can be attributed to different factors. A rough estimate of 10% can be obtained by assuming that consumption of fish that were not sport caught was the same in both years and that anglers accurately reported the overall percentage of that consumption in 1991. Less avid anglers had a very small positive discrepancy between their mail (1991) and their diary (1992) estimates of fishing participation, whereas anglers who fished more frequently had a much larger positive discrepancy. With these data, the best mathematical procedure for describing that relationship involved regressing the square root of days fished in 1991 against days fished in 1992.

Fishery managers and administrators depend heavily on angler reports of fishing participation when making resource allocation and management decisions. They use information from angler surveys to estimate effort, catch, and expenditures and to measure benefits to and satisfactions of their clientele. Fishery managers, environmental protection professionals, and health professionals also use survey information to estimate fish consumption by anglers and to measure the effectiveness of health advisory messages. Mail questionnaires or telephone interviews are often used to gather such information because they are generally less expensive and easier to implement than angler diaries or creel surveys. But there is concern about the accuracy of measures of past participation in mail questionnaires or telephone interviews. Managers need accurate information on which to base management decisions.

A number of authors have studied systematic biases, such as memory recall, digit preference, and nonresponse bias, and their influence on estimates of past participation gathered from mail questionnaires. Sudman and Bradburn (1974) called attention to two types of memory recall errors, omission and telescoping (reporting an event that occurred in a time period other than the one being asked about). Digit preference, in which re-

spondents round off responses to numbers ending in either zeros or fives, may be a special case of memory recall bias because the tendency to round increases over time (Huttenlocher et al. 1990). Nonresponse bias usually occurs because nonrespondents have lower participation rates than respondents (Brown and Wilkins 1978; Tarrant and Manfredo 1993).

These biases, particularly those influenced by memory, have been shown to be affected by frequency of participation, saliency of the topic being studied, and length of recall period. Hu and Bruning (1988) found that “high-involvement products” made a stronger impression on the consumer and thus were more accurately recalled than “low-involvement products.” Those who felt swimming was an important leisure activity were more likely to overestimate their participation (Chase and Harada 1984). Sudman and Bradburn (1974) suggested that respondents use episode enumeration (i.e., they count each episode) to recall events, but more recently Blair and Burton (1987) and Burton and Blair (1991) found that episode enumeration is used only for “vivid, infrequent” events and that other processes, such as rule-based estimation (i.e., construction of an occurrence rule and apply it to the time frame), are used for more “mundane, frequent” events unless the question time frame is

very short. A general trend towards overestimation has been found for recreation participation (Hiatt and Worrall 1977; Chase and Godbey 1983; Chase and Harada 1984; Westat 1989; Thompson and Hubert 1990; Larson and Jester 1991; Tarrant et al. 1993), fishing catch (Carline 1972), travel expenditures (Perdue and Botkin 1988; Guadagnolo 1989; Howard et al. 1992), product purchases (16–192% overestimate; Parfitt 1967), and alcohol consumption (22% overestimate; Lemmens et al. 1988).

Studies have recommended 3-month (Hiatt and Worrall 1977; Westat 1989), 2-month (Ghosh 1978), 1-month (Gems et al. 1982), and 2-week (Tarrant et al. 1993) recall periods for obtaining estimates of fishing participation. But as the recall period is shortened, the number of reports required to account for seasonal variations increases, and thus the cost of implementing the survey increases. Because direct measures of participation (e.g., direct observation, record check) that would eliminate these biases are rarely feasible, angler diaries have been used as a surrogate for actual participation measures (Sztramko et al. 1991; Pollock et al. 1994).

Diaries have their own set of problems and biases, which include low participation rates, especially by very heavy and very low users (McKenzie 1983; La Page 1987), exaggeration of catch estimates (Anderson and Thompson 1991), and recording errors (Sudman 1964; Green et al. 1986; Sztramko et al. 1991). Nevertheless, many researchers have supported their use for frequency measurements (La Page 1987; Hu and Bruning 1988; Burton and Blair 1991), especially for frequently occurring activities (Cosper and Shaw 1985; Lemmens et al. 1992). Many of the shortcomings of diaries can be addressed through careful design and an awareness of the biases (Anderson and Thompson 1991; Sztramko et al. 1991). Also, previous research has been able to establish a strong relationship between diary estimates and actual use (Parfitt 1967; Lemmens et al. 1992). Thus, a possible solution to the cost of repeated implementations versus the accuracy problems associated with long recall times might be the derivation of correction factors from diary surveys (Chase and Godbey 1983; Tarrant and Manfredo 1993). This would permit less expensive mail or telephone studies with longer recall periods.

A comparison of diary and mail methodologies, which were applied to a cohort of anglers who fished Lake Ontario, was used to examine biases

associated with 12-month recall from mail questionnaires. It was assumed that the diaries were a closer approximation of actual participation than the mail questionnaires. Thus differences between the diaries and mail questionnaires could be attributed to response bias, primarily memory recall bias. Comparisons were possible between the diaries and mail questionnaires for fishing effort, catch, expenditures, and consumption. Options were considered for estimating a correction factor that could be applied to similar mail questionnaires that involved a 12-month recall in order to obtain a more accurate estimate of participation. Sociodemographic characteristics and angler avidity were also examined to further our understanding of their effects on memory recall bias. Attempts were made to gain cooperation from all anglers selected for the study. However, the representativeness of diary participants and nonresponse bias were not primary concerns of this study because individuals were compared between years with the two different methodologies.

Methods

Sample frame.—A sample of 2,500 names was drawn from 1990–1991 New York fishing licenses purchased in six counties bordering Lake Ontario. Because these counties had the highest percentage of license buyers that fished Lake Ontario in 1988 (Connelly et al. 1990), this was the most efficient way to obtain a sample of Lake Ontario anglers. The sample included anglers with resident, non-resident, and short-term licenses. The sample was larger than necessary in anticipation of a high dropout rate during the diary year.

Survey design.—Participation in the study was solicited by mailing out personalized letters along with a postage-paid return postcard; this was followed by phone calls to nonrespondents to ascertain interest. Potential participants were encouraged to participate even if they fished only a few days per year. It was hoped that this encouragement would reduce the bias associated with the overrepresentation of avid anglers in diary projects (La Page 1987).

Sample members willing to keep a diary of fishing trips on Lake Ontario and other New York waters and their general fish consumption, and who anticipated fishing Lake Ontario in 1992, were sent a diary in early January 1992. For the purposes of this study, Lake Ontario was defined as the lake itself and all tributaries up to the first barrier impassable to fish. The definition did not include the St. Lawrence River, but did include the

lower Niagara River. This definition was identical to that used for New York State health advisory recommendations on fish consumption. For each day spent fishing on Lake Ontario, participants were asked to record the location fished; expenditures at site and en route; and the species, length, and dispensation (i.e., released, eaten, kept but not eaten, or given away) of each fish caught. For any days spent fishing on other New York waters, information was requested on location, expenditures at site and en route, and number of fish caught. A list of possible expenditure categories (e.g., bait, food, lodging, and boat rental) was provided to prompt participants, but the numbers recorded in the diary were the totals for expenditures at site and en route. Participants were also asked to record each fish meal (sport caught or otherwise) they consumed. Participants were asked to record the information in the diary on the day the activity occurred.

Participants were sent a questionnaire asking for 12-month recall of their 1991 fishing experiences, fish consumption, and general sociodemographic characteristics. Respondents were asked to segment fishing trip information by location so that Lake Ontario trips and trips to other New York waters could be distinguished and the likelihood of digit preference bias in trip reporting would be reduced. Respondents were also asked to estimate fish consumption by season to reduce recall biases and account for seasonal variation.

Participants were contacted by telephone after every 3-month period during the diary year (April, July, October 1992, and January 1993) to retrieve information recorded in the diary. The phone call was also used as a method to maintain respondent interest in the project and to check on the accuracy and completeness of responses.

During the final phone follow-up in January 1993, participants were asked to compare their fishing efforts in 1992 (the diary year) with their efforts in 1991 (the 12-month recall questionnaire year). Participants were provided with a postage-paid envelope to return their diaries after the last phone follow-up. Comparisons were made between returned diaries and phone interview sheets for the 71% of people who returned their diaries. Days of fishing and fish meals that were reported in the diaries but not recorded during the phone interview were added to the computer database developed from information taken from phone interviews. Days of fishing and fish meals reported on the phone sheets but not recorded in the diary were not removed from the computer database. We

were aware from the phone interviews that people reported items on the phone that they forgot to write in their diaries. Yearlong diary participants were defined as those who provided information from their diaries by phone for every quarter of 1992 regardless of whether they returned their diary for comparison purposes.

Analysis.—Those who participated in the diary project for the entire year fished Lake Ontario significantly more and ate more fish meals per quarter than those who participated in three or fewer quarters. The use of data from yearlong participants only would result in an upward bias to the estimates of fishing and fish consumption. To compensate for this bias, for a given quarter the mean days and meals of those who were not yearlong participants was substituted for cases with missing data in that quarter. Thus, for example, the sample size with yearlong information for days fished Lake Ontario increased from 441 to 861. Limitations to substitution for missing data include reduced variability in mean estimates and potential error associated with substitution. To provide evidence that the potential error associated with substitution was small, we examined non-yearlong participants who provided data for a given quarter versus those with missing data in that quarter. For those groups, we compared estimates of fishing effort on Lake Ontario and fish consumption in the other three quarters and found no significant differences in 20 of the 24 potential comparisons.

Data were analyzed with the SPSSX computer program (SPSS 1986). Chi-square and *t*-tests were used to test for statistically significant differences, and 95% confidence intervals were shown where appropriate. For comparisons involving the same participants between years, a paired-difference experimental design was used (Ott 1977). This is a special case of the randomized block design with two treatments (i.e., 1991 and 1992). The design filters out between-participant variability and allows a more meaningful comparison of means by testing that the mean difference equals zero (Ott 1977).

Diary results were compared with data from the 1991 12-month recall mail questionnaire, a 1988 statewide angler survey in New York (Connelly et al. 1990), a 1990–1991 Great Lakes fishing and fish consumption study (Connelly and Knuth 1993), the 1991 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (National Survey; USFWS 1993), and 1991 and 1992 Lake Ontario fishing boat censuses (Eckert 1993).

Results

Response Rates and Diary Biases

From the initial sample of 2,500 fishing license buyers, 509 were unreachable by mail or phone, 470 did not fish Lake Ontario in 1991 and did not intend to in 1992, 111 fished Lake Ontario in 1991 but did not intend to in 1992, and 208 planned to fish Lake Ontario in 1992 but refused to participate in the study. Thus, our initial diary participant sample size was 1,202. This represented 85% of those eligible to participate, based on our criteria of intention to fish Lake Ontario in 1992. The high percentage that agreed to participate reduced our concerns about the biases associated with low co-operation rates by either avid or relatively inactive anglers.

Of those who agreed to participate in the diary project, 69% returned the 12-month recall mail questionnaire on 1991 effort, consumption, and general sociodemographic characteristics.

Although a high percentage agreed to participate, participants dropped out over the course of the diary year for a variety of reasons, such as believing that the diary was too complicated or involved too much time, or for personal and health reasons. Altogether, 906 people provided some information over the course of the year, and that information was used in the analysis wherever possible. At the end of the diary year in January 1993, 516 people (43% of those who were sent diaries) remained active. This is at the low end of the full-participation percentages (43–64%) presented by Sztramko et al. (1991) from a variety of angler diary studies.

Although the dropout rate was substantial, diarists who did not participate in each quarter nevertheless contributed a useful file of their characteristics and data for the quarters when they did participate. These data were used to examine potential biases. Those who participated throughout the year were significantly older (mean age, 43 versus 39) and more educated (mean number of years of education, 14.1 versus 13.6) than those who did not. More yearlong participants lived outside New York state (55% versus 48%) and they fished Lake Ontario more in 1992 (discussed in Methods and adjusted for), and ate more fish meals in 1992 (discussed in Methods and adjusted for) than people who missed one or more quarters.

Memory Recall Biases

Significant differences in estimates were found between diary records and mail questionnaires for

days fished and fish consumption. Differences were generally not found for fishing expenditures and catch.

From diary-based information, anglers who fished Lake Ontario in 1992 fished 4.0 ± 0.4 d (mean \pm 95% confidence limit). This is significantly different (*t*-test) from 12-month recall surveys; the 1988 New York statewide angler survey found an average of 8.7 ± 0.6 d for anglers fishing Lake Ontario (Connelly et al. 1990) and the 1990–1991 Great Lakes fishing and fish consumption study found 9.1 ± 1.4 d (Connelly and Knuth 1993). The diary-based mean is also different from the 1991 National Survey estimate for Lake Ontario of 8.0 d, which was derived from 4-month recall telephone interviews (USFWS 1993).

For those fishing other New York waters, a significant difference in mean days fished was found between the 1992 diary (6.0 ± 1.0 d) and the 1991 mail questionnaire (8.7 ± 1.8 d). With the assumption that, on average, days spent fishing in one year should be similar to those in the next year, much of the difference (45%) could be attributed to memory recall bias for the 12-month mail questionnaire.

Digit preference bias may also play a role in explaining differences between the two methods. Respondents who participated in both the mail and diary portions of the study and who fished Lake Ontario at least 1 d each year were more likely to report fishing Lake Ontario a total number of days ending in zero or five in the mail questionnaire (23%) than in the diary (10%). A similar, but smaller difference, was found for fishing on other New York waters (20% versus 12%). These differences were found even though attempts were made to reduce the possibility of this type of bias by asking participants to record information by specific locations fished, which reduced the number of trips that were reported together.

The average number of meals of fish consumed by diary participants in 1992 was significantly lower (28.0 ± 1.8) than estimates of consumption from 12-month mail questionnaires (39.7 ± 2.9 for our 1991 mail questionnaire, 35.1 ± 1.3 for 1990–1991 Great Lakes anglers, and 45.2 ± 1.5 for 1988 New York State anglers). Also, the percent of meals from sport-caught fish was smaller among 1992 diary records (25.7%) than among 1991 mail questionnaire responses (38.4%).

No significant differences were found between 1992 diary estimates and 1991 mail questionnaire estimates of mean daily expenditures for Lake Ontario or other New York waters (Table 1). With

TABLE 1.—Mean per-day expenditures, in U.S. dollars, from various surveys. Values in parentheses are $\pm 95\%$ confidence intervals.

| Survey | Expenditures (US\$) | | |
|--|---------------------|--------------|----------------|
| | At site | En route | Total |
| Diary (1992) | | | |
| Lake Ontario and tributaries | 43.24 (8.80) | 17.00 (2.90) | 60.17 (10.40) |
| New York State residents ^a | 11.19 (3.86) | 8.99 (3.40) | 20.17 (5.30) |
| Out-of-state residents | 75.07 (15.42) | 25.06 (4.32) | 100.44 (17.86) |
| Other New York waters | 21.76 (8.42) | 13.90 (2.74) | 35.39 (9.80) |
| 12-month recall studies | | | |
| Lake Ontario and tributaries (1991) | 43.93 (7.22) | 16.64 (2.56) | 58.68 (7.46) |
| Other New York waters (1991) | 20.54 (4.26) | 13.86 (2.40) | 34.43 (5.58) |
| Lake Ontario and tributaries (1988) ^b | 34.06 (1.99) | 12.68 (1.07) | 46.41 (2.76) |

^a Differences between New York State residents and out-of-state residents are significant for all expenditure items (*t*-test; $P \leq 0.05$).

^b Source: Connelly et al. (1990).

similarly worded questions, and after adjusting for inflation, no difference was found for estimated expenditures for Lake Ontario trips between the 1992 diary and the 1988 New York statewide survey. Thus no evidence of memory recall bias in expenditures was found between diaries and 12-month-recall studies.

For Lake Ontario fishing in 1992, no fish were caught by diary participants on 36% of the days. This is within the range of the New York Department of Environmental Conservation (DEC) fishing boat census data for 1992 that found zero-catch days ranged from 21 to 50%, depending on species sought (Eckert 1993). No significant difference was found between Lake Ontario catch rates for the 1992 diary (2.8 ± 0.6 fish/d) and the 1991 mail questionnaire (3.1 ± 0.6 fish/d). For trips to other New York waters, on 20% of the days no fish were caught, but a significant difference was found between 1992 catch rates (7.1 ± 1.8 fish/d) and 1991 catch rates (5.0 ± 1.2 fish/d).

Respondents to the 1991 mail questionnaire were asked to report total catch by location fished (reported above as mean catch per day). Elsewhere, they were asked to report catch by major species for 1991 trips to Lake Ontario. If respondents were consistent in reporting catch, the mean catch per day for all fish should be the same as or larger than the mean catch derived from the species list because the species list for Lake Ontario was not complete. However, we found the mean catch per day to be larger for data reported from the species list (4.0) than from the total by location (3.1). A similar difference was found in the 1990–1991 Great Lakes fishing and fish consumption study (Connelly and Knuth 1993), in which a species list may have assisted in recall and thus increased the reported overall number of fish eaten.

This is consistent with previous research showing that prompted recall increases the percentage of respondents who report engaging in recreational activities (Boothby 1987).

Estimating a Correction Factor

Respondents whose data could be matched between the 1991 mail questionnaire and 1992 diary were compared ($N = 360$), which filtered out person-to-person variability. All respondents said they fished Lake Ontario in 1991, whereas only 68% said they did so in 1992. The mean days fishing (for those whose data could be matched) was significantly different between 1991 (10.7 ± 1.4 d) and 1992 (5.1 ± 0.8 d). This represents a decline of 52%.

The difference can be attributed in part to a decline in fishing on Lake Ontario in 1992 as evidenced from the final phone interviews, in which 62.5% of respondents said they thought they fished less in 1992 than in 1991. This decline in fishing is corroborated by data from the DEC fishing boat census that shows a decline of 23.8% in boat angler trips between 1992 and 1991 (Eckert 1993). However, the remainder of the decline, possibly 28.2%, could be attributed to memory recall bias, whereby 12-month recall tends to inflate the number of days fished.

Another method used to apportion the difference in days fished between a decline in the fishery and memory recall bias involved comparing anglers' appraisal of their change in effort (Table 2). If there were no recall bias, the mean number of days fished for those who thought they fished the same in 1991 as in 1992 would be very similar, allowing for potential bias in general recall of more, same, or less fishing. However, a significant positive discrepancy (44%) was found in the mean 1991 num-

TABLE 2.—Mean days fished Lake Ontario as reported by participants in 1991 (mail) and 1992 (diary) in relation to participants' perception of their change in effort between the two years.

| Participant's perception of their fishing effort in 1992 compared with 1991 | Mean days fished as reported by participants | |
|---|--|------|
| | 1992 | 1991 |
| More | 8.8 | 11.5 |
| Same | 5.5 | 7.9 |
| Less | 3.2 | 11.5 |

ber of days fished, which could be attributed to memory recall bias (Table 2). Those who thought they fished more in 1992 than in 1991 in fact reported spending 30.7% less time in 1992, although this difference was not statistically significant (Table 2). This difference can be attributed to memory recall bias as well, but the actual bias should be larger because anglers thought they fished more in 1992.

Another method used earlier to develop a correction factor for fishing effort involved the mean number of days fished on New York waters other than Lake Ontario. A 45% difference was reported between the mean 1991 days and the mean 1992 days that could be used as a correction factor.

Although differences in consumption were reported earlier, derivation of a correction factor is complicated by the decline in fishing participation between the mail questionnaire year and the diary year. Examination of the mean number of meals of fish that were not sport caught, which may overcome the decline in fishing participation bias, indicated only a 10% difference between diaries (24.5 meals) and 12-month mail questionnaires (22.1 meals).

Memory recall bias was not found for expenditures and generally not found for catch per day; thus no correction factors were estimated. However, total expenditures and total catch estimates should include a correction factor for days of effort.

Sociodemographic and Avidity Effects on Response Bias

Significant differences in days of participation were found between 1992 diary records and 1991 mail questionnaires, but the degree of difference was not the same for all groups of people. Respondents who lived in rural areas, had lower incomes, were less educated, were younger, or were

TABLE 3.—Mean days Lake Ontario was fished by project participants with different sociodemographic characteristics and avidities who participated in both 1991 and 1992.

| Sociodemographic characteristics | Mean days fished | | Percent difference |
|----------------------------------|------------------|-------------------|--------------------|
| | 1992 (diary) | 1991 (mail) | |
| Residence area | | | |
| Rural | 4.8 | 11.2 | 133 |
| Village to large city | 5.6 | 10.2 | 82 |
| Income | | | |
| \$40,000 or less | 4.0 ^a | 10.3 | 158 |
| \$45,000 or more | 6.3 | 11.3 | 79 |
| Age | | | |
| 39 years or younger | 4.0 ^a | 10.1 | 153 |
| 40 years or older | 5.8 | 11.1 | 91 |
| Sex | | | |
| Male | 5.3 | 10.5 | 98 |
| Female | 5.1 | 11.7 | 129 |
| State of residence | | | |
| New York | 5.4 | 14.5 ^a | 169 ^b |
| Other | 4.8 | 7.1 | 48 |
| Education | | | |
| High school graduate or less | 4.4 | 10.4 | 136 |
| More than high school graduate | 5.8 | 10.7 | 84 |
| Avidity in 1991 ^c | | | |
| Low (≤ 5 d) | 2.4 ^a | 2.9 ^a | 21 ^b |
| High (≥ 6 d) | 7.2 | 16.6 | 130 |
| Overall | 5.1 | 10.7 | 110 |

^a Statistically significant difference between sociodemographic or avidity groups within a year (*t*-test; $P \leq 0.05$).

^b Statistically significant difference between sociodemographic or avidity groups for discrepancy between years (*t*-test; $P \leq 0.05$).

^c Avidity was defined by the frequency of fishing Lake Ontario in 1991.

female tended to have larger (though not significant) positive discrepancies between their 1991 (mail) and their 1992 (diary) estimates of fishing participation than those who lived in more urban areas, had higher incomes, were more educated, were older, or were males (Table 3). New York State residents had the largest positive discrepancy between 1991 and 1992, significantly larger than that of nonresidents. Their estimate of participation in 1991 was twice that of nonresidents, while their 1992 participation estimates were similar. Significant differences related to income and age were found in 1992 but not in 1991. Less avid anglers had a very small positive discrepancy between their 1991 (mail) and their 1992 (diary) estimates of fishing participation, and anglers who fished more frequently had a significantly larger positive discrepancy (Table 3).

Estimates from angler diaries, which were considered more accurate, were used to predict estimates from the 12-month mail questionnaires. A null hypothesis of no differences or memory recall biases between 1991 (mail) and 1992 (diary) fish-

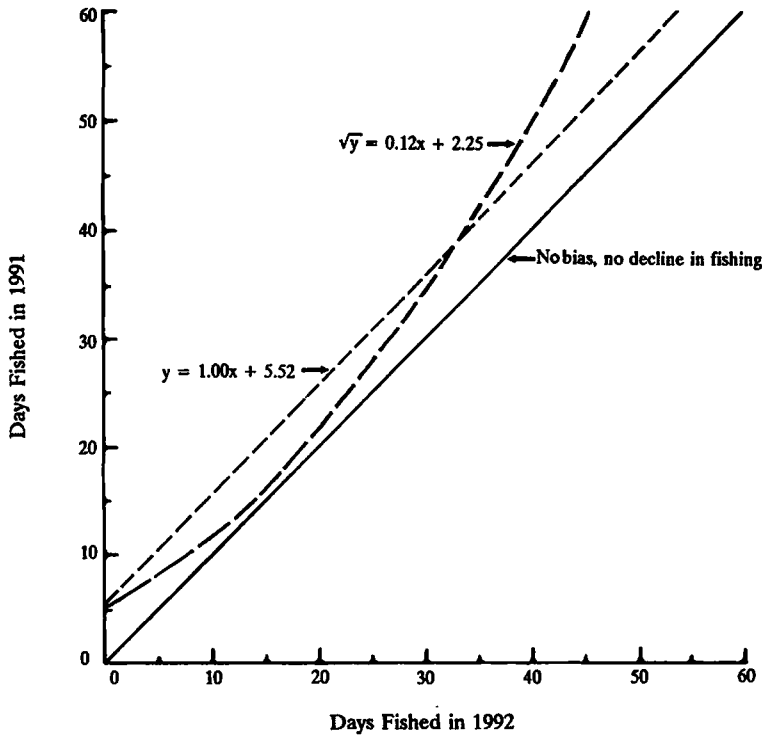


FIGURE 1.—Regression lines describing the relationship between days fished on Lake Ontario in 1991 (y), as measured by a 12-month recall mail questionnaire, and days fished on Lake Ontario in 1992 (x), as measured by angler diaries.

ing effort would imply a linear relationship extending from the origin with a slope of one (Figure 1). That is, anglers would generally fish the same amount in one year as the next, regardless of what method was used to survey them. However, because of the decline in fishing between 1991 and 1992, an alternative hypothesis implies a straight line with a slope of one that does not pass through the origin. Plotting such a line from the data, a significant relationship was found with an r^2 value of 0.277, a slope of one, and a y -intercept (1991 axis) of 5.5 (Figure 1). However, it was also hypothesized that avidity affected memory recall bias and that a more accurate line would lie closer to the null hypothesis line at lower avidity levels and curve upward at higher avidity levels. The best mathematical procedure to describe that line was to regress the square root of days fished in 1991 against days fished in 1992. That line had a higher adjusted r^2 (0.289) than the straight line and is plotted in Figure 1.

Anglers are often analyzed by their avidity level, and the opinions of more avid anglers receive greater weight in decision making. In this study

the consistency of classification of anglers based on avidity was examined. It was hypothesized that anglers classified as avid one year would generally be classified the same way the next year. Avidity (high or low) was defined in relation to the median fishing effort for 1991 and 1992. Two-thirds of anglers were classified the same in both years and one-third were misclassified (Table 4). Another way to examine the consistency of classification is to assume that avidity was correctly predicted by the diary data and examine what percentage of respondents would have been correctly classified if only a mail questionnaire were used. Under that

TABLE 4.—Avidity classification of Lake Ontario anglers in 1991 versus 1992.^a Values in parentheses are percentages of all respondents.

| Avidity in 1991 | Avidity in 1992 | |
|--------------------|-------------------|--------------------|
| | Low (≤ 2 d) | High (≥ 3 d) |
| Low (≤ 5 d) | 60.2% (26.9%) | 29.6% (16.4%) |
| High (≥ 6 d) | 39.8% (17.8%) | 70.4% (38.9%) |

^a Avidity of anglers was defined by the frequency of fishing on Lake Ontario.

scenario, 60% of the low- and 70% of the high-avidity anglers would have been correctly classified.

Discussion

No differences were found in per-day expenditure measures between diary records and mail questionnaires; this result differs from those of past research, which found both overestimates (Perdue and Botkin 1988; Westat 1989; Howard et al. 1992) and underestimates (Mak et al. 1977). Our result concurs with that of Lemmens et al. (1992), who reported that people have trouble recalling the correct number of occasions (e.g., days) but have less trouble recalling the specifics of the occasions they can recall (e.g., expenditures). Total expenditures estimated from 12-month mail questionnaires by multiplying per-day estimates by the number of days fished would be overestimated by approximately the same proportion as the number of days. Thus, future recall studies could use a correction factor to reduce calculated total expenditures to a more realistic level.

Comparisons involving catch rates generally showed little or no difference between the 1992 diary records and the 1991 mail questionnaire responses. This might argue against a correction factor, but caution is urged in this area because the results for catch by species were not definitive. Because factors such as prompted recall contributed to differences within the mail questionnaire, further research should be undertaken in this area.

Previous research has shown little consistency in overestimation of fishing activity among socio-demographic subgroups (Parfitt 1967). Our research suggests that people in lower socioeconomic strata are more likely to exaggerate their activity. However, our evidence needs to be substantiated with more detailed research in this area. Perhaps frequency of fishing (avidity) is the driving factor in overestimation and certain sociodemographic characteristics correspond with anglers who fish more frequently. Previous research (e.g., Chase and Harada 1984) and this study have shown that avid participants are more prone to overestimates in recall surveys. A mathematical model was proposed to describe the increasing discrepancy with increasing avidity. This model should be tested by other researchers and in other recreational settings. This study shows that avidity of the anglers and to a lesser extent their sociodemographic characteristics must be taken into consideration before correction factors can be applied from one study to another. Understanding the relationship

between avidity and memory recall bias can help facilitate adjustments between studies.

It was anticipated that fishing participation would remain nearly constant on Lake Ontario between 1991 and 1992, as was the case in previous studies in 1988, 1990–1991, and 1991 (Connelly et al. 1990; Connelly and Knuth 1993; USFWS 1993). Surprisingly little difference was observed between those years, in which mean days fished were estimated with mail and telephone surveys. Had fishing participation remained constant as it appeared to have done between 1988 and 1991, much of the difference noted between 1991 and 1992 could have been attributed to memory recall biases and the associated digit preference bias, and correction factors could have been estimated. However, because of the decline in fishing on Lake Ontario, it was necessary to apportion the overestimate of 1991 days of participation between memory recall biases and the 1992 decline in fishing. From this research, using estimates from Lake Ontario and other New York waters (where no overall decline in participation was expected), and assuming that diary information represents actual participation, we found that 44–45% of angler days are overestimated on a 12-month recall mail questionnaire.

Nonresponse bias in estimating correction factors is also a concern because of low participation rates in diary projects and companion mail surveys. Nonrespondents may differ from respondents in the degree of the differences between their estimates on a diary versus a mail questionnaire. For example, if nonrespondents were less avid, which has been demonstrated in a number of studies (Brown and Wilkins 1978; Connelly et al. 1990; Knuth et al. 1993), the difference between their diary and mail estimates might be smaller than that of more avid respondents shown in Figure 1.

To eliminate the confounding effect of year-to-year variability, the study could have been designed with two independent, randomly selected samples of anglers with one sample completing the diary and the other a 12-month recall mail questionnaire at the end of the same year (e.g., 1992). Correction factors calculated by this methodology would not have had to account for the decline in fishing between 1991 and 1992. However, differences in cooperation rates between the two methodologies (e.g., in our study 69 versus 43%) resulted in differences in days fished; those responding only to the mail survey and not participating in the diary portion were more likely to

fish only a few days a year, whereas those who participated in both were more avid. Mail-only participants were also more likely to be New York State residents and have less education than those who participated in both the mail and diary portions. These differences would become an important source of between-sample variability and would have to be adjusted for before correction factors could be estimated. Researchers could use this approach, attempt to adjust for biases caused by differing cooperation rates, and see if similar correction factors were derived.

Clearly there were lower average annual fish consumption rates in the diary year than in the mail questionnaire year. However, because of the lower percentage of meals of sport-caught fish during the diary year and the knowledge that sport-fishing declined in 1992 in Lake Ontario, it is not clear what portion of the decline in consumption can be attributed to different factors. From our data, a difference of 10% was obtained by using only consumption of fish that were not sport caught. To use this as a correction factor requires assumptions that consumption of fish that were not sport caught was the same in both years and that anglers accurately reported the overall percentage of these meals in 1991. Further research is needed in this area because accurate methods for estimating fish consumption by anglers is critical for calculating health advisory recommendations.

If one accepts the tenet that diaries are accurate measures of actual participation—which has its drawbacks because of omission errors and other factors (Green et al. 1986; La Page 1987)—one must still overcome the problem of low participation rates in diary projects in order to be able to generalize about the population of anglers being studied. The use of correction factors that bridge the gap between diaries and mail questionnaires, in conjunction with follow-up telephone nonresponse bias surveys, could yield the best estimates of fishing participation and consumption.

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