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ARTICLE

A Comparison of Recall Error in Recreational Fisheries Surveys with One- and Two-Month Reference Periods

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Abstract
Many fisheries monitoring programs use self-administered surveys to collect data, which are subject to recall error. Recall error occurs when respondents inaccurately remember past events due to telescoping (remembering events more recently or further back in time than they occurred) or omission error (forgetting events altogether). Previous research on the effects of variable reference periods in fisheries surveys has been inconclusive due to difficulty in disentangling method effects from recall error and in determining whether estimates from shorter recall periods are less biased or more subject to telescoping. The National Marine Fisheries Service has developed a new household mail survey, the Fishing Effort Survey (FES), in which anglers are asked to recall cumulative fishing effort over the past 2 months, from which estimates of saltwater fishing effort are produced. Here, we examined how the length of the reference period may affect the FES in four U.S. states by comparing effort estimates to two feasible alternatives: (1) a survey administered monthly with both a 1- and 2-month reference period (wherein respondents were asked to recall fishing effort for each of the past 2 months individually); and (2) a survey administered monthly with a 1-month reference period. To further explore bias in the designs, we compared total effort, fishing prevalence, and mean trips per household estimates derived from the two experimental surveys. We found no significant differences between the FES and experimental survey estimates. However, we found evidence that multiple reference periods in a single survey may reduce bias for 1-month estimates. Increased understanding of (1) techniques that can reduce recall bias and (2) the trade-offs of shorter or longer reference periods will ultimately help fisheries survey designers more accurately weigh bias against survey costs and improve the quality of data used to inform management decisions.

Self-reported data collected through retrospective recall of past events are a crucial component of a variety of social, public health, and economic research efforts (e.g., Abbott and Monsen 1979; Wright and Pescosolido 2002; Bhandari and Wagner 2006) and have been widely used to estimate recreational fishing statistics in the United States and elsewhere (e.g., Hicks et al. 1999; Ditton and Hunt 2008; Sampson 2011; Rocklin et al. 2014). Such data,

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however, are subject to various sources of nonsampling error, including measurement error. Memory or recall error is a type of measurement error that occurs when respondents are unable to accurately remember or recall past events (Neter and Waksberg 1964; Eisenhower et al. 2011). Recall errors are typically classified as either telescoping error or omission error (Sudman and Bradburn 1973; Chu et al. 1992). Telescoping occurs when a respondent misplaces an event in time, usually placing the event more recently in time than it actually occurred; omission error, also referred to as "recall decay," occurs when a respondent forgets an event.

Several factors are thought to affect a respondent's ability to remember and report past events, including (1) the number of events (i.e., reporting becomes more time consuming as the number of events increases); (2) the extent to which events are important or memorable (salience); (3) the frequency or regularity of events; and (4) the length of the reference period, or the time period for which recall of an activity is utilized by the respondent: longer reference periods potentially require recollection of events that are more distant as well as a greater number of events (Blair and Burton 1987). It is generally accepted that the greater the length of the reference period, the greater the expected bias due to recall error.

Identifying how to best minimize recall error while maximizing the quantity of information collected and optimizing a survey's budget remains a challenge (Clarke et al. 2008). Researchers have developed several strategies to enhance memory and subsequently reduce recall error (Sudman and Bradburn 1974). These include aided recall, which stimulates recall by providing memory cues, such as pictures or calendars; requesting that respondents consult personal records, such as bank statements or receipts; landmark procedures, which relate the reference period to a landmark event, such as a major holiday, personal milestone, or natural disaster (Loftus and Marburger 1983; Gaskell et al. 2000); adjusting the duration of the reference period (Chu et al. 1989); and bounded recall, which bounds respondent memory against a prior interview (Neter and Waksberg 1964) or a previous question within a single interview (Sudman et al. 1984). Researchers frequently utilize a combination of these approaches to improve the quality of survey responses.

Prior studies have been inconsistent with respect to the effects of reference period length on recreational fisheries survey measures (Gems et al. 1982; Chu et al. 1992; Tarrant et al. 1993; Connelly and Brown 1995, 2011; Connelly et al. 2000). For example, Gems et al. (1982) found that a 2-month reference period resulted in lower estimates of fishing activity than a 2-week reference period and attributed the difference to omission error associated with a longer reference period. In contrast, others have suggested that longer reference periods result in overestimation of fishing activity (Chu et al. 1992; Tarrant et al. 1993; Connelly and Brown 1995). Still others report no difference in reported fishing activity as a function of the duration of the reference period (Connelly and Brown 2011). An enhanced understanding of how recall affects recreational fisheries data collection programs is needed to continue improving the accuracy of recreational fisheries statistics.

One factor that may contribute to inconsistent findings is the difference among survey designs that have been utilized to examine recall error in recreational fishing surveys. For example, some studies have compared angler diaries to mail surveys with longer reference periods (e.g., Tarrant et al. 1993), while others have used mail surveys to examine one reference period and telephone surveys for another (e.g., Connelly et al. 2000). In all of these studies, the authors acknowledged that it was difficult in such designs to disentangle method effects from recall bias. Others have used the same survey methods with two different reference periods to better isolate recall bias (e.g., Connelly and Brown 2011), but they acknowledged that even in using identical methodologies, it was difficult to conclude whether shorter reference periods reduced recall error or were instead subject to more telescoping bias than longer reference periods.

The National Marine Fisheries Service (NMFS) of the National Oceanic and Atmospheric Administration has redesigned its marine recreational fisheries data collection program, creating the Marine Recreational Information Program (MRIP; see National Research Council 2006; National Academies of Sciences, Engineering, and Medicine 2017). In January 2018, the MRIP transitioned to a new survey, known as the Fishing Effort Survey (FES), to collect data about recreational shore and private boat fishing trips along the U.S. Atlantic and Gulf of Mexico coasts. The FES is a self-administered mail survey that asks household residents to report recreational saltwater fishing trips that occurred during 2-month reference periods, or "waves." These data are used to estimate fishing effort (i.e., the total number of shore and private boat fishing trips) for each of six 2-month waves as well as annual fishing effort at the end of each calendar year. The FES replaced the legacy Coastal Household Telephone Survey, a random-digit dial, landline telephone survey that NMFS had used to estimate fishing effort since 1981 (Brick et al. 2012). The FES has been identified as a more efficient and accurate approach for monitoring recreational fishing effort than the Coastal Household Telephone Survey (Andrews et al. 2014; National Academies of Sciences, Engineering, and Medicine 2017). However, the MRIP continues to examine the impacts of measurement errors, including recall error, on estimates in an effort to understand potential biases and limitations of the FES design.

Accurate statistics are essential for quantifying the effects of recreational fishing on fish stocks and developing sound, evidence-based management strategies and policies. Continuous catch and effort monitoring, for example, is needed to assess trends, evaluate the impacts of management regulations, and project how different management scenarios might influence a fishery. Minimizing biases, including recall error, in recreational fisheries surveys is therefore a necessity for effective management; large biases reduce data quality and the subsequent utility of the statistics produced from those data to fisheries scientists and managers. Understanding the magnitude of biases that occur in existing survey methods—as well as exploring methods to help mitigate such biases—can help to improve data quality so that managers are provided with the best possible scientific information to use in their decision making (National Standard 2, Magnuson–Stevens Fisheries Conservation and Management Reauthorization Act of 2006).

This study examined recall error in the FES by evaluating the impacts of bounded recall and the length of the reference period on reports of recreational saltwater fishing trips. We compared FES estimates of shore and private boat fishing effort to estimates derived from two experimental designs: one in which respondents were asked to report fishing trips for a single month (i.e., a 1-month reference period); and another that asked respondents to recall fishing trips for each of two separate months (i.e., reporting for the most recent month, bounded by reporting for the prior month). All design elements other than the reference period were identical between the FES and experimental treatments in an effort to minimize confounding effects. In comparing results from the experimental surveys, we explored possible mechanisms for any suspected recall biases.

METHODS

Experimental design.— The FES is administered at the end of 2-month, mutually exclusive reference periods and asks respondents to recall the cumulative number of shore and private boat fishing trips that occurred during the reference period. From July to December 2015 (Table 1), two experimental questionnaires, which differed from the FES in the duration of the reference period, were administered in parallel to the FES in four states (Massachusetts, Maryland, Georgia, and Florida). One treatment (treatment 1) asked about fishing trips for two individual months (the most recent month and the prior month). The second treatment (treatment 2) asked about fishing trips for only the most recent month (see Appendix Figure A.1.1 for the differences between FES, treatment 1, and treatment 2 questionnaires). The experimental treatments were feasible modifications to the FES design that would provide greater temporal resolution and might potentially improve the accuracy of survey estimates.

With the exception of the manipulation of reference periods, the design of the FES and that of the experimental treatments were the same (Figure 1). The sample frame for each survey was the U.S. Postal Service's computerized delivery sequence file, consisting of all residential household addresses within each study state. The Massachusetts, Maryland, and Georgia samples were stratified into substate regions (groups of counties) defined by geographic proximity to the coast (coastal and noncoastal), while all counties in Florida were included in a single stratum due to the relatively high rate of fishing throughout the state. Within the geographic strata, we selected addresses using simple random sampling and matched them to the National Saltwater Angler Registry (MRIP 2018). This partitioned the sample into two additional strata: license matched (wherein the households contain one or more licensed anglers) and license unmatched (wherein no licensed anglers were identified in the household). This stratification provided additional information to optimize sampling; previous studies (e.g., Andrews et al. 2010, 2013; Brick et al. 2012) have demonstrated that residents of households that match to license databases respond to fishing surveys at a higher rate and are more likely to have fished during the reference wave than residents of unmatched households.

TABLE 1. Data collection schedule for the Fishing Effort Survey (FES; 2-month reference period), experimental treatment 1 (T1; both 1- and 2-month reference periods), and experimental treatment 2 (T2; 1-month reference period). Survey questionnaires were mailed out for the FES every 2 months (at the end of August, October, and December). Treatment 1 questionnaires were mailed out monthly from August to December. Treatment 2 questionnaires were sent out monthly from July to December.

	Experimental month					
Variable or event	Jul	Aug	Sep	Oct	Nov	Dec
Treatment	T2	FES, T1, T2	T1, T2	FES, T1, T2	T1, T2	FES, T1, T2
First survey mailing	Jul 27, 2015	Aug 25, 2015	Sep 24, 2015	Oct 26, 2015	Nov 24, 2015	Dec 28, 2015
Reminder postcard	Aug 3, 2015	Sep 1, 2015	Oct 1, 2015	Nov 2, 2015	Dec 1, 2015	Jan 4, 2016
Reminder phone call	Aug 6, 2015	Sep 3, 2015	Oct 2, 2015	Nov 4, 2015	Dec 2, 2015	Jan 4, 2016
Second survey mailing	Aug 17, 2015	Sep 15, 2015	Oct 15, 2015	Nov 16, 2015	Dec 15, 2015	Jan 18, 2016

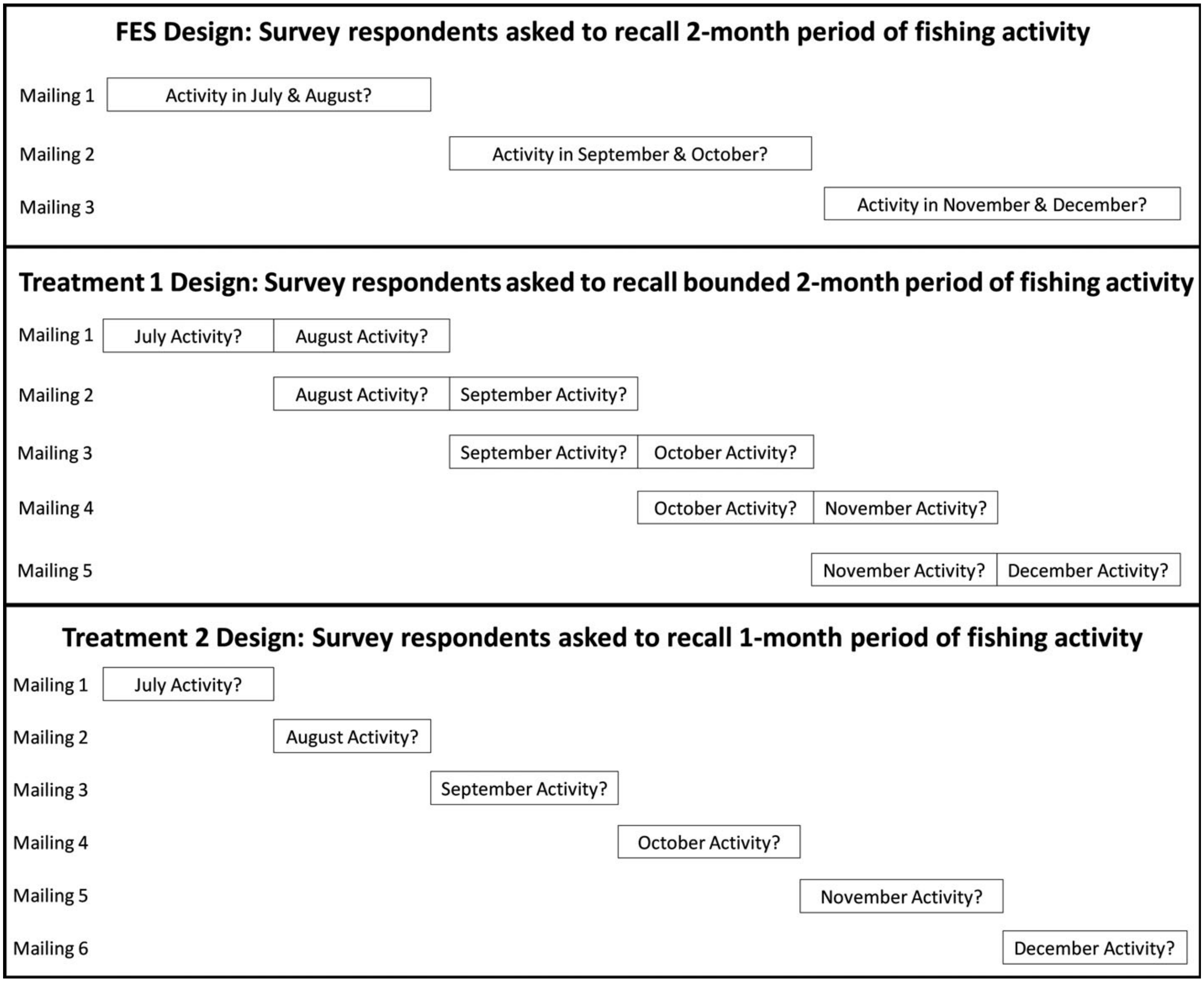

FIGURE 1. Schematic of the Fishing Effort Survey (FES) design compared to those of the experimental surveys: the FES was administered every 2 months and had a 2-month reference period (i.e., time frame for which survey respondents were asked to report events). Treatment 1 was administered monthly; respondents were given two reference periods and were asked to differentiate between fishing trips that occurred within the past month (1 month ago) and the month prior to that (2 months ago). Treatment 2 was administered monthly with a 1-month reference period.

The final sampling allocation was achieved by retaining all license-matched addresses in the sample and subsampling unmatched addresses at a rate of approximately 30%. The assignment to experimental treatments was completed after matching and subsampling; addresses within each stratum were randomly assigned to receive one of the two experimental versions of the survey. Sampling for the FES was conducted independently from the experimental treatments. In total, 39,539 questionnaires were mailed (Table 2), including treatment 1 (11,983 questionnaires), treatment 2 (12,017 questionnaires), and the FES (15,539 questionnaires). Table 2 presents sample sizes by state, and Appendix Table A.2.1 presents sample sizes by stratum.

Data collection.— Reported saltwater fishing trips were collected from occupants of each sampled address (up to a maximum of five household members) through a self-administered questionnaire. The data collection period began 1 week prior to the end of the reference month with an initial survey mailing that included a cover letter stating the purpose of the survey, a survey questionnaire, a postage-paid business reply envelope, and a prepaid US$2 cash incentive. One week after the initial mailing, households received an automated voice telephone reminder

TABLE 2. Sample sizes and responses by state for the 6-month experimental period (FES = Fishing Effort Survey). For a more detailed breakdown of sample sizes and responses for individual strata (i.e., by month, state, geographic stratum [coastal/noncoastal], and license status [matched/unmatched]), see Table A.2.1.

State	Treatment 1		Treatment 2		FES	
	Initial sample size	Responses	Initial sample size	Responses	Initial sample size	Responses
Florida	2,998	961	3,002	999	1,590	527
Georgia	2,995	988	3,005	974	4,244	1,402
Maryland	2,994	1,043	3,006	1,062	5,564	1,968
Massachusetts	2,996	1,142	3,004	1,062	4,141	1,554

message and a thank you/reminder postcard. Three weeks after the initial mailing, households received a second questionnaire, a nonresponse conversion letter designed to persuade nonresponding households to participate in the survey (Olson et al. 2011), and another postage-paid business reply envelope (see Table 1 for the data collection schedule for the experiment). Data were collected for approximately 13 weeks after the initial survey mailing for each reference month.

Fishing effort estimation.— Initial comparisons were of total shore and private boat fishing effort across the four experimental states for the entire 6-month experimental period. However, given the large influence of Florida, which accounted for approximately 75% of total effort for the four experimental states, we decided to consider Florida separately from the three other states. We considered shore and private boat fishing separately because the activities can be very different in terms of cost and time commitments—two factors that are likely to impact memory. Both treatment 1 and treatment 2 estimates were based upon the month immediately preceding survey administration; for treatment 1, this coincided with the most recent month of the 2-month reference period.

Initially, we compared FES trip estimates to experimental estimates to evaluate the impact of the different reference periods on survey estimates. Specifically, we hoped to determine whether estimates derived from a longer reference period were susceptible to recall decay. Next, we compared the experimental estimates to each other. We expected estimates from the two treatments to be similar since both were based upon reported fishing activity during the most recent month. Differences between treatments would presumably reflect the impact of the bounded recall design—asking about a behavior for multiple periods—on reporting. In addition to comparing the estimated number of trips across experimental treatments, we also compared fishing prevalence (percentage of households that reported fishing) and the mean number of trips reported per fishing household. Differences in these measures could help identify a mechanism for recall errors (Table 3).

Fishing prevalence and mean trips per household were calculated for treatments 1 and 2 by using established weighted mean estimators (SAS Institute 2016). Estimates of total fishing effort ($\widehat{T}_r$) for the FES, treatment 1, and treatment 2 were generated using the Horvitz–Thompson total estimator, a standard method for estimating the total of a stratified sample (Horvitz and Thompson 1952),

$$\widehat{T}_r = \sum_{h=1}^{H} \sum_{i=1}^{n_h} w_{hi} t_{hi},$$

where w_{hi} is the weight of address i in stratum h; and t_{hi} is the reported number of recreational fishing trips for address i in stratum h. The sample weights (w_{hi}) were calculated in a series of four steps that included (1) a base weight reflecting the sample inclusion probability; (2) an adjustment to account for unit nonresponse; (3) a post-stratification adjustment to account for incomplete coverage of the target population (e.g., Brick and Kalton 1996) using the most recent, reliable estimates of the number of residential households available from the American Community Survey (U.S. Census Bureau 2015) as population controls; and (4) use of an established procedure for trimming the estimated mean square error (see Potter 1990) to minimize the effects of extreme weights on the sampling variance.

The variance of the fishing effort estimates was calculated using Taylor series linearization (Dienes 1957; SAS Institute 2016). The Taylor series obtains a linear approximation of a nonlinear function, and the variance estimate of the nonlinear function is then estimated by the variance of the Taylor series approximation of that function (Woodruff 1971; Fuller 1975). The method calculates the estimated variance as

$$\widehat{V}(\widehat{T}_r) = \sum_{h=1}^{H} \left[\frac{n_h}{n_h - 1} \left(\sum_{i=1}^{n_h} w_{hi}^* t_{hi} - \frac{1}{n_h} \sum_{i=1}^{n_h} w_{hi}^* t_{hi} \right)^2 \right].$$

RESULTS

Of the over 10,000 questionnaires mailed for each of the experimental treatments, between 647 and 665 were undeliverable, and between 3,385 and 3,440 were completed and

TABLE 3. Statistical comparisons made between the survey estimates (FES = Fishing Effort Survey; T1, T2 = experimental treatments 1 and 2), along with the purpose of each, the expected outcomes, and potential mechanisms behind the expected outcomes.

Comparison	Primary purpose of comparison	Expected outcome	Potential mechanisms
FES total effort to T1 total effort	Identify recall decay in the longer reference period (FES)	FES estimates lower than T1 estimates	Recall decay in the FES.
FES total effort to T2 total effort	Identify recall decay in the longer reference period (FES)	FES estimates lower than T2 estimates	Recall decay in the FES or telescoping in T2.
T1 total effort to T2 total effort	Examine the impact of a bounded recall design (T1) on estimates	Comparable estimates with no systematic differences	No difference in recall because the reference periods are the same (if T2 estimates are instead higher than T1 estimates, it would suggest telescoping in T2).
T1 fishing prevalence to T2 fishing prevalence	Explore mechanisms of observed recall error	Comparable estimates with no systematic differences	No difference in recall because the reference periods are the same (differences between treatments suggest that recall error is likely due to nonfishing households erroneously reporting fishing activity, thus indicating telescoping, social desirability, or a combination of both factors).
T1 mean trips per household to T2 mean trips per household	Explore mechanisms of observed recall error	Comparable estimates with no systematic differences	No difference in recall because the reference periods are the same (differences between treatments suggest that recall error is likely due to fishing households over- or underestimating the number of trips they took, indicating that recall ability is impacted by the frequency/regularity of fishing activity).

returned (see Table 2 for responses by state and Table A.2.1 for responses by stratum). Of the nearly 16,000 FES questionnaires that were mailed during the 6-month experimental period, 745 were undeliverable, and 5,657 were returned. Adjusted response rates across all surveys were very similar, ranging from 36.21% to 37.25%.

Differences in estimated fishing trips between the FES and the two experimental treatments were not statistically significant for either shore or private boat fishing. However, treatment 2 estimates were systematically higher than FES estimates for both fishing modes (Figure 2). In contrast, differences between FES and treatment 1 estimates were neither significant nor systematic (Figure 2).

Comparisons between the experimental treatments demonstrated that treatment 2 trip estimates were systematically higher than treatment 1 estimates for both fishing modes (Figure 2). Differences between treatments were significant ($P < 0.05$) for both shore and private boat fishing in Florida and for private boat fishing in the remaining states. Differences in trip estimates resulted from differences in fishing prevalence between the two treatments; a higher percentage of households reported fishing when the overall reference period was limited to a single month (Figure 3). Differences in fishing prevalence between treatments 1 and 2 were significant for both shore and private boat fishing in Florida as well as for private boat fishing in the other states. In contrast, differences between treatments in terms of the mean trips per household were relatively minor and not significant (Figure 4).

DISCUSSION

The FES estimates of total fishing effort were not significantly different from experimental estimates derived from a 1-month recall period (either treatment 1 or treatment 2). However, FES estimates were systematically lower than experimental estimates when the recall period was limited to a single month (treatment 2). This could mean that FES respondents were forgetting or omitting trips from the longer (2-month) recall period, resulting in

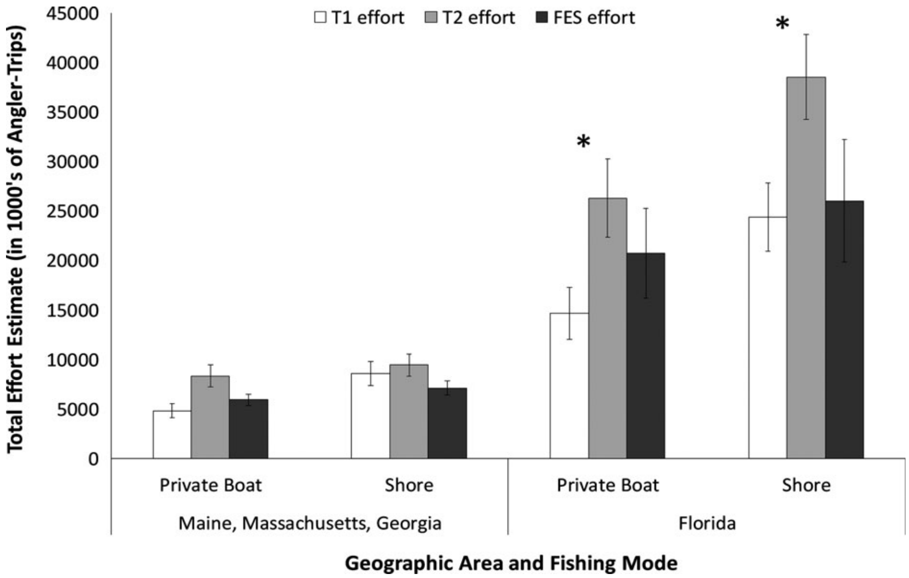

FIGURE 2. Comparison of fishing effort estimates (±SE; thousands of trips) from treatments 1 (T1) and 2 (T2) to each other and to the Fishing Effort Survey (FES) estimates by geographic area and by fishing mode. Estimates for each treatment were calculated for each reference period (T1 used 1-month estimates derived from the most recent month in the treatment's 2-month period; T2 used 1-month estimates; and the FES used 2-month estimates) and were summed across the 6-month experimental period. There were no significant differences in total fishing effort between the FES and either T1 or T2 ($P > 0.05$). Significant differences between T1 and T2 estimates are indicated by asterisks ($P < 0.05$).

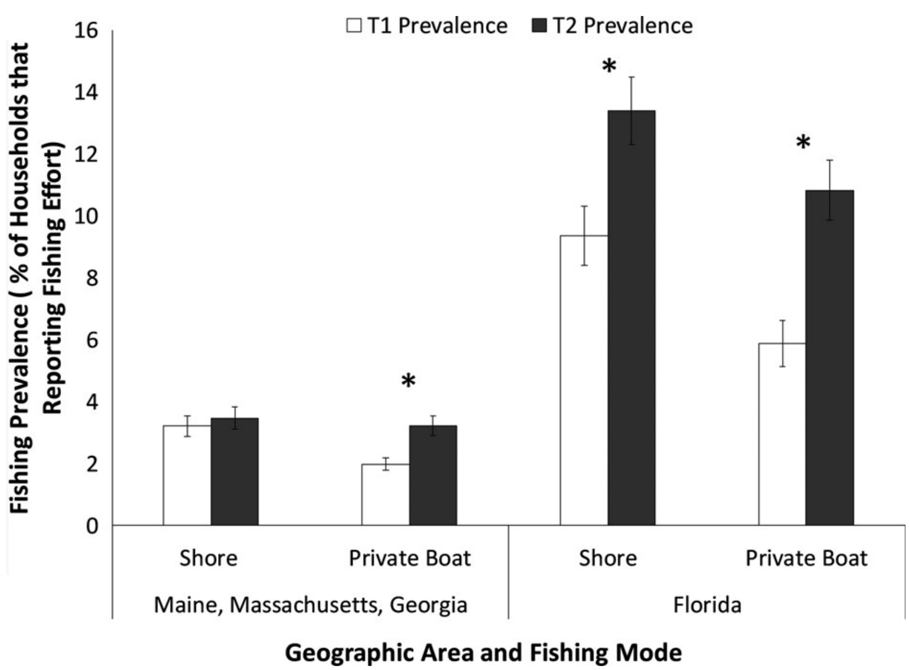

FIGURE 3. Comparison of fishing prevalence (±SE; percentage of households reporting fishing) in treatment 1 (T1; using the most recent of the 2 months within the treatment) and treatment 2 (T2; 1-month reference period) by geographic area and fishing mode. Significant differences between T1 and T2 metrics are indicated by asterisks ($P < 0.05$).

moderate underestimates of fishing effort. If this was the case, we would also expect FES estimates to be lower than estimates derived from the most recent month of a 2-month reference period (treatment 1). Differences between FES and treatment 1 estimates were neither significant nor systematic, suggesting that differences between FES and

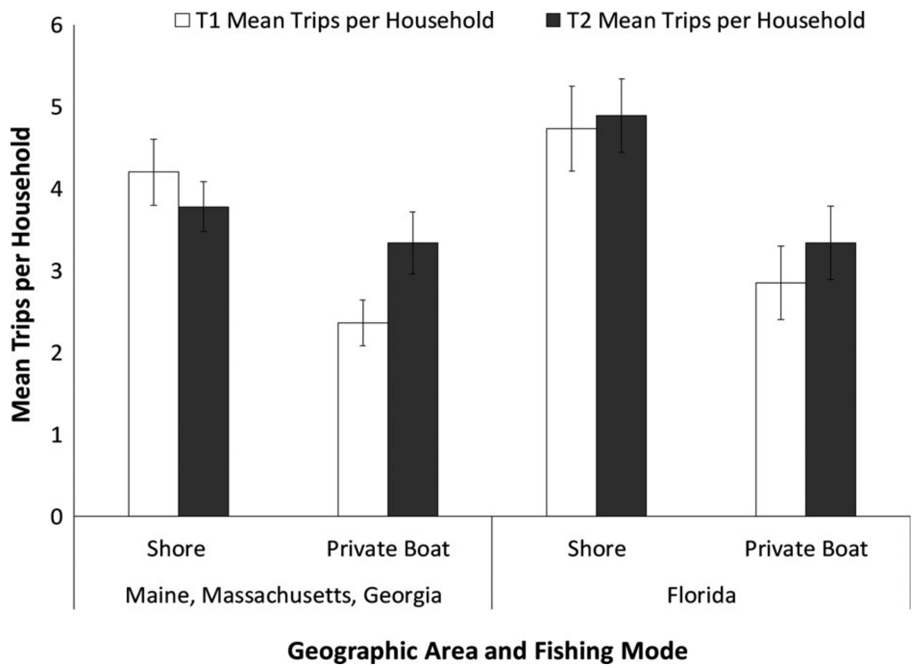

FIGURE 4. Comparison of mean fishing trips per household (±SE) in treatment 1 (T1; using the most recent of the 2 months within the treatment) and treatment 2 (T2; 1-month reference period) by geographic area and fishing mode. There were no significant differences in mean trips per household between T1 and T2 ($P > 0.05$).

treatment 2 estimates were not the result of omission error in the FES.

An alternative explanation for the differences between FES estimates and those based upon a single month (treatment 2) is that when asked to report for a single month, respondents telescoped trips from prior months into the reference period. This explanation is consistent with the observed differences between treatment 2 and treatment 1 estimates, both of which were based upon reported fishing trips during the most recent month and had the same recall period. The distinction between treatments 1 and 2 was that treatment 1 utilized a bounded design, asking first about fishing activity during the more distant month before asking about the more recent month.

Differences between trip estimates from treatments 1 and 2 were the result of differences in fishing prevalence rather than differences in the number of trips reported per household: more households reported fishing when the reference period was limited to a single month, but those households that did report fishing reported a similar number of trips, regardless of treatment. This result may reflect social desirability bias (Chu et al. 1989) or the desire by respondents to complete the requested task of reporting some level of fishing effort (Sudman and Bradburn 1974). In other words, respondents may think they are being helpful by providing a positive response to questions about fishing effort. Anglers who actually did fish are able to satisfy this desire without having to telescope trips into the reference period. The longer FES reference period may help to satisfy this desire and may partially mitigate the impacts of telescoping error by increasing the probability that a respondent actually did fish during the reference period.

Similarly, asking about fishing trips for two separate months, as in treatment 1, may minimize telescoping error for the most recent month by providing bounds against which responses are based. Neter and Waksberg (1964), who utilized a panel approach to improve recall and minimize telescoping error, initially described the potential benefits of bounded recall. In their design, the initial interview provided a recall bound for subsequent interviews. Sudman et al. (1984) modified the design to apply bounded interviewing in a single contact by asking about behaviors for multiple periods—first an earlier period and then a more recent period. Sudman et al. (1984) and others (Loftus et al. 1990) found that this approach reduced telescoping in the more recent reference period, resulting in lower, more accurate estimates. Our results suggest that bounded recall (as in treatment 1) minimizes telescoping for the most recent reference month by providing an additional opportunity for respondents to report a socially desirable behavior.

Based upon the results from this study, we cannot attribute differences in estimates between the FES and experimental treatments to recall error in the FES design. In fact, limiting the recall period to a single month appeared to increase recall error, resulting in overestimates of fishing effort. These results were consistent across geographic regions and fishing modes. If shorter, 1-month estimates are desired, however, our results suggest that a bounded 2-month design may be optimal for reducing recall error by using data from the second, most recent month of the reference period. These findings highlight the need for careful consideration of changes to survey designs, as subtle questionnaire differences can have substantial impacts on survey results. In weighing the trade-offs of survey design changes, consideration must also be given to precision, the subsequent sampling requirements needed to support different levels of resolution, and the impact of increased sampling on survey costs.

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Appendix 1: Difference in Questionnaires

FES Questionnaire (Q's 15 and 16)	Treatment 1 Questionnaire (Q's 15 and 16)	Treatment 2 Questionnaire (Q's 15 and 16)
Please think only about recreational saltwater fishing in <Merged State>. **15** How many days did you go recreational saltwater fishing from the shore in <Merged State>? The shore includes docks, bridges, causeways, beaches, banks, or any other shore-based place or area. ☐ No shore recreational saltwater fishing in the last 12 months → ***Go to question 16*** ☐☐ Number of days in July and August of 2015 ☐☐ Total number of days in last 12 months **16** How many days did you go recreational saltwater fishing from a private or rental boat that returned to shore in <Merged State>? Do not include charter boats or commercial boats that have a captain or crew who helped locate and catch fish. ☐ No private boat recreational saltwater fishing in last 12 months → ***Go to Household Member 2*** ☐☐ Number of days in July and August of 2015 ☐☐ Total number of days in last 12 months **If you have more household members, continue to household member 2.**	**Please think only about recreational saltwater fishing in <Merged State>.** **15** **How many days did you go recreational saltwater fishing from the SHORE in <Merged State>?** *The shore includes docks, bridges, causeways, beaches, banks, or any other shore-based place or area. Do not include freshwater fishing.* ☐ Did not recreational saltwater fish from shore in the last 12 months → ***Go to question 16*** ☐☐ Number of days shore fishing in Jun. of 2015 ☐☐ Number of days in Jul. of 2015 ☐☐☐ Total number of days in last 12 months, including Jun. and Jul. **16** **How many days did you go recreational saltwater fishing from a private or rental BOAT that returned to shore in <Merged State>?** *Do not include charter boats or commercial boats where a paid captain or crew helped locate and catch fish.* ☐ Did not recreational saltwater fish from private boat in last 12 months. ☐☐ Number of days boat fishing in Jun. of 2015 ☐☐ Number of days boat fishing in Jul. of 2015 ☐☐☐ Total number of days boat fishing in last 12 months, including Jun. and Jul. **If you have more household members, continue to household member 2.**	**Please think only about recreational saltwater fishing in <Merged State>.** **15** **How many days did you go recreational saltwater fishing from the SHORE in <Merged State>?** *The shore includes docks, bridges, causeways, beaches, banks, or any other shore-based place or area. Do not include freshwater fishing.* ☐ Did not recreational saltwater fish from shore in the last 12 months → ***Go to question 16*** ☐☐ Number of days in Jul. of 2015 ☐☐☐ Total number of days in last 12 months, including Jul. **16** **How many days did you go recreational saltwater fishing from a private or rental BOAT that returned to shore in <Merged State>?** *Do not include charter boats or commercial boats where a paid captain or crew helped locate and catch fish.* ☐ Did not recreational saltwater fish from private boat in last 12 months. ☐☐ Number of days boat fishing in Jul. of 2015 ☐☐☐ Total number of days in last 12 months, including Jul. **If you have more household members, continue to household member 2.**

FIGURE A.1.1. Difference among the treatment 1, treatment 2, and Fishing Effort Survey (FES) questionnaires. The questionnaires consisted of 16 questions for up to five people living in the household. The surveys differed only in questions 15 and 16, which were about recalling shore and private boat fishing activity. Questions 15 and 16 for each of the three surveys used in this study are presented.

Appendix 2: Sample Sizes and Response Rates

TABLE A.2.1. Sample sizes and response rates per stratum and the estimated total number of households in each stratum for treatment 1 (T1), treatment 2 (T2), and the Fishing Effort Survey (FES).

Survey	Month	State	Geographic stratum (coastal or noncoastal)	License status (matched or unmatched)	Sample size	Complete surveys	Estimated number of households in the stratum
T1	Jul	FL	Coastal	Matched	108	41	699,510
		FL	Coastal	Unmatched	392	116	6,512,564
		GA	Coastal	Matched	157	68	45,540
		GA	Coastal	Unmatched	160	45	261,939
		GA	Noncoastal	Matched	48	19	147,656
		GA	Noncoastal	Unmatched	134	43	3,094,723
		MD	Coastal	Matched	34	14	70,723
		MD	Coastal	Unmatched	329	98	1,848,157
		MD	Noncoastal	Matched	33	10	8,173
		MD	Noncoastal	Unmatched	103	43	235,552
		MA	Coastal	Matched	115	54	44,695
		MA	Coastal	Unmatched	331	118	1,870,372
		MA	Noncoastal	Matched	20	13	16,355
		MA	Noncoastal	Unmatched	33	13	605,543
T2	Jul	FL	Coastal	Matched	108	42	699,510
		FL	Coastal	Unmatched	392	135	6,512,564
		GA	Coastal	Matched	158	61	43,604
		GA	Coastal	Unmatched	161	44	261,939
		GA	Noncoastal	Matched	48	15	147,656
		GA	Noncoastal	Unmatched	134	45	3,094,723
		MD	Coastal	Matched	34	11	70,723
		MD	Coastal	Unmatched	329	121	1,848,157
		MD	Noncoastal	Matched	34	27	8,173
		MD	Noncoastal	Unmatched	104	41	235,552
		MA	Coastal	Matched	115	50	44,695
		MA	Coastal	Unmatched	332	109	1,870,372
		MA	Noncoastal	Matched	21	3	16,355
		MA	Noncoastal	Unmatched	33	12	605,543
T1	Aug	FL	Coastal	Matched	90	35	603,521
		FL	Coastal	Unmatched	410	135	6,608,553
		GA	Coastal	Matched	157	62	37,507
		GA	Coastal	Unmatched	160	56	268,036
		GA	Noncoastal	Matched	48	22	137,828
		GA	Noncoastal	Unmatched	134	38	3,104,551
		MD	Coastal	Matched	26	9	91,796
		MD	Coastal	Unmatched	355	136	1,827,084
		MD	Noncoastal	Matched	8	5	6,464
		MD	Noncoastal	Unmatched	110	46	237,261
		MA	Coastal	Matched	94	48	76,538
		MA	Coastal	Unmatched	358	126	1,838,529
		MA	Noncoastal	Matched	10	6	13,417
		MA	Noncoastal	Unmatched	38	15	608,481

TABLE A.1. Continued.

Survey	Month	State	Geographic stratum (coastal or noncoastal)	License status (matched or unmatched)	Sample size	Complete surveys	Estimated number of households in the stratum
T2	Aug	FL	Coastal	Matched	90	36	603,521
		FL	Coastal	Unmatched	410	129	6,608,553
		GA	Coastal	Matched	158	65	37,507
		GA	Coastal	Unmatched	161	54	268,036
		GA	Noncoastal	Matched	48	18	137,828
		GA	Noncoastal	Unmatched	134	43	3,104,551
		MD	Coastal	Matched	26	9	91,796
		MD	Coastal	Unmatched	356	110	1,827,084
		MD	Noncoastal	Matched	9	7	6,464
		MD	Noncoastal	Unmatched	110	49	237,261
		MA	Coastal	Matched	94	44	76,538
		MA	Coastal	Unmatched	358	121	1,838,529
		MA	Noncoastal	Matched	10	4	13,417
		MA	Noncoastal	Unmatched	38	14	608,481
FES	Jul/Aug	FL	Coastal	Matched	74	24	647,686
		FL	Coastal	Unmatched	309	96	6,564,388
		GA	Coastal	Matched	359	155	47,275
		GA	Coastal	Unmatched	366	110	268,962
		GA	Noncoastal	Matched	109	43	141,962
		GA	Noncoastal	Unmatched	305	96	3,089,723
		MD	Coastal	Matched	60	22	86,113
		MD	Coastal	Unmatched	879	326	1,832,767
		MD	Noncoastal	Matched	20	8	7,593
		MD	Noncoastal	Unmatched	272	100	236,132
		MA	Coastal	Matched	158	86	67,843
		MA	Coastal	Unmatched	699	264	1,847,224
		MA	Noncoastal	Matched	25	15	16,754
		MA	Noncoastal	Unmatched	66	20	605,144
T1	Sep	FL	Coastal	Matched	101	46	680,637
		FL	Coastal	Unmatched	398	123	6,531,437
		GA	Coastal	Matched	157	66	39,333
		GA	Coastal	Unmatched	160	49	266,210
		GA	Noncoastal	Matched	48	22	122,817
		GA	Noncoastal	Unmatched	134	41	3,119,562
		MD	Coastal	Matched	29	9	102,387
		MD	Coastal	Unmatched	352	118	1,816,493
		MD	Noncoastal	Matched	10	5	7,593
		MD	Noncoastal	Unmatched	108	40	236,132
		MA	Coastal	Matched	91	40	74,142
		MA	Coastal	Unmatched	361	125	1,840,925
		MA	Noncoastal	Matched	15	8	20,797
		MA	Noncoastal	Unmatched	32	9	601,101

TABLE A.1. Continued.

Survey	Month	State	Geographic stratum (coastal or noncoastal)	License status (matched or unmatched)	Sample size	Complete surveys	Estimated number of households in the stratum
T2	Sep	FL	Coastal	Matched	102	31	680,637
		FL	Coastal	Unmatched	399	129	6,531,437
		GA	Coastal	Matched	158	64	39,333
		GA	Coastal	Unmatched	161	52	266,210
		GA	Noncoastal	Matched	48	14	122,817
		GA	Noncoastal	Unmatched	134	39	3,119,562
		MD	Coastal	Matched	29	11	102,387
		MD	Coastal	Unmatched	353	117	1,816,493
		MD	Noncoastal	Matched	10	2	7,593
		MD	Noncoastal	Unmatched	109	38	236,132
		MA	Coastal	Matched	91	32	74,142
		MA	Coastal	Unmatched	361	112	1,840,925
		MA	Noncoastal	Matched	16	9	20,797
		MA	Noncoastal	Unmatched	33	12	601,101
T1	Oct	FL	Coastal	Matched	96	34	648,276
		FL	Coastal	Unmatched	404	109	6,563,798
		GA	Coastal	Matched	140	40	38,814
		GA	Coastal	Unmatched	177	65	266,729
		GA	Noncoastal	Matched	64	26	116,218
		GA	Noncoastal	Unmatched	117	25	3,126,161
		MD	Coastal	Matched	21	9	90,872
		MD	Coastal	Unmatched	360	108	1,828,008
		MD	Noncoastal	Matched	10	7	8,928
		MD	Noncoastal	Unmatched	108	39	234,797
		MA	Coastal	Matched	76	38	74,315
		MA	Coastal	Unmatched	376	133	1,840,752
		MA	Noncoastal	Matched	11	2	19,729
		MA	Noncoastal	Unmatched	36	14	602,169
T2	Oct	FL	Coastal	Matched	96	33	648,276
		FL	Coastal	Unmatched	404	134	6,563,798
		GA	Coastal	Matched	141	49	38,814
		GA	Coastal	Unmatched	178	46	266,729
		GA	Noncoastal	Matched	65	20	116,218
		GA	Noncoastal	Unmatched	118	30	3,126,161
		MD	Coastal	Matched	22	10	90,872
		MD	Coastal	Unmatched	360	118	1,828,008
		MD	Noncoastal	Matched	10	4	8,928
		MD	Noncoastal	Unmatched	109	40	234,797
		MA	Coastal	Matched	76	37	74,315
		MA	Coastal	Unmatched	376	123	1,840,752
		MA	Noncoastal	Matched	12	5	19,729
		MA	Noncoastal	Unmatched	37	13	602,169

TABLE A.1. Continued.

Survey	Month	State	Geographic stratum (coastal or noncoastal)	License status (matched or unmatched)	Sample size	Complete surveys	Estimated number of households in the stratum
FES	Sep/Oct	FL	Coastal	Matched	92	34	725,942
		FL	Coastal	Unmatched	336	112	6,486,132
		GA	Coastal	Matched	214	85	42,708
		GA	Coastal	Unmatched	226	71	262,835
		GA	Noncoastal	Matched	94	29	121,331
		GA	Noncoastal	Unmatched	158	39	3,121,048
		MD	Coastal	Matched	67	31	108,769
		MD	Coastal	Unmatched	926	289	1,810,111
		MD	Noncoastal	Matched	33	20	14,731
		MD	Noncoastal	Unmatched	276	103	228,994
		MA	Coastal	Matched	138	58	67,227
		MA	Coastal	Unmatched	772	280	1,846,442
		MA	Noncoastal	Matched	27	7	23,117
		MA	Noncoastal	Unmatched	69	19	600,180
T1	Nov	FL	Coastal	Matched	89	29	604,383
		FL	Coastal	Unmatched	410	116	6,607,691
		GA	Coastal	Matched	146	57	31,139
		GA	Coastal	Unmatched	172	42	204,749
		GA	Noncoastal	Matched	63	18	115,953
		GA	Noncoastal	Unmatched	119	32	3,196,081
		MD	Coastal	Matched	25	13	105,665
		MD	Coastal	Unmatched	356	110	1,813,215
		MD	Noncoastal	Matched	12	6	10,713
		MD	Noncoastal	Unmatched	106	43	233,012
		MA	Coastal	Matched	77	37	75,292
		MA	Coastal	Unmatched	375	118	1,839,775
		MA	Noncoastal	Matched	9	2	15,440
		MA	Noncoastal	Unmatched	39	13	606,458
T2	Nov	FL	Coastal	Matched	90	35	604,383
		FL	Coastal	Unmatched	411	124	6,607,691
		GA	Coastal	Matched	146	54	31,139
		GA	Coastal	Unmatched	172	45	204,749
		GA	Noncoastal	Matched	63	22	115,953
		GA	Noncoastal	Unmatched	119	25	3,196,081
		MD	Coastal	Matched	25	13	105,665
		MD	Coastal	Unmatched	357	112	1,813,215
		MD	Noncoastal	Matched	12	8	10,713
		MD	Noncoastal	Unmatched	107	38	233,012
		MA	Coastal	Matched	77	33	75,292
		MA	Coastal	Unmatched	375	114	1,839,775
		MA	Noncoastal	Matched	9	5	15,440
		MA	Noncoastal	Unmatched	39	17	606,458

TABLE A.1. Continued.

Survey	Month	State	Geographic stratum (coastal or noncoastal)	License status (matched or unmatched)	Sample size	Complete surveys	Estimated number of households in the stratum
T1	Dec	FL	Coastal	Matched	92	30	628,325
		FL	Coastal	Unmatched	408	147	6,583,749
		GA	Coastal	Matched	120	46	33,030
		GA	Coastal	Unmatched	198	51	202,858
		GA	Noncoastal	Matched	43	16	118,533
		GA	Noncoastal	Unmatched	139	39	3,193,501
		MD	Coastal	Matched	15	11	68,610
		MD	Coastal	Unmatched	366	112	1,850,270
		MD	Noncoastal	Matched	17	9	16,187
		MD	Noncoastal	Unmatched	101	43	227,538
		MA	Coastal	Matched	84	44	84,902
		MA	Coastal	Unmatched	367	143	1,830,165
		MA	Noncoastal	Matched	11	8	17,955
		MA	Noncoastal	Unmatched	37	15	603,943
T2	Dec	FL	Coastal	Matched	92	42	628,325
		FL	Coastal	Unmatched	408	129	6,583,749
		GA	Coastal	Matched	120	45	33,030
		GA	Coastal	Unmatched	198	70	202,858
		GA	Noncoastal	Matched	43	15	118,533
		GA	Noncoastal	Unmatched	139	39	3,193,501
		MD	Coastal	Matched	16	3	68,610
		MD	Coastal	Unmatched	366	124	1,850,270
		MD	Noncoastal	Matched	18	13	16,187
		MD	Noncoastal	Unmatched	101	36	227,538
		MA	Coastal	Matched	85	45	84,902
		MA	Coastal	Unmatched	368	130	1,830,165
		MA	Noncoastal	Matched	11	5	17,955
		MA	Noncoastal	Unmatched	37	13	603,943
FES	Nov/Dec	FL	Coastal	Matched	157	75	694,039
		FL	Coastal	Unmatched	622	186	6,518,035
		GA	Coastal	Matched	564	215	32,190
		GA	Coastal	Unmatched	970	264	203,263
		GA	Noncoastal	Matched	235	94	132,273
		GA	Noncoastal	Unmatched	644	201	3,180,195
		MD	Coastal	Matched	116	58	80,165
		MD	Coastal	Unmatched	2,196	735	1,840,010
		MD	Noncoastal	Matched	36	22	12,231
		MD	Noncoastal	Unmatched	683	254	230,199
		MA	Coastal	Matched	395	198	76,860
		MA	Coastal	Unmatched	1,941	712	1,838,207
		MA	Noncoastal	Matched	25	12	17,995
		MA	Noncoastal	Unmatched	221	81	603,903