

ARTICLE

Electronic Self-Reporting: Angler Attitudes and Behaviors in the Recreational Red Snapper Fishery

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Abstract

Managing large multiuser fisheries involves large amounts of data and information, including information directly from anglers. Angler-provided information may come in the form of attitudinal and behavior surveys, in addition to voluntary reporting of catch information. In this study, we wanted to better understand anglers fishing for Red Snapper *Lutjanus campechanus* in the Gulf of Mexico. Toward this end, we conducted an in-season attitudinal survey in 2018 to collect angler opinions in five areas: (1) interests, motivations, and barriers to electronic catch reporting, (2) important aspects of the Red Snapper fishery, (3) reasons why anglers report catch, (4) dockside reporting compared with electronic reporting, and (5) perceptions of fishery management agencies. Concurrently in the summer of 2018, an electronic smartphone app was made available for recreational anglers to voluntarily report their catch. We had 3,016 survey results that represented an 18% reporting rate. The survey results suggested that 84% of respondents already use a variety of smartphone apps in relation to fishing and that at least 80% reported that they were willing to electronically report their catch. Despite this high reported willingness to electronically report their catch, data from electronic reports showed that only about 1% of respondents actually reported. The development and use of electronic reporting applications (i.e., smartphone apps) holds promise to provide a wide variety of timely data to fishery managers; however, as in our study and others, usage rates remain low and challenges remain if self-reporting and other nonprobabilistic sampling methods are to be useful to fishery managers.

In many fisheries, management is complex. Successful management of a fishery involves an accurate understanding of a dynamic biological resource, the ecosystem in which that resource operates, and the harvest and removal

of the resource by humans. Within the domain of fishery removals, it is often necessary to understand the behaviors and outcomes of distinctive sectors that may act differently and exert different pressures on the resource.

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Received December 13, 2019; accepted May 28, 2020

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The fishery for Red Snapper *Lutjanus campechanus* in the Gulf of Mexico has a long management history that includes periods of overfishing and frequent changes to management strategies in both the recreational and commercial sectors (SEDAR 2018). In the 1990s, Red Snapper reached extremely low population levels, accompanied by very low spawning potential ratios and other indicators of overfishing (SEDAR 2018). In the last decade, the population has begun rebuilding. However, the species remains popular among anglers, ultimately causing debates over the best ways to manage the high demands on Red Snapper harvest while also rebuilding stock biomass. Furthermore, harvest sectors (e.g., private recreational anglers, commercial harvesters, and charter for-hire operations) have historically disagreed on catch allocation, which can exacerbate the interpretations about the science used by state and federal fishery managers.

Owing to Red Snapper's geographic distribution in both U.S. state and federal waters, additional management complexity has been introduced as multiple agencies seek common ground for a shared resource. Given the increasing number of management options and data sources that exist in fisheries today, it is a challenge for management agencies to understand perceptions and attitudes within their jurisdiction. Ultimately, the success of management is connected to anglers understanding management motivations and following regulations (Beddington et al. 2007; Brinson and Wallmo 2017); therefore, there is great incentive for agencies to understand angler opinions and attitudes to inform the adoption of regulations.

In an effort by the Louisiana Department of Wildlife and Fisheries (LDWF) to continually understand and manage their recreational Red Snapper fishery, several measures were implemented in 2018. Notably, the 2018 Red Snapper private recreational fishing season in the federal waters of the Gulf of Mexico took place under an Exempted Fishing Permit (EFP) proposed by each of the five Gulf of Mexico states (NOAA Fisheries 2019). Exempted Fishing Permits are a research tool under the Magnuson Stevens Act designed for purposes of testing management strategies and conducting scientific research (NOAA Fisheries 2019). Each EFP must be authorized by the National Oceanic and Atmospheric Administration (NOAA) and include measures to prevent overfishing; however, once the EFP was authorized, LDWF had the oversight to set the season. Louisiana's EFP allowed for a private recreational Red Snapper season in state and federal waters that was several weeks long (May 25 to August 12) in 2018, compared with much shorter seasons (e.g., just a few days to weeks) in previous years.

Another component of the private recreational EFPs included the use and evaluation of electronic reporting methods. Improved and integrated reporting by recreational

anglers is one potential solution toward the collection of data needed for stock assessment, as well as a method to increase involvement (and subsequent buy-in of assessment results) of recreational anglers. Throughout the Gulf of Mexico and other U.S. recreational fisheries, electronic angler self-reporting (eASR) is gaining recognition as one possible solution to low-cost, rapid data collection from a large number of respondents (Lorenzen et al. 2016; Venturelli et al. 2016; Crandall et al. 2018). For instance, more timely data could provide decision-making bodies with more confidence to determine when to keep the season open, close harvest, or change to a different season structure (e.g., a "weekends only" strategy). Electronic angler self-reporting also has the opportunity to collect data from anglers that launch from private docks and private marinas, which are not included in most traditional dockside intercept surveys. Additionally, as seen with data collected through other citizen science fields, eASR data has the potential to instill greater angler confidence in the resulting data (Crandall et al. 2018). In other fisheries, scientists have found that when fishermen participate in cooperative research, they learn more about the methods used to collect data and how those data are used to make management decisions; this involvement has helped promote greater trust of the data, more support for the subsequent stock assessment results, and a greater sense of stewardship, which can all help lead to a more adaptive management process (Mackinson and Nøttestad 1998; Heyman 2011). Through eASR, individual anglers report their daily catch on a smartphone app or computer, which is directly provided to a management agency in near real time. Prior to the 2018 recreational Red Snapper season, LDWF developed, beta tested, and successfully released a voluntary electronic reporting platform accessible via the Web and a smartphone-based app. Other than a short experiment electronically reporting Yellowfin Tuna *Thunnus albacares* in 2013, this was the first time that the LDWF attempted to obtain effort estimates from an angler self-reporting mobile application.

Despite the potential for improvements in data collection using eASR, foundational components of fishery management must also be in place to allow for testing and validation of eASR as a tool to improve traditional recreational surveys and the data they generate.

Louisiana's LA Creel program offers a strong foundation for survey-based fishery management information. In December 2017, Louisiana's LA Creel program was the first Gulf of Mexico state recreational survey to receive certification from NOAA Fisheries (NOAA Fisheries 2018). Additionally, it is the only state survey in the Gulf of Mexico to have received full certification for all recreationally pursued marine fish species in the state, not just Red Snapper. Starting in 2014, officials from LDWF, NOAA Fisheries, and several third-party consultants worked to refine the LA Creel sampling and estimation

methods that eventually led to the certification (NOAA Fisheries 2018). One critical component that went into the design of LA Creel was providing for ample dockside intercepts for the level of angler effort from a given area. This allowed not only a statistically valid sample size but also increased awareness and participation from anglers returning after a day of fishing. The other critical component was the development of an offshore endorsement or permit to define the universe of anglers possessing or harvesting reef fish and highly migratory species. Other U.S. Gulf of Mexico states have since followed this model, including Florida's Gulf Reef Fish Angler endorsement (from the Florida Fish and Wildlife Conservation Commission) and most recently Alabama's Reef Fish Endorsement (Alabama Department of Conservation and Natural Resources). As designed, LDWF's Recreational Offshore Landing Permit (ROLP) is free but the sign-up process is separate from the general fishing license application, thus ensuring that a participating angler has a vested interest when they are required to renew. By defining the offshore angling universe through enrollment, the LDWF is able to target their offshore surveys more efficiently and reach a more representative sample of offshore anglers, which is also important when it comes to estimating offshore effort. Based on these critical components and the certification of LA Creel, the LDWF has established a federally recognized data collection program that has become one of the most respected in the Gulf of Mexico region and has widespread support from scientists, nongovernmental organizations, and fishery managers. Such support creates a foundation for experimenting with data collection and innovative fishery management approaches.

There are often misconceptions by both anglers and managers due to a lack of communication or clarity in the management process. This study was undertaken to better understand angler attitudes regarding some Red Snapper management changes while also identifying motivations and barriers to eASR in Louisiana's private recreational Red Snapper fishery. Surveys, like the one presented in this study, can help the recreational angling community share their thoughts so that managers have a more accurate understanding of their stakeholders. Specifically, an in-season survey was conducted that asked anglers landing fish in Louisiana waters their thoughts on a range of management strategies and catch-reporting options. Along with the survey, we analyzed the attributes of anglers and trips that were electronically self-reported in order to better characterize the individuals that adopted voluntary self-reporting. Findings from the study will also be used to help determine if collecting user-supplied data through a smartphone app or Web site is feasible and identify areas to improve eASR participation for more timely and accurate data in the Louisiana private recreational Red Snapper fishery.

METHODS

In-season attitudinal survey.—In the spring of 2018, a survey was developed to measure attitudes and thoughts held by LDWF ROLP holders about management of Red Snapper in Louisiana and about eASR. The survey was developed to collect information to advance understanding for five relevant areas:

1. Interests, motivations, and barriers to electronic catch reporting.
2. Important aspects of the Red Snapper fishery.
3. Reasons why anglers report catch.
4. Dockside reporting (LA Creel) compared with electronic reporting.
5. Perceptions of fishery management agencies.

A total of 53 questions were developed using a combination of open- and closed-ended, multiple choice, rating, and preference (Likert scale) solicitation methods. Within the five primary areas of interest, specific questions were developed to ask current ROLP holders their thoughts and perceptions about the areas of interest. Some questions were unique with respect to the magnitude and direction of the possible responses, whereas other questions were derivative or inverse of some questions. For example, some questions that asked about perceptions of how well an action was being done may have been followed by a question that asked about perceptions of how poorly the same action was being done. Although these questions were written to potentially pick up on a nuance that might not be interpreted in one version of the question, when the second question resulted in an inverse distribution of responses to the first question, we have omitted reporting and analyzing both questions. (A complete version of the survey can be found in Supplement 1 available in the online version of this article.) The survey was panel-tested with a group of approximately 20 anglers with ROLP privileges (or individuals familiar with the ROLP fishery), and adjustments were made to the instrument to improve brevity and readability.

In order to produce a measure of angler avidity, participants were first asked to disclose the number of offshore trips they took in the last year (Table 1). Avidity was then used as strata through which select survey responses were analyzed. Although we did not evaluate all questions through the avidity strata, in many cases we considered that angler avidity could influence an answer. For example, it is possible that high-avidity anglers hold different attitudes about management agencies than do low-avidity anglers.

On June 8, 2018, a 53-question survey was distributed via e-mail to 17,262 current ROLP holders using e-mail addresses provided by LDWF. Out of those, 412 of the e-mail addresses were invalid, resulting in a total of 16,850

TABLE 1. Survey options for avidity along with the numbers and percentage of respondents identifying that option. Because some avidity classes were low in number and similar to another avidity class, responses were clustered.

Reported avidity	% (and number) reporting	Avidity cluster
Never	13 ($n = 387$)	Low
Once per year	21 ($n = 622$)	Low
A few times per year	47 ($n = 1,421$)	Low
Once per month	6 ($n = 167$)	Medium
A few times per month	10 ($n = 313$)	Medium
Once per week	1 ($n = 34$)	High
A few times per week	1 ($n = 22$)	High
Daily	<1 ($n = 3$)	High

e-mail requests reaching potential survey holders. The survey closed on June 22, 2018, with a total of 3,016 surveys completed, representing an 18% completion rate (the

distribution of ROLP holders is shown in Figure 1). For a population size of $N = 16,850$, we were targeting a sample size of $n = 376$ in order to have a 95% confidence level and a marginal error rate of 5% (Dillman 2007), and this sample size was exceeded. An additional 1,029 surveys were started and not completed, although answers were recorded to whatever portion of the survey they completed, and we will include those responses in our analysis. All survey actions—survey design, participation, and communication—were done through the survey software Qualtrics with Louisiana State University Institutional Review Board approval. Given the nature of our questions (most were simple agree/disagree responses), we have opted to avoid any complex statistical models for data analysis and instead chose to focus on reporting descriptive statistics because they make the point(s) we are trying to show quantitatively.

Mobile electronic reporting.—During the 2018 Red Snapper season in Louisiana, there was an option to report recreational catch with a mobile (smartphone) app (or via a Web site on a personal computer) that was linked to a fishing trip created by a ROLP holder. All trips and associated trip information were logged by the

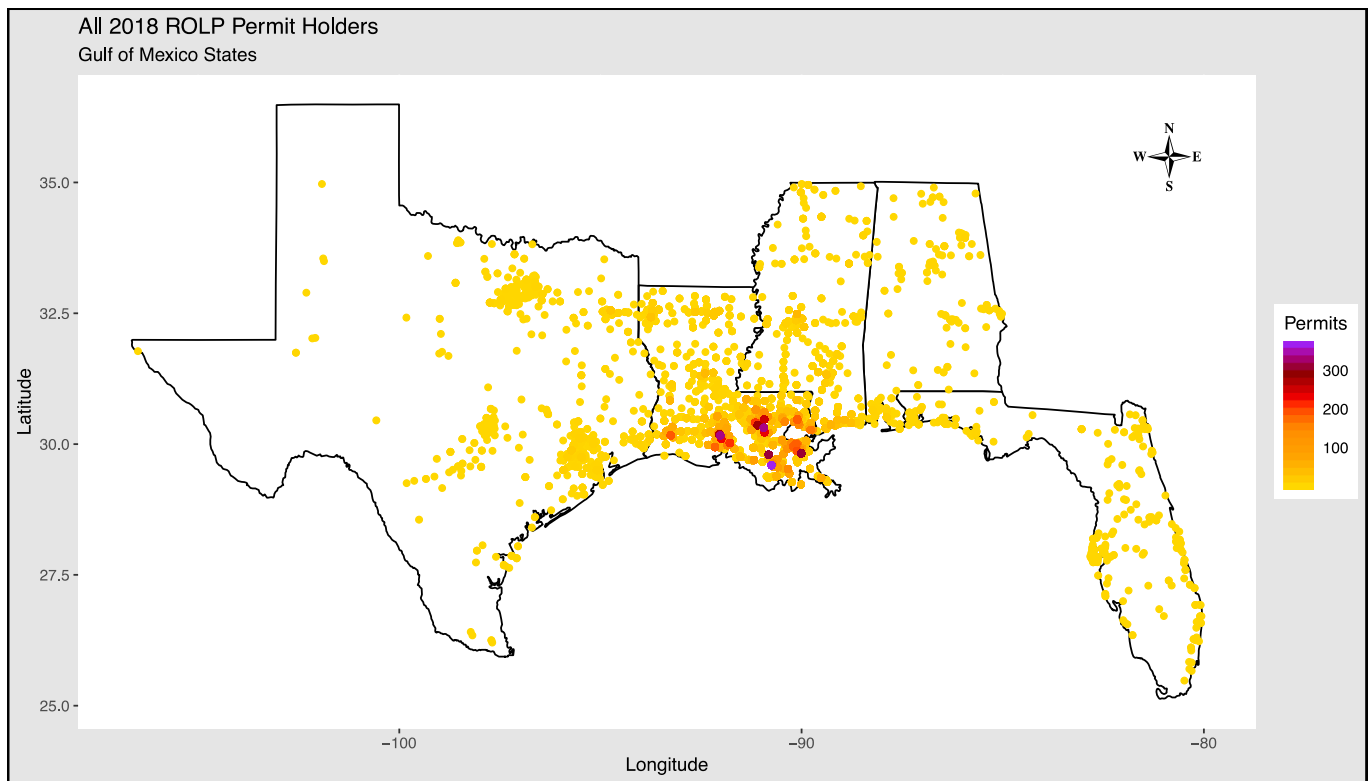


FIGURE 1. Spatial distribution and density of all 2018 Recreational Offshore Landing Permit (ROLP) holders in U.S. states with access to the Gulf of Mexico. Note that ROLP holders exist in all 50 U.S. states and even outside the USA; however, the vast majority of ROLP holders are in close proximity to the Gulf of Mexico, with most residing in Louisiana. [Color figure can be viewed at [afsjournals.org](https://onlinelibrary.wiley.com/terms-and-conditions).]

LDWF in an effort to understand any trends and patterns in electronic self-reporting.

RESULTS

In-Season Attitudinal Survey

Interest in electronic catch reporting.—We first sought to understand what interest ROLP holders had in electronic reporting. To this end, we developed eight questions in the survey (Supplement 1 questions [S1Q] 5, 6, 8–13). To begin to understand any existing use of apps by anglers, we asked ROLP holders if they used any types of apps for fishing activities (S1Q5). From five possible answers representing different generic apps (i.e., types of information an app might provide, not specific app brands), we found that the most common response was the use of a weather app (Figure 2). Overall 84% of respondents use mobile apps before, during, or after a fishing trip for a number of reasons (e.g., monitor the weather, report catch via another voluntary fishing application, share experience via social media, etc.). We next wanted to understand how often ROLP holders planned to use the voluntary ROLP app associated with the 2018 EFP for Red Snapper (S1Q6). Of the 2,945 people that responded, the most common response (34%) was that they would use the app 100% of the time, while 23% indicated they would never use it and 25% responded that they would use it only when they caught fish. When

broken down by avidity, the distribution of responses was similar among groups, suggesting that avidity was not underlying any strong motivations to use the ROLP app for catch reporting.

The ROLP holders were then asked about their attitudes toward voluntary (S1Q8) and mandatory (S1Q9) electronic reporting of Red Snapper catch. The vast majority (80%) of respondents indicated they would be willing to voluntarily report their catch, and nearly all the remaining responses were neutral (i.e., did not disagree with the statement; Figure 3). Similarly, an overwhelming majority (84%) of the respondents were in favor of (67%) or neutral (17%) towards mandatory reporting. Recreational Offshore Landing Permit holders were then asked if they trust the LDWF to use eASR data to manage the fishery (S1Q10), and the responses were overwhelmingly positive, with 80% of anglers indicating they trust the LDWF (Figure 4). Of note was that the high-avidity ROLP anglers were slightly less positive than the medium- and low-avidity anglers; in general, high-avidity anglers agreed less with trusting the LDWF to use self-reported data, although the numbers of the high-avidity group were much smaller compared with the other groups. (We do not have any indication why this difference exists, and our survey was not designed to capture this information.) When asked if self-reporting by anglers would help the state better manage the fishery (S1Q11), again 80% of ROLP holders thought it would, with very few (5%) disagreeing or strongly disagreeing (Figure 5).

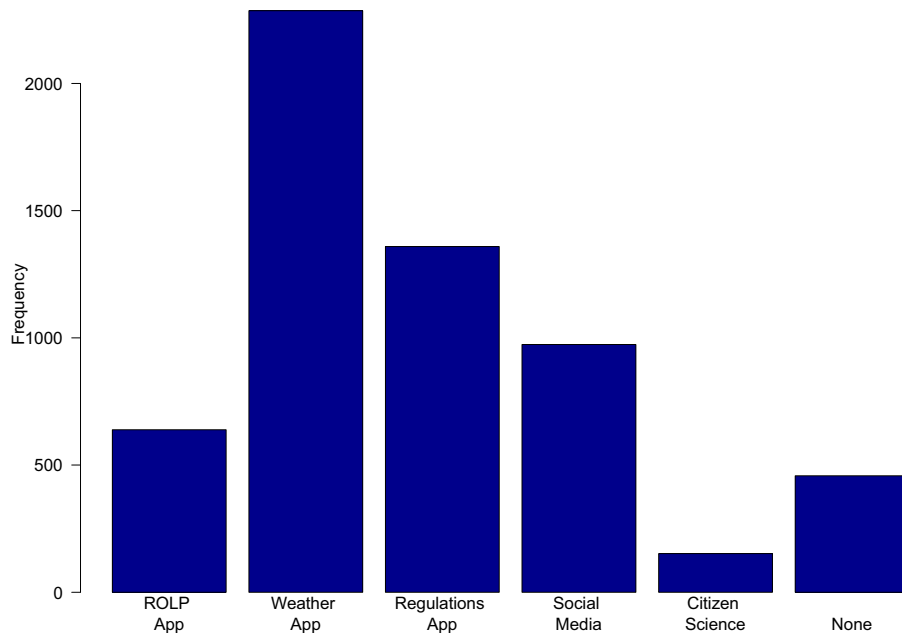


FIGURE 2. Frequency of use of different mobile apps associated with fishing activity as reported by ROLP holders. Note that respondents were allowed to report more than one app. [Color figure can be viewed at [afsjournals.org](https://onlinelibrary.wiley.com/terms-and-conditions).]

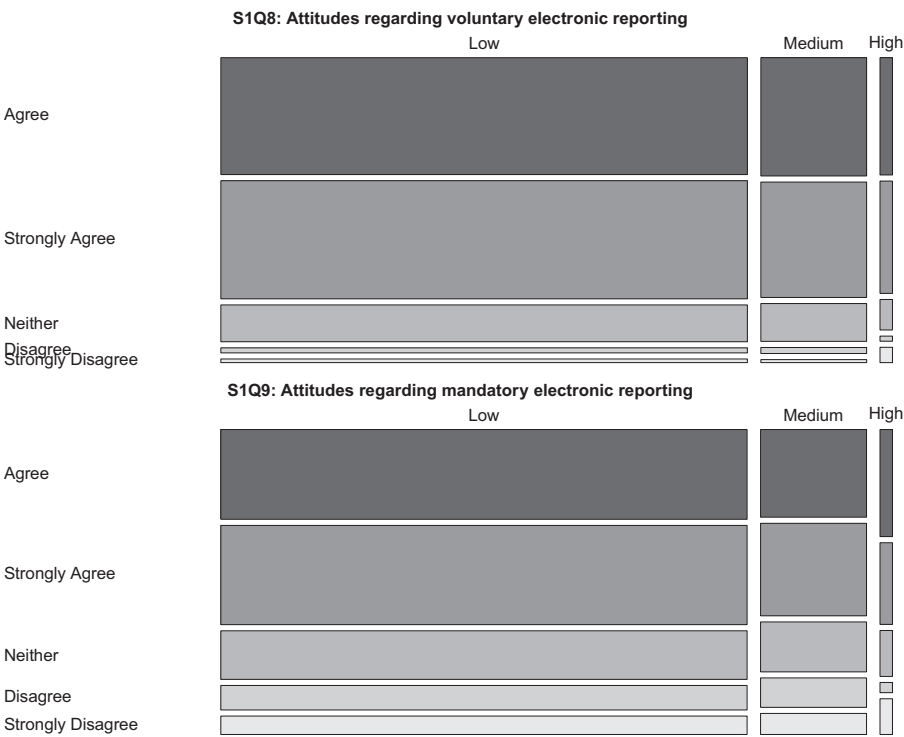


FIGURE 3. Mosaic plot of ROLP holder attitudes regarding their willingness to report Red Snapper catch under a voluntary reporting program (top plot) and a mandatory program (bottom plot). Angler attitudes and avidity groups are shown in the left and top axes, respectively.

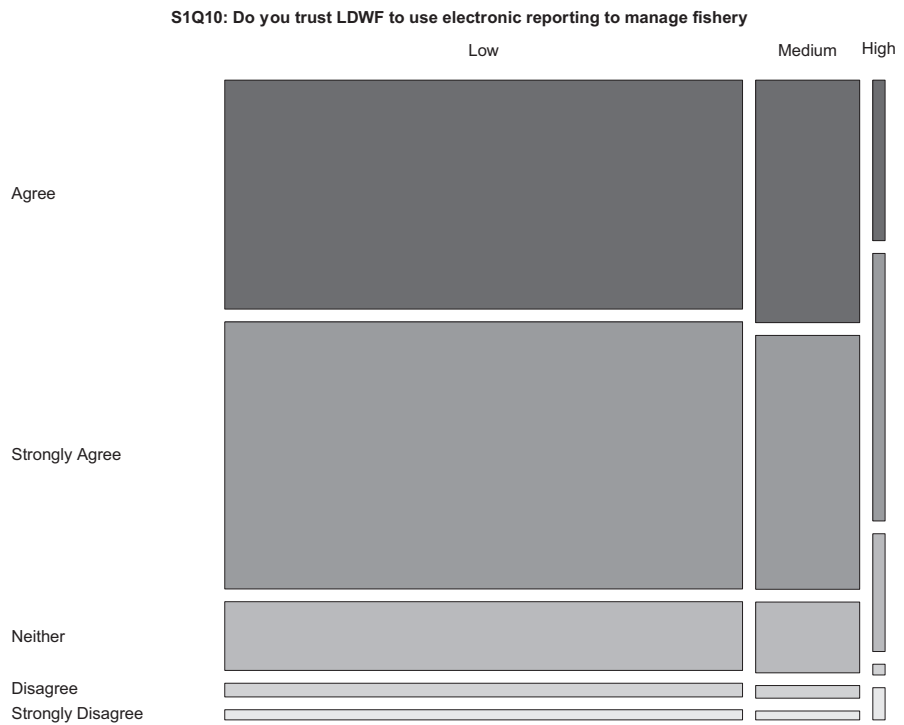


FIGURE 4. Mosaic plot of ROLP holder attitudes (left side) broken into avidity groups (top labels) regarding their trust of the LDWF to use electronic reporting to help manage the Red Snapper fishery. The “agree” and “strongly agree” categories represent 80% of the overall responses.



FIGURE 5. Mosaic plot of ROLP holder attitudes (left side) broken into avidity groups (top labels) regarding whether self-reporting by all anglers would help the state better manage the fishery. The “agree” and “strongly agree” categories represent 80% of the overall responses.

The final two questions in this section had to do with whether self-reporting catch would hurt individual access (S1Q12) and whether accurate reporting would strengthen the case for state management (S1Q13). Only 8% of responses thought that self-reporting would hurt individual access, suggesting that 92% of anglers thought it would not hurt access or felt neutral about it. Most responses (81%) felt that accurate reporting would strengthen the case for state management, with only 3% disagreeing.

Important aspects of the Red Snapper fishery.—The next set of questions addressed different aspects of the Red Snapper fishery in an attempt to understand what the most important aspects of the fishery are to the respondents. Three questions (S1Q14–17) were asked similar to previous Likert-scale questions (possible responses: strongly agree, agree, neither agree nor disagree, disagree, or strongly disagree); however, to analyze the answers we combined the two positive (agree and strongly agree) responses per question and then combined results from all four questions (Figure 6). Respondents reported that future generations catching Red Snapper was the highest-ranking aspect of the fishery, suggesting long-term conservation of the fishery is the most important aspect to anglers. Balancing fishery abundance with fishery access was ranked next most important. Individually, fishery abundance and fishery access were ranked somewhat less

important. Despite these rankings, positive responses for all questions ranged between 80–94%, which suggests that all aspects of the fishery have value.

Reasons why anglers report catch.—The next 11 questions were designed to understand the reasons why anglers report catch or why they would be willing to report catch. Although the possible responses were strongly encouraged, encouraged, neither discouraged nor encouraged, discouraged, or strongly discouraged, we combined the “strongly” responses with their associated positive or negative response, although there were relative few responses in the “strongly” categories. Each of the 11 questions in this section asked ROLP holders about a specific reason that may or may not motivate them to report their catch (Figure 7).

The motivator that resonated most with the respondents was “improving the quality of fisheries data” followed by “hopes that accurate reporting will extend my season by reducing uncertainty in the data.” Additionally, all 11 answers are similar in that they only report 2–5% disagreement, which suggests that none of the motivators to report catch invoke a strong negative response. However, the answers greatly differ in their proportions of agreement and neutral feeling. Only a little over half of respondents suggested they were encouraged to report based on the reporting of other anglers, a manager’s expectation, or for a personal record (e.g., journal of

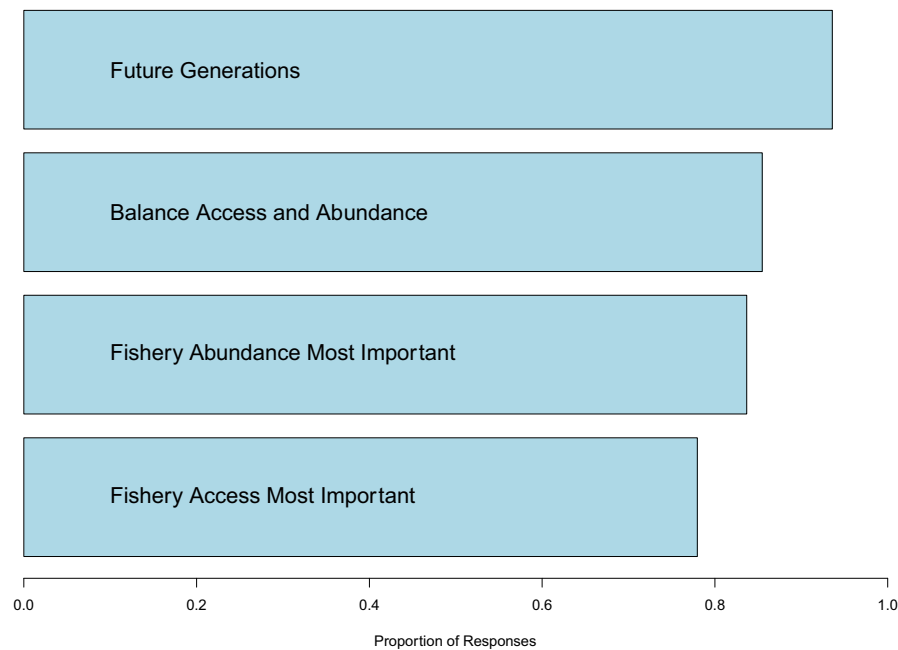


FIGURE 6. Proportions of positive responses of ROLP holders for four different aspects of the fishery. [Color figure can be viewed at [afsjournals.org](https://onlinelibrary.wiley.com/doi/10.1002/mfm.10472).]

catches). However, the vast majority of ROLP holders were positive in their encouragement to report when it came to “extending the Red Snapper season by reducing uncertainty” and to “improve the quality of the fisheries data.”

Dockside reporting (LA Creel) compared with electronic reporting.—Because the LDWF has an existing dockside sampling program, known as LA Creel, which has received favorable reviews by both anglers and scientists, it was important to understand perceptions of eASR directly compared with the existing and successful catch reporting program. To better understand this comparison, we asked ROLP holders the degree to which they agreed or disagreed with seven statements about dockside reporting and electronic reporting (Figure 8). Support for LA Creel was clear: 62% of ROLP anglers thought that LA Creel is a good data collection program (30% were neutral on this question). Considering the support for the existing LA Creel program, there were also positive responses for electronic reporting. Sixty-nine percent of respondents thought that adding electronic reporting for private docks (which are not currently included in the LA Creel sampling) would help managers. A substantial majority thought that combining electronic reporting and LA Creel would result in more accurate data (74%) and more timely data (78%). Similarly, the notion of moving to only electronic reporting was supported by only 27% of ROLP anglers, although it is notable that only

25% disagreed with this idea and nearly half (48%) were neutral.

To further look into some of the responses comparing electronic reporting to LA Creel, we examined four of the questions in terms of avidity, under the thinking that more avid anglers either encounter LA Creel more often or would be electronically reporting more often and therefore may have different opinions. For four questions (S1Q38, S1Q41, S1Q42, and S1Q43; Figure 9) we saw generally comparable responses by avidity group, although for S1Q38 and S1Q43 we observed higher agreement for high-avidity anglers, suggesting that they were in strong support of only electronic reporting (S1Q38) but somewhat also in stronger agreement that electronic reporting is not as accurate as dockside data. This is somewhat contradictory, although the differences are not large.

Perceptions of fishery management agencies.—The last section of our 2018 in-season Red Snapper survey included nine questions designed to understand respondents’ opinions on different fishery management agencies, management scenarios, and data collection programs. Questions in this section were often worded as the inverse of another question, and although the answer to the inverse question could be inferred from the negative response from the initial question, we wanted specific questions and language to avoid such inferences. Although the neutral responses ranged between 14–48%, we saw greater variability among the positive and negative

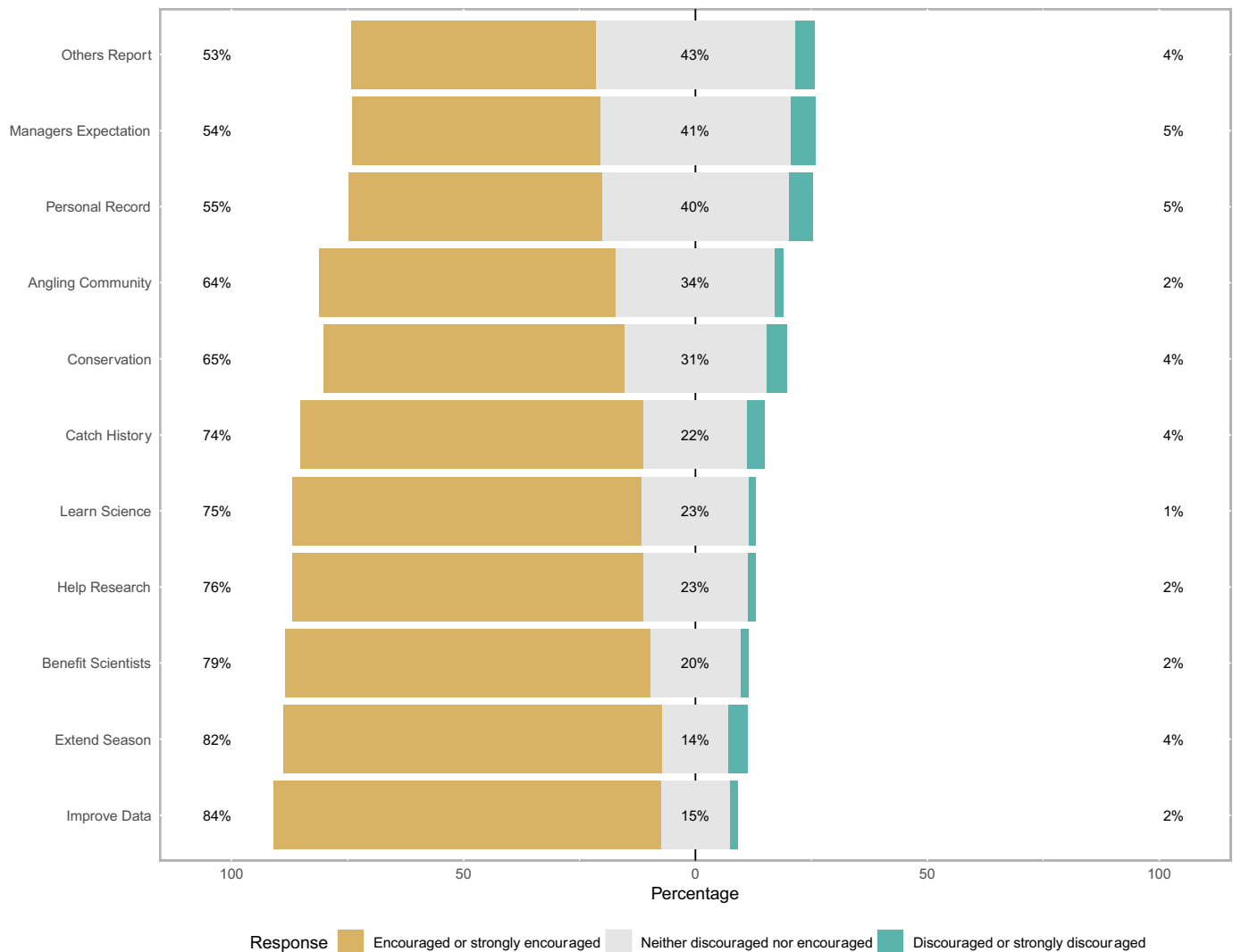


FIGURE 7. Percentages of ROLP anglers who were encouraged, neither encouraged nor discouraged, or discouraged about 11 different possible reasons they might report their catch. (Note that both encouraged and discouraged responses are combined with their respective strongly encourage or strongly discourage option in the survey.) [Color figure can be viewed at [afsjournals.org](https://onlinelibrary.wiley.com/terms-and-conditions).]

responses (which can be attributed to the inverse questions). Notably, the vast majority of ROLP holders (84%) held the opinion that the National Marine Fisheries Service underestimates the Red Snapper population in the Gulf. A smaller majority (56%) also thought that the National Marine Fisheries Service overestimates the amount of Red Snapper caught by the recreational fishery. Perceptions of the LDWF were more balanced as 80% of responses were positive or neutral regarding LDWF estimating recreational Red Snapper catch close to the actual catch. Only 25% of respondents thought that the LDWF overestimated recreational Red Snapper catch. Although we asked a total of nine questions, we wanted to look more into three specific questions (S1Q45, S1Q48, and S1Q51) because the other five questions are largely the

inverse of the three questions we are reporting on. For these four questions, we saw greater agreement among the high-avidity anglers, suggesting they may have different opinions about how management agencies estimate the Red Snapper population and recreational catch of that population.

Mobile Electronic Reporting Rates

Voluntary electronic reporting first started May 3, 2018, and the last electronic reporting was completed on September 6, 2018, which was concurrent with the private recreational Red Snapper season. Throughout the electronic reporting process, the term “trip” is variously defined as it can be thought of as a multiday designation within the app, an individual activity, or in other ways.

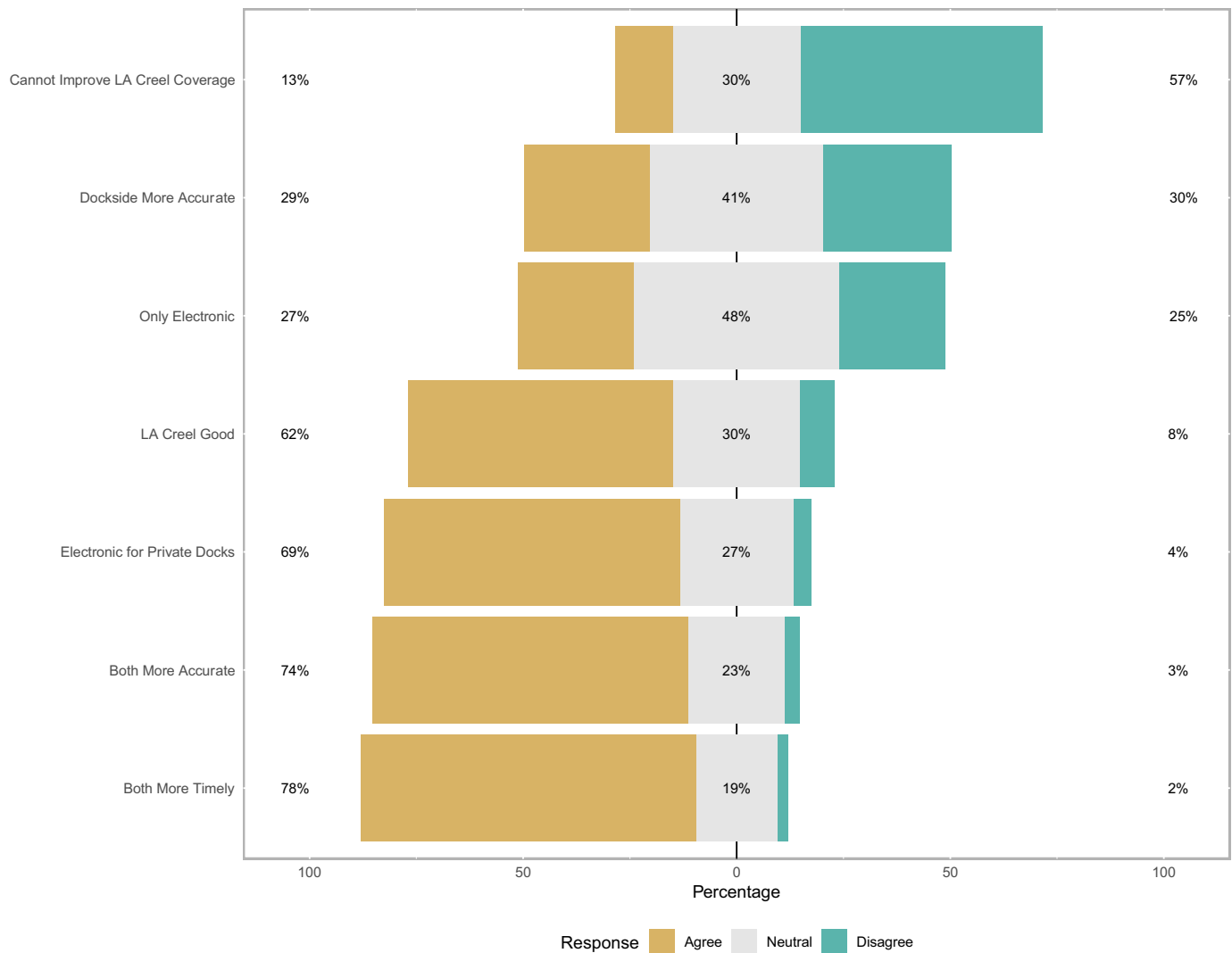


FIGURE 8. Percentages of ROLP anglers who agree, disagree, or are neutral about seven different statements comparing electronic reporting with LA Creel (dockside) reporting. Note that the full questions can be found in Supplement 1. [Color figure can be viewed at [afsjournals.org](https://onlinelibrary.wiley.com/terms-and-conditions).]

Here, we define a trip as a day of fishing by a single vessel. We realize there is no perfect definition of trip; however, multiday trips tend to aggregate important information or may include one or more days in which no fishing took place. We also let the angler define a day; however, when setting up a trip, anglers selected a day based upon a traditional 24-h calendar day.

At the close of the 2018 season, we recorded a total of 1,159 self-reported entries, where an entry is a trip or intended trip. Intended trips were trips created but not necessarily followed through in either the fishing or the reporting of fishing. Of these 1,159 trip entries, 44 trip entries were blank (never returned to), 142 trip entries contained no reported information (returned to but no information provided), and 143 trip entries reported no

fishing taking place. Our analysis will report only on the $n=835$ trips that reported fishing taking place. Fishing trips were reported by ROLP holders who lived throughout Louisiana, with a few trips reported by out-of-state residents. The LDWF estimates a total of 89,592 trips targeting Red Snapper during the 2018 season, which put the 835 electronic reports at approximately 1% of the total trips.

Trips that included fishing occurred throughout the summer, with a clear peak in activity taking place in June. May and August trips were lower in amount; however, the season did not open until May 25, and by July 13 the regulations had changed to weekends only (whereas the season was 7 d/week before July 13), both factors that may have reduced overall numbers. Of the 835 fishing

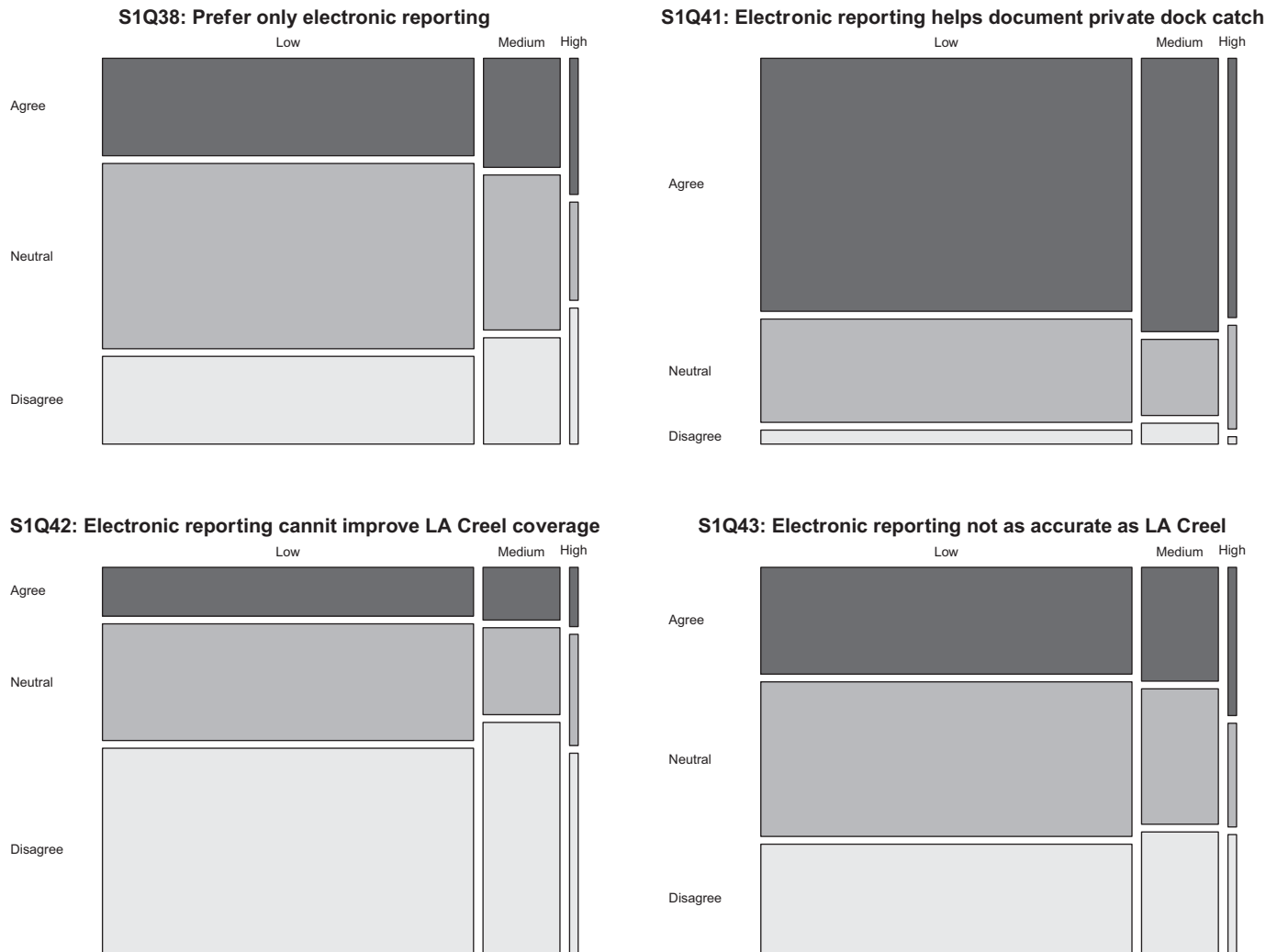


FIGURE 9. Mosaic plots of ROLP holder attitudes (left side) broken into avidity groups (top labels) regarding four questions pertaining to dockside reporting compared with electronic reporting.

trips reported, there were 202 unique ROLP permit numbers associated with the trips, including 15 ROLP permits that were associated with >10 trips, and 3 ROLP permit numbers that were associated with >20 trips. Along with these unique ROLP permit numbers we also counted 172 unique vessels that were associated with the fishing trips. The ROLP app users were asked if, for a given fishing trip, they were using a private dock, which is of interest primarily because LA Creel does not survey at private docks or private access (although they do ask if anglers returned to public or private docks). In the electronic reporting, 16% of trips (131 trips) reported using private access, while the majority of trips from a marina (public) included 26 different marinas.

Although we define a trip as a day of fishing, as we previously explained, fishing trips could be specified for more than 1 d within the app. Thinking about trips in this way,

the majority of trips (75%) were still specified for 1 d. Eighteen percent of trips were specified for 2 d, and while the maximum trip length was 5 d, only 7% of trips specified between 3 and 5 d. Water depth where they caught fish was reported by 79% of anglers, with a mean water depth of 49 m (ranging from 6.1 to 183 m). App users were also asked to report whether they kept or discarded (for sublegal reasons or other reasons) their catch. As the total catch increased there was a trend of keeping the catch, and this increase in number of harvested fish may simply represent those anglers that were targeting Red Snapper.

DISCUSSION

Estimation of harvest and effort for recreational fisheries has traditionally followed probabilistic sampling methods, whereby inferences are made by the design of

the sample collection. For example, dockside sampling for a fixed amount of time or phone calls to a fixed amount of license holders represents a common probabilistic sampling design used in recreational fisheries. Probabilistic sampling designs have a long history in statistics and are relatively well understood. Electronic angler self-reporting of harvest (among other methods) represents not only a new data source but also a new sampling design known as nonprobabilistic sampling. The benefits of nonprobabilistic sampling include the ability to access large numbers of samples (e.g., recreational anglers) very quickly and for very little money. The theory behind nonprobabilistic sampling is, unfortunately, less developed than probabilistic sampling, and the inherent biases (e.g., selection bias based on angler avidity) of nonprobabilistic sampling are often assumed to be overwhelmed by the large sample sizes that can often be had (Brick 2018). Studies of nonprobabilistic sampling designs are less conclusive than traditional methods, although there is the possibility of developing hybrid methods that draw on the strengths of both sampling theories. Although our work does not advance the discussion on nonprobabilistic sampling design, we recognize the potential value in large amounts of low-cost data that can be generated quickly for recreational fishery managers. Additionally, given the interest of anglers to improve data collection through their own electronic reporting, there is a clear need for state and federal fishery managers to pilot innovative designs that test hybrid models of probability and nonprobability sampling.

Fisheries management in Louisiana benefits from a strong recreational effort and harvest survey program known as LA Creel. Despite the strengths of LA Creel, there exist areas for improvement, such as near real-time (instantaneous) data collection, reduction of costs, and expansion of the data sources to include private docks and marinas. Near real-time data collection would result in more timely harvest information for managers, which could be used to make more informed in-season management decisions. By allowing state or federal fisheries managers to more accurately predict when to open and close the season, managers could reduce the risk of overfishing the federal or state specific annual catch target. Specific electronic reporting actions, such as the hail-out function (i.e., trip declaration process) that is mandatory in Mississippi, could be used to inform management decisions related to scaling up or down the level of enforcement and/or dockside intercepts.

There were several common misconceptions about angler perceptions towards eASR that we wanted to investigate through this research and which we were able to address based on our data collection. Below is an overview of these misconceptions and evidence suggesting they do not represent significant barriers to eASR.

Misconception 1: Anglers Cannot or Do Not Want to Use Mobile Applications Prior to or during Their Offshore Fishing Trips

The vast majority of respondents (92%) confirmed using mobile apps associated with their fishing trip for a number of reasons (monitor the weather, report catch via another voluntary fishing application, share experience via social media, etc.). Evidence from this study indicates that offshore anglers in Louisiana are already using mobile applications related to their offshore fishing experience.

Misconception 2: Anglers Believe That Self-Reporting Will Hurt Their Access to the Fishery

This was perhaps the most surprising finding of the study, and the evidence dispels the common misconception. The vast majority (84%) of the respondents were willing or neutral to report electronically if the LDWF were to make it mandatory. Similarly, 84% reported that they trust the LDWF to use their data and 83% believe that self-reporting by all anglers will help the state better manage the fishery. Finally, 91% either agreed or were indifferent to the ideas that eASR would not hurt their access to the fishery. In other words, less than 10% of Louisiana's offshore Red Snapper anglers believe eASR to a state agency would hurt their individual access to the fishery. It is also worth noting that there could be some outcome expectancy behavior (Ajzan 1991) taking place with self-reporting; i.e., anglers may be more likely to say they will self-report if it is more likely to increase the possibility of state management (as opposed to federal management).

Misconception 3: Recreational Anglers Are Not Willing to Electronically Self-Report Their Catch

A large majority of the respondents (84%) reported that they are willing to electronically report their catch. Additionally, 59% of the respondents planned to report during the 2018 Red Snapper season. Considering this was the first Red Snapper season to provide options to report catch via a smartphone app, this was a substantial majority that planned to report. Still, there is a significant gap between willingness to report and actual electronic reporting rates. The use of the voluntary ROLP app by anglers to electronically report their trips was relatively low during the 2018 private recreational Red Snapper season, which is not surprising considering that the use of this app was voluntary. In states like Texas and Florida, where electronic reporting through iSnapper (Stunz et al. 2014) and iAngler (Ahrens 2013) is not mandatory, the primary method to increase reporting rates is education and outreach, which can be costly and depends on state funds or federal grant programs. In other Gulf of Mexico states like Alabama and Mississippi, where certain aspects of electronic reporting are mandatory, the reported

participation rates can be as low as 30% in Alabama in 2017 (with the mobile app Outdoor Alabama) and as high as 86% in Mississippi in 2017 (with the mobile app Tails n' Scales). There is no question that more research is needed to understand management strategies, motivations, and incentives that help increase recruitment and retention of anglers that are willing to report. There is some research suggesting that US\$1 and \$2 prepaid incentives raised response rates significantly and were cost effective (Brick 2018). This approach also needs further investigating and analysis to understand what level of eASR would provide sufficient data for in-season and out-of-season management decisions.

Study Limitations

No survey is perfect, but most well-designed surveys can be useful. To this end, we wanted to evaluate our participation rate and potential for nonresponse bias in a broader context. This survey had an overall response rate of 18%. Increasingly, it is difficult—and potentially incorrect—to think about a universal response threshold. First, surveys are conducted using one or many methods (e.g., phone, internet, mail, etc.) and response rates among survey methods are often not similar (Dillman et al. 2014). Another source of response rate variability is whether the population surveyed is external (e.g., the public or some other large group) or internal (e.g., a group whose members know each other or some other small group). E-mail surveys and external surveys both often result in lower response rates than other methods, which may be one reason we had a response rate of 18% as opposed to a higher rate. Despite the perceived importance of response rate, low response rates may yield as good or better data than high response rates; for example, Visser et al. (1996) found that lower response rates (around 20%) produced more accurate results than did surveys with higher response rates (60–70%). Finally, perhaps the most important metric is the number of responses related to the number of total surveys. This was considered in our survey design; based on a total population of around 17,000 ROLP license holders, we targeted a sample size of 376 respondents in order to have a 95% confidence level and a marginal error rate of 5%. Our nearly 3,000 responses clearly surpassed this statistical threshold and should provide confidence in our response rate.

Nonresponse bias is another consideration that can affect any survey instrument. Ideally, a follow-up survey could be conducted to estimate nonresponse bias or demographic information can be compared among respondents and nonrespondents. We were unable to conduct any follow-up surveys on the same group due to concerns about limiting survey fatigue; the LDWF generously shared ROLP holder information for a single survey, and the LDWF needs this group to be receptive to future surveys.

Additionally, while we did not have detailed demographic information about respondents, we were able to compare response rates among states to evaluate whether participation was driven by select places. Obviously, ROLP permit holders residing in Louisiana dominated the group, but there were 10 other states that had between 50 and 1,100 ROLP licenses. When evaluating the response rates by state, we found that state response rates were between 5% and 30%, and mostly between 10% and 20%, suggesting that no state was substantially over- or underrepresented. Despite the confidence we have that nonresponse bias was minimal, it remains important to consider that our results and interpretations could be biased if the anglers that responded held (more) positive attitudes about electronic reporting than those who decided not to participate.

Ultimately, our study reflects what may be an accurate picture of recreational catch reporting in the Louisiana and Gulf of Mexico recreational Red Snapper fishery—that is, a large amount of participation and interest in generating the best possible data for managers, especially through electronic self-reporting. The hypothetical bias we found between anglers' willingness to report and their actions to actually report was expected as it is much easier to indicate an interest in something than to actually undertake it. While the low eASR rates indicate that additional research, survey design, and public outreach is needed before higher rates of reporting can be expected, the overall interest and willingness to report presents an optimistic starting point for any future eASR efforts.

ACKNOWLEDGMENTS

The authors would like to thank the participating ROLP holders for their input in both surveys and to those anglers that reported their catch electronically. We also thank Dave Nieland for his input early in the process of survey design. Nicole Smith and Kevin Bland provided assistance on numerous occasions in the form of e-mail distribution lists, data interpretation, and other technical guidance. There is no conflict of interest declared in this article.

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