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MANAGEMENT BRIEF

Mode Effect and Response Rate Issues in Mixed-Mode Survey Research: Implications for Recreational Fisheries Management

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Abstract

While the social, economic, and ecological impact of recreational fisheries is well established, the inherent diversity of both fisheries resources and resource users, particularly anglers, continues to present a challenge for management agencies. To better understand the diversity of recreational anglers, agencies often utilize survey methods to collect data on angler characteristics and preferences. However, obtaining necessary and representative data is becoming more challenging, exacerbated by declining response rates and an increase in the number of single and mixed-mode survey designs researchers can choose to collect data. We examined three survey designs—surface mail with a Web push, e-mail, and mixed mode—each with varying modes of solicitation and response, in the context of a statewide survey of licensed Texas anglers. Our findings illustrated that response rates varied considerably among these three survey designs. We also observed significant variation in terms of anglers' sociodemographic characteristics based on solicitation and response modes of each survey design. Interestingly, we observed limited variation in terms of anglers' behaviors, preferences, and motivations. Our results highlight the need for researchers and managers to be aware of the various survey designs available and the variability that particular survey designs can introduce into data.

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The importance of recreational fisheries has been increasingly recognized in the USA and abroad for their social (Wilde et al. 1996; Hickley and Tompkins 1998), economic (Hutt et al. 2012), and ecological impacts (McPhee et al. 2002; Coleman et al. 2004). However, the diffuse nature of access and heterogeneity in preferences of anglers makes managing recreational fisheries particularly challenging. Thus, effective management of recreational fisheries necessitates in-depth knowledge of angler attitude and behavior (Ward et al. 2013). To that end, ecological data relevant to understanding the populations and habitat characteristics of target species are often incorporated into decision-support models for fisheries management (Hillborn and Walters 1992). However, data concerning the characteristics, preferences, and behaviors of recreational anglers, which enable managers to gauge the efficacy of management decisions and policy, are only recently, relative to ecological data, being included in decisions for recreational fisheries management (Fenichel et al. 2012).

Obtaining these data on a scale applicable to fisheries management agencies with statewide jurisdictions is a challenge for human dimensions researchers in the United States. Human dimensions data have historically been collected through mail-back questionnaires delivered to a sample of residential addresses from a population of licensed anglers. However, response rates for mail-back questionnaires have declined precipitously over recent decades within both the context of natural resource management (Connelly et al. 2003) and the social sciences generally (National Research Council 2013; J. A. Boser and K. Green, paper presented at the MidSouth Educational Research Association annual meeting, 1997). This decline has brought into question the ability of mail-based survey methods to obtain representative data for use in recreational fisheries management, particularly when knowledge of the characteristics of the broader population of anglers is limited.

In response, managers have sought alternative methods of data collection. Mixed-mode designs—those utilizing a combination of solicitation and response modes, e.g., mail and e-mail—have emerged as one such alternative. These methods are potentially more cost effective, limit sampling biases, and increase response rates (Connelly et al. 2003; Stoop et al. 2010; Kreuter 2013; Gigliotti and Dietsch 2014). However, participants of mixed-mode surveys can vary significantly in terms of their sociodemographic characteristics depending on the method by which they were initially solicited and ultimately chose to respond (e.g., e-mail compared with mail-back questionnaires; Graefe et al. 2011; Lesser et al. 2011; Sexton et al. 2011). Although mode effects concerning sociodemographic characteristics are fairly well documented (Vaske 2011), the extent to which different modes of survey solicitation and response influence variables of interest to recreational fisheries management, including angler behaviors, motivations, preferences, and expenditures, is relatively unknown but of practical importance.

The purpose of this study is to compare differences in response rates, sociodemographic characteristics, and angler behaviors, motivations, preferences, and expenditures between and within samples obtained from three common survey designs. Our findings provide insights regarding the strengths and limitations of these survey methods for researchers designing and analyzing survey-based data. Likewise, our results provide needed clarification concerning variability in factors of interest to recreational fisheries management.

Survey Methods and Evaluation in Human Dimensions Research

Mixed-mode surveys typically solicit participants to complete a questionnaire using a combination of data collection modes. For example, participants can be sent (1) a hard copy mail-back questionnaire to their residential address, (2) a solicitation letter sent to their residential address with a link to a Web site to complete the questionnaire online, and/or (3) an invitation via e-mail to complete an online questionnaire. Participants may be contacted multiple times through each of the modes described above or through additional prompts, e.g., advance-notice letter, thank you cards, or reminder cards, depending on the specific study design (Dillman et al. 2014). In addition to the advantages to mixed-mode designs previously mentioned, they also lessen the time it takes to collect data, improve response rates, decrease nonresponse bias (Dillman et al. 2009; Stern et al. 2014), reduce monetary costs (Schmidt 1997; Greenlaw and Brown-Welty 2009), and reduce coverage error (Dillman et al. 2014).

While mixed-mode designs are a potentially effective alternative to customary mail-based methods, they are not without their own sources of potential bias or mode effects (Bradburn 1983; Babbie 1998; Dillman 2000; Sax et al. 2003; de Leeuw 2005; Vaske 2011). In general, the mode in which a questionnaire is administered may affect a participant's answers to specific questions, place an unaccounted response burden on a participant, or otherwise affect a participant's ability to receive or respond to the questionnaire. Here, mode refers to the method of data collection—how an individual's participation is solicited and subsequently completes the questionnaire—and mode effect refers to variation in sample characteristics as a function of the method of collection. For example, limited access to the Internet, unfamiliarity with the Internet, or a lack of a computer can constrain participation in Web-based surveys, and while stratified-sampling and statistical-weighting techniques can alleviate potential biases associated with mode effects, those techniques only do so if the relevant population data to be used for weighting against are known.

Although mode effects can vary from context to context, research has observed a number of common differences in participants' characteristics as a function of survey methods (Schwarz et al. 1991; Dillman and Christian 2005; Elliott

et al. 2009; Vannieuwenhuyze et al. 2010; Shin et al. 2012). A recent special issue of the journal *Human Dimensions of Wildlife* published several studies that addressed some of these concerns. In a survey of National Wildlife Refuge visitors, Sexton et al. (2011) observed significant differences in education and income based on the participant's mode of response. Their results indicated participants who completed online questionnaires were significantly wealthier and received more years of formal education than individuals who responded to questionnaires through the mail. Similarly, a survey of Pennsylvania recreationists conducted by Graefe et al. (2011) found significant differences in age, income, and education among study participants based on their mode of response, with online participants tending to be younger, wealthier, and possess more years of formal education. Among licensed Oregon hunters, Lesser et al. (2011) also observed differences in participant characteristics based on mode of response. Their results illustrated that, while controlling for age and gender, an individual's decision to respond depended on the mode of solicitation, i.e., by mail invite only or through an Internet and mail invite, with older participants less likely to complete an online questionnaire.

While these and other studies have furthered our knowledge of mode effects' impact on the distribution of participants' sociodemographic characteristics, they do not, for the most part, address the potential impact mode effects may have on variables of more substantive interest to recreational fisheries managers. For example, indicators of anglers' harvest orientations and catch rates have potential implications for setting bag limits for specific species (Schroeder and Fulton 2013). An understanding of angler fishing-related expenditures can also reveal the economic impact and value that recreational fisheries have to communities and the state (Southwick Associates 2013). Likewise, an understanding of angler satisfaction provides agencies with a broader understanding of the extent to which they are meeting the public's angling needs (Beardmore at al. 2015).

The Current Study

The Texas Parks and Wildlife Department's (TPWD) Statewide Survey of Licensed Anglers provides a context in which to explore these issues. The statewide survey is conducted approximately every 5 years to assess Texas anglers' motives, preferences, satisfaction, sociodemographic characteristics, expenditures, and behaviors associated with the recreational fisheries of Texas. Since 1993, the survey has experienced a precipitous decline in response rate (Figure 1 in present paper; Kyle et al. 2014). In response to this decline, researchers have explored alternative modes of survey collection, including mixed-mode designs. However, questions remain regarding the most appropriate sampling design and analyses to attend to these concerns. To address these questions, we designed a quasiexperimental study incorporating three common sampling designs into the most recent Statewide Survey of Licensed Anglers: mixed mode, e-mail only, and surface mail with Web push. We were interested in determining whether these three survey designs produce samples with similar patterns of angler participation (e.g., behaviors, motivations, preferences, and expenditures), sociodemographic characteristics, and response rates. Similarities and differences among the samples produced by these designs can elucidate how variables of interest to managers are influenced by the survey methods used to assess them, and therefore the management decisions informed by them.

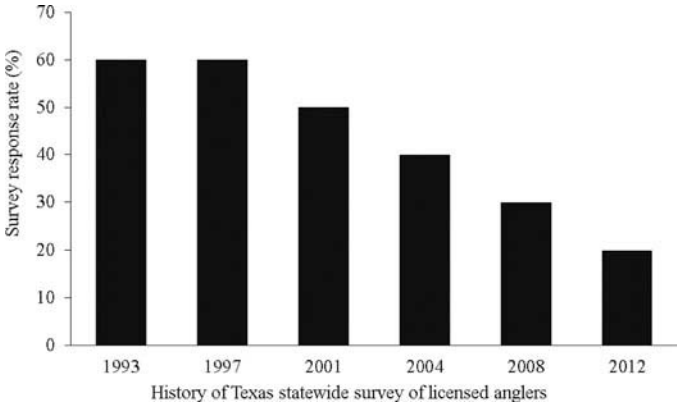

FIGURE 1. Response rates for the Texas Statewide Survey of Licensed Anglers from 1993 to 2012. Between 1993 and 2008, the statewide survey design was entirely a mail-back questionnaire. The 2012 survey response rate reflects only the mixed-mode treatment questionnaires.

METHODS

Data collection.—In partnership with TPWD, the Statewide Survey of Licensed Anglers was administered via three modes of solicitation: a surface mail with Web push, a mixed mode with both mail (with Web push) and e-mail invitation, and an e-mail invitation. Freshwater and saltwater anglers (n = 9,000) were sampled from the larger population of approximately 1.2 million resident license holders in Texas (license period: September 1, 2011, through August 31, 2012). Texas residents can purchase fishing licenses at a range of locations across Texas, including TPWD offices, TPWD managed state parks, commercial outdoor stores, and online through the TPWD Web site. The range of personal information collected at the point of sale varies as a consequence of the resident's personal characteristics (e.g., does not possess an e-mail account) and the capacity of the unit selling the license (e.g., does not collect e-mail address information). The only information collected from *all* licensed Texas anglers is postal address and age. Approximately 5% of license holders provided their e-mail address for the 2011–2012 license period. For all three solicitation modes, the collection protocols were modified from the framework outlined by Dillman et al. (2014). Letters, survey packets, and e-mails were synchronized to arrive at

participants' households in the last week of September 2012. The collection protocols for each sample were as follows:

1. Surface mail with a Web push (n = 4,000): Four postal invitations were sent to participants with a Web push contained within each, 1 week apart.
   a. Letter sent informing participants of the study purpose and invitation to complete the questionnaire online with a URL link provided in the body of the letter. The online questionnaire was constructed and administered through Qualtrics software. The letter indicated that a hard copy of the questionnaire would be sent in 2 weeks if there was no online completion.
   b. One week following (a), a thank-you or reminder postcard was sent to all participants. The postcard also contained the URL link to the online questionnaire.
   c. One week following (b), a second solicitation letter was sent to nonparticipants inviting them to complete the questionnaire via the URL provided within the body of the letter. Again, we indicated that a hard copy of the questionnaire would be sent in 1 week if there was no online completion.
   d. Last, a survey packet containing a cover letter (including the URL for the online questionnaire), a hard copy of the questionnaire, and a reply, postage paid, self-addressed return envelope for the completed questionnaire.
2. E-mail only (n = 4,000): Four e-mail invitations were sent 1 week apart. Similar to the cover letter sent to the Web-push group, the e-mail invitations outlined the study purpose and invited participants to complete the questionnaire online. Both a URL to be entered into participants' browser and hyperlinked icon ("Take Survey") were provided for participants to access the questionnaire.
3. Mixed mode (n = 1,000): Four simultaneous mail and e-mail invitations were sent 1 week apart. These solicitations replicated the protocols outlined for the Web-push group with simultaneous solicitation using the protocols outlined for the e-mail-only group. The sending of e-mail and postal invitations was synchronized to arrive simultaneously with e-mail invitations sent approximately 2 d after the mailing of hard copies.

Measures.—We selected questionnaire items measuring avidity, motives, satisfaction, trip expenditures, days spent fishing, and sociodemographics to compare participants across modes of survey solicitation and response. Motivations, for example, have demonstrated utility for understanding angler satisfaction, management preferences, and attitudes toward fisheries management decisions (Fedler and Ditton 1994; Fisher 1997; Arlinghaus 2006). Satisfaction is also an important construct in recreational fisheries management that has been tied to an individual's continued involvement with angling (Holland and Ditton 1992; Fedler and Ditton 1994; Sutton 2007; Sutton et al. 2009).

Motivation items were adapted from the Recreation Experience Preference (REP) scale (Driver 1983) to measure both angling-specific and activity-general motives for engagement in recreational angling. These items were measured on a five-point, Likert agreement scale: 1 = strongly disagree and 5 = strongly agree. Confirmatory factor analysis (CFA) was conducted in STATA 12 (StataCorp 2011) to test the measurement properties of the hypothesized constructs (n = 1,865). Following the recommendations of Hu and Bentler (1999), the data were an adequate fit for the model (χ^2 = 472.29, P < 0.001; root mean square error of approximation = 0.06; comparative fit index = 0.94; non-normed fit index = 0.92). Item descriptions, means, standard deviations, fully standardized factor loadings, and measures of internal consistency are presented in Table 1. Based on these results we created item parcels that represented the means of the items measuring each construct to be used in further analysis (Little et al. 2002).

Consistent with past research, avidity was measured using a single ordinal item (Graefe 1980; Salz and Loomis 2004; Sutton 2007). The avidity item asked, "compared to your other recreational activities would you rate recreational fishing as (1) your most important outdoor activity, (2) your second most important outdoor activity, (3) your third most important activity, or (4) only one of many outdoor activities." This item was subsequently recoded as 1 = most important activity and 0 = not most important activity for analysis. Satisfaction was measured using a single item that asked participants, "Overall how satisfied are you with fresh/saltwater fishing in Texas?" on a five-point Likert scale ranging from 1 = not at all satisfied to 5 = extremely satisfied. Additionally, participants were asked to recall the number of days that they spent fishing over the previous 12 months (freshwater from farm ponds or stock tanks, lakes or reservoirs from a boat, lakes or reservoirs from shore or piers, rivers and streams from a boat, rivers and streams from shore or piers; saltwater bays from a boat, bays from shore or piers, gulf from a boat, gulf from shore or piers). These categories were summed to obtain a total number of days spent fishing over the past 12 months in freshwater and saltwater (responses that totaled over 365 d were removed from the analysis). Similarly, participants were asked to estimate "typical" monetary expenditure per "typical" fishing trip for items such as gas, equipment, food, and lodging. These values were summed across all categories for each participant and coded based on whether the trip took place in saltwater or freshwater.

We also assessed angler age, gender, income, race, and ethnicity. Age was measured as continuous variable corresponding to participants' ages in years. Gender was measured as a dichotomous variable (0 = male, 1 = female). Income was a categorical variable measuring approximate household income in the previous 12 months (1 = less than US$40,000,

TABLE 1. Confirmatory factor analysis using full information maximum likelihood estimator (n = 1,865) of motivation constructs obtained from exploratory factor analysis (all items were statistically significant at $P \leq 0.001$).

Motivation	Mean	SD	λ	Z-value
Activity-general motives (α = 0.81)				
To be outdoors	4.46	0.71	0.61	31.15
For family recreation	3.92	1.07	0.42	17.16
To experience new and different things	3.38	1.17	0.60	29.83
For relaxation	4.25	0.85	0.64	33.35
To be close to water	3.74	1.10	0.61	30.38
To get away from the demands of other people	3.66	1.27	0.55	25.14
To be with friends	3.89	1.03	0.42	17.12
To experience unpolluted natural surroundings	3.97	1.07	0.61	30.72
To get away from the regular routine	4.06	1.01	0.64	33.71
Activity-specific motives (α = 0.78)				
For the experience of the catch	4.04	0.92	0.57	26.38
To test my equipment	2.33	1.13	0.60	28.86
To win a trophy or prize	1.64	0.99	0.41	16.19
To develop my skills	3.03	1.21	0.74	43.74
To obtain a trophy fish	2.29	1.27	0.54	24.07
For the fun of catching fish	3.68	1.13	0.69	37.71

2 = $40,000 to $79,999, 3 = $80,000 to $119,999, and 4 = greater than $120,000). Race (1 = white or Caucasian, 2 = all other races) and ethnicity (1 = of Hispanic or Latino origin, 2 = not of Hispanic or Latino origin) were reported as dichotomous variables.

Analysis.—We conducted a series of t-tests, ANOVA, and chi-square tests to determine differences in indicators of angling preferences, behaviors, and sociodemographics across the three treatment groups and modes of response. The first set of analyses compared motivations, satisfaction, days spent fishing, average trip expenditures, and participant age across the three treatment groups using ANOVA. We compared, gender, income, race, ethnicity, and avidity, across the three treatment groups using chi-square tests. Mixed-mode and Web-push participants were then coded based on whether they responded electronically or through surface mail, i.e., mode of response. The previous pattern of analysis was then repeated based on the mode of response using t-tests and chi-square tests. Last, we conducted a series of two-way comparisons for each of the continuous variables to examine differences in both mode of solicitation (mixed mode × Web push) and mode of response (online × paper).

RESULTS

Response Rates

Effective response rates based on mode of solicitation were 20.0% for the Web-push group (n = 697 of 3,486), 29.2% for the e-mail-only group (n = 784 of 2,685), and 63.6% for the mixed-mode group (n = 407 of 640). Within the Web-push sample, 53.8% of participants completed and returned hard copies of the questionnaire and 46.2% completed the questionnaire online. For the mixed-mode sample, 29.5% of participants completed hard copies while 70.5% completed the questionnaire online.

Mode of Solicitation

We observed significant differences in the number of days spent fishing in freshwater (F = 4.25, df = 2, P < 0.01) and the age of participants (F = 3.83, df = 2, P = 0.02) across the three modes of survey solicitation (Table 2). Pairwise comparisons illustrated that participants in the e-mail-only group (M = 19.69, SD = 25.28) spent significantly fewer days fishing than participants in the Web-push group (M = 26.03, SD = 37.54) (Table 2). In terms of age, participants in the e-mail-only group (M = 50.20, SD = 13.43) were significantly younger than individuals in the mixed-mode group (M = 52.50, SD = 14.07) (Table 2). Chi-square tests revealed significant differences in gender between the three groups (χ^2 = 53.50, df = 2, P < 0.001, Cramer's V = 0.17) (Table 3) with proportionately more women in the Web-push group. Participants' income also significantly varied across the three modes of solicitation (χ^2 = 89.78, df = 2, P < 0.001, V = 0.16) (Table 3). The proportion of participants indicating that their income was greater than $120,000 per year in the e-mail-only, mixed-mode, and Web-push groups were 42.78, 38.56, and 29.93%, respectively. No significant differences in race, ethnicity, avidity, motivations, satisfaction, or average trip expenditures were detected between participants by mode of survey solicitation.

TABLE 2. Mode of survey solicitation (between groups) ANOVA for angler characteristics and sociodemographic variables. *F*-values marked with an asterisk (*) are significant ($P \leq 0.05$).

Variable	E-mail only mean (SD)	Mixed-mode mean (SD)	Web-push mean (SD)	*F*-value
		Motivations		
General[a]	3.96 (0.62)	3.94 (0.68)	3.89 (0.68)	1.81
Specific[a]	2.87 (0.75)	2.86 (0.73)	2.77 (0.82)	2.49
		Satisfaction		
Freshwater[a]	3.57 (0.79)	3.58 (0.76)	3.51 (0.88)	0.73
Saltwater[a]	3.62 (0.83)	3.66 (0.81)	3.57 (0.85)	0.92
		Days spent fishing		
Freshwater[b]	19.69 (25.28) z	20.54 (30.96) zy	26.03 (37.54) y	4.25*
Saltwater	17.98 (20.42)	18.35 (24.52)	23.09 (39.76)	2.03
		Average trip expenditures (US$)		
Freshwater	329.58 (858.98)	397.49 (717.29)	304.86 (541.91)	0.57
Saltwater	455.48 (811.70)	398.03 (672.05)	547.69 (1039.20)	1.78
		Age		
Age[b]	50.20 (13.43) z	52.50 (14.07) y	51.60 (15.09) zy	3.83*

[a] Mean score value is on a scale ranging from 1 (not important or satisfied) to 5 (extremely important or satisfied).

[b] Different lowercase letters indicate significant differnces in means across solicitation groups ($P < 0.05$).

Mode of Response

Results of comparisons within mode of survey response also yielded significant differences in activity-general (t = 4.31; df = 1,390, 1; $P < 0.001$) and activity-specific motivations (t = 4.71; df = 1,390, 1; $P = 0.02$), days spent fishing in freshwater (t = 4.19; df = 979, 1; $P < 0.001$), days spent fishing in saltwater (t = 3.21, df = 615, $P < 0.001$), and the age of participants (t = 6.11, df = 1,819, $P < 0.001$) (Table 4). Participants who completed the survey via the Web expressed stronger activity-specific and activity-general motives, were

TABLE 3. Chi-square test results for the mode of survey solicitation of angler characteristics and sociodemographic variables. Chi-square values marked with a double asterisk (**) are highly significant ($P \leq 0.01$).

Variable	E-mail only	Mixed mode	Web push	χ^2	Cramer's V
		Gender			
Male	95.76	94.32	85.61	53.50**	0.17
Female	4.24	5.68	14.39		
		Income			
Under $40,000	5.94	10.90	17.34	89.78**	0.16
$40,000 to $79,999	22.27	22.61	33.39		
$80,000 to $119,999	29.01	27.93	23.34		
Over $120,000	42.78	38.56	25.93		
		Race			
White or Caucasian	95.70	96.71	94.61	2.63	0.04
Other than white	4.30	3.29	5.39		
		Ethnicity			
Hispanic or Latino	93.37	92.33	91.74	1.37	0.03
Not Hispanic or Latino	6.63	7.67	8.26		
		Fishing avidity			
Most important	26.96	28.57	31.60	3.08	0.05
Not most important	71.43	73.04	68.40		

TABLE 4. Summary of mean comparisons for mode of response (*t*-tests) for angler characteristics and sociodemographic variables between survey participants that responded via a paper copy or the Web. *t*-test values marked with an asterisk (*) or double asterisk (**) are significant ($P \leq 0.05$) or highly significant ($P \leq 0.01$), respectively.

Variable	Paper response mean (SD)	Web response mean (SD)	*t*-value
Motivations			
General[a]	3.78 (0.72)	3.97 (0.62)	4.71**
Specific[a]	2.75 (0.84)	2.86 (0.75)	2.35*
Satisfaction			
Freshwater[a]	3.55 (0.84)	3.55 (0.81)	0.11
Saltwater[a]	3.60 (0.82)	3.62 (0.83)	0.24
Days spent fishing			
Freshwater	30.20 (43.82)	19.88 (26.52)	4.19**
Saltwater	27.26 (48.77)	17.90 (21.18)	3.20**
Average trip expenditures ($)			
Freshwater	413.43 (751.22)	306.92 (723.12)	1.49
Saltwater	481.25 (830.71)	471.89 (880.10)	0.13
Age (years)			
Age	54.60 (14.69)	50.0 (13.82)	6.11**

[a] Mean score value is on a scale ranging from 1 (not important or satisfied) to 5 (extremely important or satisfied).

younger, and spent fewer days fishing in both saltwater and freshwater. Chi-square tests revealed significant differences in gender ($\chi^2 = 31.20$, df = 1, $P < 0.001$, $V = 0.13$) and income ($\chi^2 = 58.58$, df = 1, $P < 0.001$, $V = 0.18$) across modes of survey response (Table 5). A lower proportion of females completed the questionnaire via the Web (14.1% paper versus 6.1% Web). The proportion of participants reporting an income greater than $120,000 was 26.55% for paper-based responses and 39.16% for Web-based responses. No significant differences were observed for race, ethnicity, avidity, satisfaction, or average trip expenditures across mode of survey response.

Results from post hoc comparisons revealed significant differences in activity-general motives ($F = 7.55$, df = 3, $P < 0.001$), days spent fishing in freshwater ($F = 3.74$, df = 3, $P < 0.01$), and the age of participants ($F = 12.09$, df = 3, $P < 0.001$) across mode of solicitation and response (Table 6). For activity-general motives, post hoc analyses illustrated that participants completing the questionnaire online, regardless of mode of solicitation, expressed stronger motives. Alternately, paper-based participants reported significantly more days spent fishing and were older than Web-based participants, regardless of the mode solicitation. No significant differences were observed for activity specific motives, satisfaction, days spent fishing in saltwater, or average trip expenditures.

DISCUSSION

The purpose of this study was to compare response rates within samples obtained from three survey designs used in human dimensions research. We also tested for variation among respondents in terms of the mode of solicitation (i.e., surface mail versus e-mail) and mode or response (i.e., hard copy versus electronic). In the discussion that follows, we first address the issue of response rate generated by the three survey designs. We then shift to the variability associated with each of the designs and the potential biases and sources of sampling error associated with each of the designs. We conclude with recommendations for human dimensions of fisheries research.

Response Rates

Our findings suggest that mixed-mode designs were most effective for generating the highest response rates. Our mixed-mode design relied on both surface-mail and e-mail invitations to participants and generated response rates that were more than twice that of e-mail-only or surface-mail (with Web push) invitations. This mixed-mode design, however, relies on the availability of both the respondents' e-mail and postal addresses. In the context of TPWD, only 5% of licensed anglers provided their e-mail address at the time of license purchase. These licenses are typically purchased online or directly from TPWD offices. All other licenses are purchased from commercial vendors who may only have the capacity or wherewithal to collect data on the licensee's age. We suspect many other state agency angler databases have a similar composition, although there are signs of an increasing trend in access to and use of the Internet for purchases such as hunting and fishing licenses. Thus, if response rates are of central concern and resources are available to facilitate the collection (e.g., costs for printing and postage, labor for data entry), then mixed modes are clearly advantageous. As we discuss below, Web-based collections do introduce bias and potential sampling error. This bias is not necessarily fatal and there are postcollection tools that can help to ameliorate it.

Beyond tools to address bias, we are also seeing an increase in Internet access from underrepresented groups. Internet access has become an important social justice issue given that people of lower socioeconomic status have historically reported a disproportionately lower rate of Internet use (Jaeger et al. 2015; Pew Research Center 2015). Consequently, there has been some effort by governments at varying levels to help facilitate greater access. While different methods have the potential to unintentionally marginalize underrepresented populations in the decision-making process, increasing Internet accessibility will enable these groups to participate.

Finally, a concern for the development of Web-based designs will be ensuring the accessibility of the questionnaire on various hardware and software platforms. As suggested by Sexton et al. (2011), choosing a Web-based sampling design depends on the availability of technology to meet the needs of

TABLE 5. Chi-square tests of angler characteristics and sociodemographic variables by mode of survey response. Chi-square values marked with a double asterisk (**) are highly significant ($P \leq 0.01$).

Variable	Paper response (%)	Web response (%)	χ^2	Cramer's V
Gender				
Male	85.89	93.94	31.20**	0.13
Female	14.11	6.06		
Income				
Under $40,000	17.92	8.66	58.58**	0.18
$40,000 to $79,999	33.63	23.71		
$80,000 to $119,999	21.90	28.47		
Over $120,000	26.55	39.16		
Race				
White or Caucasian	95.26	95.63	0.11	0.01
Other than white	4.74	4.37		
Ethnicity				
Hispanic or Latino	93.80	92.10	1.43	0.03
Not Hispanic or Latino	6.20	7.88		
Fishing avidity				
Most important activity	67.74	72.12	2.60	0.04
Not most important activity	32.26	27.88		

the surveying effort. Currently, survey software (e.g., Qualtrics, Google Forms) appears to be accommodating these issues and is evolving at pace with technology. Ensuring that respondents can easily complete questionnaires on multiple devices (e.g., smart phones, tablets, different browser software) remains imperative.

In terms of recommending a sampling design to researchers or managers, our results suggest that if a high response rate is the priority the mixed-mode design we describe is warranted. However, we also suggest survey designers and management agencies consider their priorities, such as the desired number of responses, costs, and available resources they have access to for conducting their surveys, given the limited variability we observed in terms of angler behavior, preferences, motivations, and expenditures. In the context of our study, the lack of variability in these variables suggests an e-mail-only solicitation is a potential option for future collection efforts when coupled with conventional weighting techniques (e.g., age) on the collected data (Dillman et al. 2014).

Solicitation Mode Effects

In addition to the observed response-rate differences yielded by the different modes of solicitation, our analysis of between-group variability revealed little variation in respondents' motives, satisfaction, and related to fishing trip expenditures. While we did observe variation in sociodemographic characteristics of respondents, this variation was not manifested in those indicators that provide more managerially actionable insight. These findings diverge from past human dimensions of fisheries work where sociodemographic profiles often correspond with variability in factors related to preferences, motivations, and avidity (Loomis and Ditton 1987; Fedler and Ditton 1994; Wilde et al. 1998; Kagervall et al. 2014). However, market segmentation research in other recreational and leisure contexts illustrate that sociodemographic segmentation often does not identify variation in attitudes and behaviors that are more activity-specific and of particular interest to managers (Kyle et al. 2004, 2005, 2007). That is, although a particular solicitation mode may reveal variation among sociodemographic indicators, those differences do not necessarily correspond with or manifest in differences in the preferences, motivations, or other related measures of a participant's angling experience. While the presence of this bias has the potential to undermine an agency's effort to implement specific policy owing to the bias attributable to the sampling design, additional research is warranted to confirm that this form of sampling error has implications for fisheries management. The issue is serious given the mandates of the TPWD and similar government agencies to serve their constituencies. Evidence suggesting otherwise exposes agency policy to challenge from stakeholders impacted by the sampling error.

Response Mode Effects

Aside from soliciting participants through the mail or their e-mail, our Web-push and mixed-mode designs provided participants with the option to respond via a paper or Web-based questionnaire. Nearly 50% of Web-push participants and 70% of mixed-mode participants chose to respond online. These results mirror the study by Greenlaw and Brown-Welty (2009)

TABLE 6. Summary of within-group and between-group analysis (ANOVA and Tukey's post hoc mean comparisons) for angler characteristics and sociodemographic variables. *F*-values marked with an asterisk (*) or double asterisk (**) are significant ($P \leq 0.05$) or highly significant ($P \leq 0.01$), respectively.

	Web push		Mixed mode		
Variable	Paper response mean (SD)	Web response mean (SD)	Paper response mean (SD)	Web response mean (SD)	*F*-value
			Motivations		
General[a,b]	3.81 (0.72) zy	3.97 (0.61) x	3.65 (0.71) zy	4.02 (0.65) x	7.55**
Specific[a]	2.74 (0.84)	2.81 (0.77)	2.76 (0.74)	2.89 (0.73)	1.41
			Satisfaction		
Freshwater[a]	3.56 (0.88)	3.44 (0.87)	3.51 (0.67)	3.60 (0.79)	1.17
Saltwater[a]	3.57 (0.86)	3.56 (0.83)	3.71 (0.65)	3.65 (0.85)	0.64
			Days spent fishing		
Freshwater	31.58 (46.15)	20.87 (26.33)	24.88 (33.28)	19.41 (30.33)	3.74*
Saltwater	28.34 (52.65)	18.49 (22.56)	23.46 (32.21)	17.01 (22.09)	2.04
			Average trip expenditures ($)		
Freshwater	349.68 (622.49)	244.40 (404.72)	668.39 (1108.15)	302.68 (491.98)	0.57
Saltwater	515.64 (914.66)	578.16 (1147.59)	358.18 (392.66)	408.62 (729.25)	1.78
			Age (years)		
Age[b]	53.70 (13.11) zy	48.93(14.69) x	57.29 (13.11) zy	50.51 (14.00) x	12.09**

[a] Mean score value is on a scale ranging from 1 (not important or satisfied) to 5 (extremely important or satisfied).

[b] Different lowercase letters indicate significiant differences in means across solicitation groups ($P < 0.05$).

where they too used a Web-push design. They reported more than two-thirds of Web-push participants responded via the Web (61.7%). Additionally, the response rate of participants in our Web-push sample who chose to complete the questionnaire online reflected a higher online response rate than other studies using similar Web-push designs (e.g., 64.8% versus 35.2%: Schonlau et al. 2003; 80% versus 20%: Diment and Garrett-Jones 2007).

In terms of sociodemographic differences, the results of our within-group analyses were consistent with past research (Kaplowitz et al. 2004; Börkan 2010; Graefe et al. 2011; Lesser et al. 2011; Sexton et al. 2011; Gigliotti and Dietsch 2014). We observed that Web-based participants were significantly younger and wealthier than those who responded via mail-back. Paper-based participants reported being older and having spent significantly more days fishing during the past 12 months, regardless of the mode solicitation. These results, when coupled with the proportion of respondents opting to complete the questionnaire online, even when given the option of a hard copy (46.2% for Web push and 70.2% for mixed mode), signals a trend for how future surveys could be conducted. Given the growing prevalence of Internet use and its increased availability, management agencies would do well to develop protocols that enable them to capture anglers' e-mail addresses to solicit and facilitate online responses (Graefe et al. 2011). While the mixed-mode design was clearly the most successful in terms of soliciting response, the provision of online options has advantages in terms of cost and time.

Lastly, the pattern of results observed across paper and Web-based responses of Web-push and mixed-mode participants were consistent with the main effect of response mode, i.e., Web-based participants in both treatments were younger, expressed higher activity-general motivations, and spent fewer days fishing (in freshwater). The lack of observed interaction between Web and paper suggests that differences among participants might be driven more by the mode in which they chose to respond rather than the mode in which they were solicited. This particular insight warrants further investigation as it directly relates to our earlier discussion of sampling design recommendations, and researchers and managers need to balance the financial and logistic constraints of obtaining those data and adequately sampling their constituents.

Conclusion

One approach for addressing bias in data after collection is to weight the data using an indicator for which the researcher has accurate population data and has evidence the indicator is disproportionately affecting the probability of participation from all members of the targeted sample frame. The procedure, offered in most statistical software

packages, corrects for underrepresentation among the affected group such that the proportional representation of the collected data is consistent with that of the population (Dillman et al. 2014). In our data, the only population statistic available was for age. While weighting might appear to resolve any sampling bias issues, population estimates are required and justification is required for the selection of a specific weight. Thus, care must be taken when identifying a weighting variable, if an appropriate one is available. Given the body of evidence illustrating that age is related to Internet use and, thus, exposure to survey solicitations and ultimately survey response, age was deemed a reasonable weight.

There is, however, potential for agencies to be "spooked by statistical voodoo" that accompanies statistical procedures such as these, with agency staff preferring to let the raw data speak alone. While firmly established in the literature (Bandilla et al. 2003; Dillman et al. 2014), data manipulations, such as postcollection weighting, could potentially be construed as tampering. Given the political environment in which angling regulations are situated, staff strive to present data in its simplest and most easily consumed format. Agency adversaries could potentially focus a critique on the manner in which data had been handled and undermine findings that are inconsistent with their preferences. As long as the analyst is able to justify decisions related to the selected weight, with reference to the literature, weighting ultimately assists with obtaining findings from their sample data that more closely reflects the population.

Therefore, with these findings in mind, we make the following recommendations:

1. Mixed-mode survey designs that solicit participation using both surface mail and e-mail and offer choice on mode of response media generate the strongest response rates. This design offers the greatest likelihood for reducing bias. It will likely include an age bias that can be remedied by weighting if reasonable population data on age or other legitimate correlates can be identified. Weighting by age can also reduce bias in other related correlates. Mixed-mode design limitations include the requirement of an e-mail address and carry a heightened expense associated with printing, postage, and additional labor. For designs that employ Dillman-like protocols, collections can also take 2 to 3 months for completions to return.
2. E-mail-only designs offer the most cost- and time-efficient method of collection. While not generating the response rate of a mixed-mode design, it is superior to the surface-mail design. For reasons identified above, it will likely be biased by age. Beyond lower response rates, e-mail-only solicitations require access to e-mail addresses. Last, society's growing use of smart phones and other small Internet devices requires questionnaire design software be usable on these devices. For large questionnaires, questionnaire completion on a small device can be cumbersome and would likely contribute to respondent attrition.
3. The surface mail design with Web push generated the lowest response rate. Given the low response, it potentially carries the most serious bias across indicators of importance. While offering the option of a Web completion, the design can be costly and time consuming when using Dillman et al. (2014) survey protocols.

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REFERENCES

Anderson, D. K., and R. Ditton 2004. Demographics, participation, attitudes and management preferences of Texas anglers. Texas A&M University, College Station.

Arlinghaus, R. A. 2006. On the apparently striking disconnect between motivation and satisfaction in recreational fishing: the case of catch orientation of German anglers. North American Journal of Fisheries Management 26:592–605.

Beardmore, B., L. M. Hunt, W. Haider, M. Dorrow, and R. Arlinghaus 2015. Effectively managing angler satisfaction in recreational fisheries requires understanding the fish species and anglers. Canadian Journal of Fisheries and Aquatic Sciences 72:500–513.

Börkan, B. 2010. The mode effect in mixed-mode surveys mail and Web surveys. Social Science Computer Review 28:371–380.

Bradburn, N. M. 1983. Response effects. Pages 293–398 *in* R. Peter, H. Rossi, J. D. Wright, and A. B. Anderson, editors. Handbook of survey research. Academic Press, New York.

Coleman, F. C., W. F. Figueira, J. S. Ueland, and L. B. Crowder. 2004. The impact of United States recreational fisheries on marine fish populations. Science 30:1958–1960.

Connelly, N. A., T. L. Brown, and D. J. Decker. 2003. Factors affecting response rates to natural resource-focused mail surveys: empirical evidence of declining rates over time. Society and Natural Resources 16:541–549.

de Leeuw, E. D. 2005. To mix or not to mix data collection modes in surveys. Journal of Official Statistics 21:233–255.

Dillman, D. A. 2000. Mail and Internet surveys: the tailored design method. Wiley, Hoboken, New Jersey.

Dillman, D. A., and L. M. Christian. 2005. Survey mode as a source of instability in responses across surveys. Field Methods 17:30–52.

Dillman, D. A., G. Phelps, R. Tortora, K. Swift, J. Kohrell, J. Berck, and B. L. Messer. 2009. Response rate and measurement differences in mixed-mode surveys using mail, telephone, interactive voice response (IVR) and the Internet. Social Science Research 38:1–18.

Dillman, D. A., J. D. Smyth, and L. M. Christian. 2014. Internet, mail, and mixed-mode surveys: the tailored design method, 4th edition. Wiley, Hoboken, New Jersey.

Diment, K., and S. Garret-Jones. 2007. How demographic characteristics affect mode preference in a postal/Web mixed-mode survey of Australian researchers. Social Science Computer Review 2:420–427.

Driver, B. L. 1983. Master list of items for recreation experience preference scales and domains. U.S. Forest Service, Rocky Mountain Forest and Range Experiment Station, Flagstaff, Arizona.

Elliott, M. N., A. M. Zaslavsky, E. Goldstein, W. Lehrman, K. Hambarsoomians, M. K. Beckett, and L. Giordano. 2009. Effects of survey mode, patient mix, and nonresponse on CAHPS hospital survey scores. Health Services Research 44:501–518.

Fedler, A. J., and R. B. Ditton. 1994. Understanding angler motivations in fisheries management. Fisheries 19(4):6–13.

Fenichel, E. P., J. K. Abbott, and B. Huang. 2012. Modeling angler behavior as part of the management system: synthesizing a multi-disciplinary literature. Fish and Fisheries 14:137–157.

Fisher, M. R. 1997. Segmentation of the angler population by catch preference, participation, and experience: a management-oriented application of recreation specialization. North American Journal of Fisheries Management 17:1–10.

Gigliotti, L., and A. Dietsch. 2014. Does age matter? The influence of age on response rates in a mixed-mode survey. Human Dimensions of Wildlife: An International Journal 19:280–287.

Graefe, A., A. Mowen, E. Covelli, and N. Trauntvein. 2011. Recreation participation and conservation attitudes: differences between mail and online participants in a mixed-mode survey. Human Dimensions of Wildlife: An International Journal 16:183–199.

Graefe, A. R. 1980. The relationship between level of participation and selected aspects of specialization in recreational fishing. Doctoral dissertation. Texas A&M University, College Station.

Greenlaw, C., and S. Brown-Welty. 2009. A comparison of Web-based and paper-based survey methods testing assumptions of survey mode and response cost. Evaluation Review 33:464–480.

Hickley, P., and H. Tompkins. 1998. Recreational fisheries: social, economic, and management aspects. Wiley-Blackwell, London.

Hillborn, R., and C. J. Walters. 1992. Quantitative fisheries stock assessment: choice, dynamics, and uncertainty. Chapman Hall, New York.

Holland, S. M., and R. B. Ditton. 1992. Fishing trip satisfaction: a typology of anglers. North American Journal of Fisheries Management 12:28–33.

Hutt, C. P., K. M. Hunt, S. F. Steffen, S. C. Grado, and L. E. Miranda. 2012. Economic values and regional economic impacts of recreational fisheries in Mississippi reservoirs. North American Journal of Fisheries Management 33:44–55.

Jaeger, P. T., N. T. Taylor, and U. Gorham 2015. Libraries, human rights, and social justice: enabling access and promoting inclusion. Rowman and Littlefield, New York.

Kagervall, A., T. A. Heberlein, G. Hellström, and G. Ericsson. 2014. Conceptualization and measurement of catch-and-release norms. Human Dimensions of Wildlife: An International Journal 19:139–153.

Kaplowitz, M. D., T. D. Hadlock, and R. Levine. 2004. A comparison of Web and mail survey response rates. Public Opinion Quarterly 68:94–101.

Kreuter, F. 2013. Facing the nonresponse challenge. Annals of the American Political and Social Science 645:23–35.

Kyle, G. T., J. D. Absher, and C. Chancellor. 2005. Segmenting forest recreationists using their commitment profiles. Journal of Park and Recreation Administration 23:64–86.

Kyle, G. T., A. R. Graefe, and R. E. Manning. 2004. Attached recreationists… Who are they? Journal of Park and Recreation Administration 22:66–84.

Kyle, G. T., W. Norman, L. Jodice, A. R. Graefe, and A. Marsinko. 2007. Segmenting anglers using their consumptive orientation profiles. Human Dimensions of Wildlife 12:115–132.

Kyle, G. T., M. A. Schuett, K. Lee, J. Yoon, C. Ding, and K. E. Wallen. 2014. Demographics, participation, attitudes, and management preferences of Texas anglers. Texas A&M University, College Station.

Landon, A. C., J. Jun, G. T. Kyle, J. Yoon, and M. A. Schuett. 2012. Demographics, participation, attitudes and management preferences of Texas anglers. Texas A&M University, College Station.

Lesser, V. M., D. K. Yang, and L. D. Newton. 2011. Assessing hunters' opinions based on a mail and a mixed-mode survey. Human Dimensions of Wildlife: An International Journal 16:164–173.

Little, D. T., W. A. Cunningham, G. Shahar, and K. F. Widaman. 2002. To parcel or not to parcel: exploring the question, weighing the merits. Structural Equation Modeling 9:151–173.

Loomis, D. K., and R. B. Ditton. 1987. Analysis of motive and participation differences between saltwater sport and tournament fishermen. North American Journal of Fisheries Management 7:482–487.

McPhee, D. P., D. Leadbitter, and G. A. Skilleter. 2002. Swallowing the bait: is recreational fishing in Australia sustainable? Pacific Conservation Biology 8:40–51.

National Research Council. 2013. Nonresponse in social science surveys: a research agenda. National Academies Press, Washington, D.C.

Petchenik, J., and D. J. Watermolen. 2011. A cautionary note on using the Internet to survey recent hunter education graduates. Human Dimensions of Wildlife 16:216–218.

Pew Research Center. 2015. Collecting survey data (April 27). Available: http://www.pewresearch.org/methodology/u-s-survey-research/collecting-survey-data/. (April 2015).

Salz, R. J., and D. K. Loomis 2004. Saltwater anglers' attitudes towards marine protected areas. Fisheries 29(6):10–17.

Sax, L. J., S. K. Gilmartin, and A. N. Bryant. 2003. Assessing response rates and nonresponse bias in Web and paper surveys. Research in Higher Education 44:409–432.

Schmidt, W. C. 1997. World-wide web survey research: benefits, potential problems, and solutions. Behavior Research Methods, Instruments, and Computers 29:274–279.

Schonlau, M., B. J. Asch, and C. Du. 2003. Web surveys as part of a mixed mode strategy for populations that cannot be contacted by e-mail. Social Science Computer Review 21:218–222.

Schroeder, S. A., and D. C. Fulton 2013. Comparing catch orientation among Minnesota Walleye, Northern Pike, and bass anglers. Human Dimensions of Wildlife 18:355–372.

Schwarz, N., F. Strack, H. J. Hippler, and G. Bishop. 1991. The impact of administration mode on response effects in survey measurement. Applied Cognitive Psychology 5:193–212.

Sexton, N. R., H. M. Miller, and A. M. Dietsch. 2011. Appropriate uses and considerations for online surveying in human dimensions research. Human Dimensions of Wildlife: An International Journal 16:154–163.

Shin, E., T. P. Johnson, and K. Rao. 2012. Survey mode effects on data quality: comparison of Web and mail modes in a U.S. national panel survey. Social Science Computer Review 30:212–228.

Southwick Associates. 2013. Sportfishing in America: an economic force for conservation. American Sportfishing Association, Alexandria, Virginia.

StataCorp. 2011. Stata statistical software: release 12. StataCorp, College Station, Texas.

Stern, M. J., I. Bilgen, and D. A. Dillman. 2014. The state of survey methodology challenges, dilemmas, and new frontiers in the era of the tailored design. Field Methods 26:284–301.

Stoop, I., J. Billiet, A. Koch, and R. Fitzgerald. 2010. Improving survey response: lessons learned from the European Social Survey. Wiley, West Sussex, UK.

Sutton, S. G. 2007. Constraints on recreational fishing participation in Queensland, Australia. Fisheries 32:73–83.

Sutton, S. G., K. Dew, and J. Higgs. 2009. Why do people drop out of recreational fishing? A study of lapsed fishers from Queensland, Australia. Fisheries 34:443–452.

Tseng, Y., N. Wolber, and R. Ditton 2006. Demographics, participation, attitudes and management preferences of Texas anglers. Texas A&M University, College Station.

Vannieuwenhuyze, J., G. Loosveldt, and G. Molenberghs. 2010. A method for evaluating mode effects in mixed-mode surveys. Public Opinion Quarterly 74:1027–1045.

Vaske, J. J. 2011. Advantages and disadvantages of Internet surveys: introduction to the special issue. Human Dimensions of Wildlife: An International Journal 16:149–153.

Ward, H. G. M., M. S. Quinn, and J. R. Post. 2013. Angler characteristics and management implications in a large, multistock, spatially structured recreational fishery. North American Journal of Fisheries Management 33:576–584.

Wilde, G. R., R. B. Ditton, S. R. Grimes, and R. K. Riechers. 1996. Status of human dimensions surveys sponsored by state and provincial fisheries management agencies in North America. Fisheries 21(11):12–17.

Wilde, G. R., R. K. Riechers, and R. B. Ditton. 1998. Differences in attitudes, fishing motives, and demographic characteristics between tournament and nontournament black bass anglers in Texas. North American Journal of Fisheries Management 18:422–431.