THE EMERGENCE AND USE OF ANGLER SELF-REPORTING APPS IN RECREATIONAL FISHERIES

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Contents

Executive Summary

Angler self-reporting is a citizen-science based approach of using cell phone apps as a means to collect precise recreational angling data. In recent years, state and federal managers, recreational anglers, and environmental NGOs have expressed keen interest in expanding the use of voluntary angler self-reporting for fishery catch estimates. Catch estimates are used to dictate the following year management measures, such as season length, bag limits, minimum size limits, and other fishery management measures (NOAA). In order for citizen science to succeed in recreational fisheries, anglers must have an interest in collecting measurable, high quality data that can be used in fisheries management.

An extensive review of over 200 citizen science projects conducted by Roy et al. (2012) provided guidelines for the best practices employed in successful citizen science projects. The review highlights the needs for maintaining user engagement, marketing and outreach expertise, understanding the value that volunteers receive from involvement with the project, and the use of volunteer-generated data. Using this theoretical framework of citizen science best practices, the current status of angler self-reporting programs was reviewed through stakeholder interviews. Semi-structured interviews were conducted with principals in two angler self-reporting apps, a principal in one for-profit angler app, and seven fisheries scientists at the federal and state levels.

Results indicate that angler self-reporting currently suffers from low user engagement and statistical bias in self-reported data. Apps indicate they are struggling to reach potential users. This could be a result of low marketing expertise or failing to understand the motivations of citizen scientists. Fishery scientists cite statistical challenges as a major hurdle to incorporating self-reported data into catch estimates. Scientists indicate that angler self-reported data suffers from self-selection, whereby citizen scientists select themselves to report their data which may not be representative of the entire angling population. Therefore, using their data could present problems for managing the fishery based

on angler self-reported data. Scientists indicate that using angler self-reported data for catch estimates would be enabled by creating additional surveys to provide an unbiased sampling frame. However, it could take years and significant resources to develop, test, and implement surveys for angler self-reported data. Scientists also cite the value and use of other types of data, such as biological or supplementary data, that are not at risk for self-selection bias and can be used for fisheries management.

Responses also suggest that some stakeholders seek to change behavior with angler self-reporting apps. An extensive background literature review indicates that there is no evidence that citizen science changes behavior. However, smartphone apps present the opportunity to incorporate new management styles that traditionally have suffered from logistical challenges when incorporated in fisheries management, such as harvest tags and the participation of angling management organizations. Harvest tags are used in hunting and in some select fisheries, where anglers or hunters purchase their individual quota before harvesting, and identify their individual quota with a physical tag (R. J. Johnston). Harvest tags are known to reduce derby fishing or hunting and lengthen hunting and fishing seasons. Angling management organizations also incorporate rights-based management similar to harvest tags (Sutinen and Johnston). Results from the interviews lead to the conclusion that practitioners may find more success in using apps to implement innovative management structures as opposed to using angler self-reporting to achieve behavior change.

Introduction

An increase in the use of smartphones has been met with a strong interest from scientists and environmental groups to harness technology for data collection, environmental education and public engagement. According to a Pew survey conducted in 2015, 64% of American adults own a smartphone, up from 35% in 2011 with ownership high among young Americans, those in higher income brackets and with higher education levels (Smith). As a result, scientists, policy-makers, and NGOs have investigated the use of technology in reporting fishery data across the commercial and recreational sectors. Electronic logbooks have been extensively investigated and, in some regions, applied to commercial sectors and, more recently, the for-hire sector (Gulf States Marine Fisheries Commission). However, using technology in the recreational sector is still in its infancy. Questions remain as to the applicability of angler self-reported data for fisheries management as well as the ability for volunteer angler self-reporting to appeal to anglers.

Most states and fishery management councils currently rely on a federal survey program, the Marine Recreational Information Program (MRIP), for estimating the amount of recreational catch per species per season (NOAA). Some states have opted out of using MRIP but use some form of survey similar to MRIP for recreational catch estimates. MRIP has been administered by interviewers in one of two ways: by telephone survey or by dockside survey. The interviewers ask questions related to catch and effort, which are then included into the larger statistical program to estimate the entire effort and catch for the region (Marine Recreational Information Program). These catch estimates are used to dictate the following year season length, bag limits, length limit and other management factors. This survey method can be problematic, though, because there are over 11 million anglers and limitations to both the dockside and telephone surveys. These surveys are time-consuming to conduct and analyze. Regions such as the mid-Atlantic, South Atlantic and the Gulf of Mexico have shown interest in using apps to engage anglers for data collection, and use this data in fisheries management.

Angler self-reporting provides several potential benefits that the current MRIP survey methods lack. MRIP estimates require interviewers writing with pen and paper to record the responses of hundreds of individuals, and it takes considerable time to transcribe these responses and analyze them. This has been particularly challenging in the Gulf of Mexico, where fishery managers are required by the Magnuson-Stevens Act to close the federal recreational red snapper season when the sector reaches its quota (50 CFR 600.305 (a)(2)). The challenges of surveying the vast number of recreational anglers and estimating the amount of red snapper harvested in a limited time frame has created divisions between the recreational sector and fishery managers, as recreational anglers feel frustrated at what some groups are calling the over-regulation of red snapper (J. Dute). However, the recreational sector has exceeded its quota six years out of the last eight years, making the commercial sector nervous for the security of the rebuilding red snapper stock (Lallo). In the 2014 lawsuit *Guindon v. Pritzker*, commercial anglers sued the Secretary regarding the lack of accountability measures (Civil action No. 13-00988, D.C. 2014), as required by Magnuson-Stevens (50 CFR Ch. VI section 600.310 (b)(1)(iii)) to ensure that recreational anglers do not exceed their quota. For regions such as the Gulf of Mexico, there is a need for making accurate and timely catch estimates for the recreational sector. App developers and NGOs have responded by providing voluntary angler self-reporting apps for not only the Gulf of Mexico (Texas A&M University), but also the South Atlantic (Cunningham) and the Mid-Atlantic (Chesapeake Bay News).

Angler self-reporting apps could provide better in-season estimates to catch during the season, and could prevent and lessen the amount of catch caught over the quota (Texas A&M University). In addition, recreational angler self-reporting could provide opportunities for anglers to become more involved in the fisheries process. Surveys have shown that anglers do not believe they are sufficiently represented in the management process, and some angling groups are seeking refuge in Congress to secure their interests (Lallo). Legislation currently making its way through Congress could undo basic

fishery protections, reallocate quota from the commercial sector to the recreational sector, and dilute scientific input to fishery management by limiting federal authority as outlined in the Magnuson-Stevens Act (Wenick). If an angler self-reporting app opens the communication channels and provides opportunities for anglers to be more involved, there may be a chance to diffuse these tensions and also improve fisheries management.

This master's project investigates the use and emergence of voluntary angler self-reporting apps for use in fisheries management. I use a qualitative approach to interview current angler self-reporting apps and fishery scientists to determine the current challenges, successes and opportunities for using angler self-reporting for management. I look specifically at the techniques used by apps to engage anglers and how fishery scientists are using angler self-reported data.

Background Literature

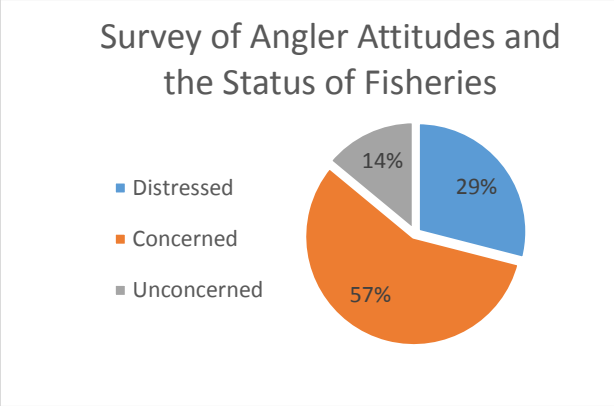
Angler self-reporting is a combination of fisheries management, recreational fisheries and citizen science. There is little background literature on angler self-reporting currently, but there is a wealth of information on fisheries management and citizen science. Additionally, it is apparent that fisheries policies themselves are a significant contributor to the frustrations felt by recreational anglers, especially in regions such as the Gulf of Mexico. As a result, I researched extensively fishery policy, citizen science, and recreational anglers to evaluate the status of angler self-reporting.

Recreational anglers

In 2001, Radomski et al. called for a social science quest to quantify sport anglers' values, yet almost 15 years later major gaps still remain (Radomski, Grant and Jacobson) in spite of the fact that recreational fishing is a major industry and economic driver. NOAA reports approximately 11.7 million anglers participated in saltwater fishing in the U.S. in 2012 (Gustavo, Brinson and Wallmo). Despite such a vast number of anglers, engaging recreational anglers has been challenge.

Recreational Angler Attitudes

In 2013, the National Oceanic and Atmospheric Administration (NOAA) conducted a survey assessing attitudes and preference of recreational anglers (Brinson). The survey found that 84% of anglers felt it was important that they were represented in the fisheries management process, but only 29% felt the needs and interest of the recreational fishing community were adequately considered. Other concerns included pollution, habitat destruction and lack of enforcement as hindering anglers in the South Atlantic, and poor data collection and media inaccuracies in the Pacific (Responsive Management). A 2012 survey of recreational angler values commissioned by the Environmental Defense Fund found that a majority of survey respondents reported top values to be access to as many fish or more fish for future generations and support for regulations that promote these values. Anglers also supported new management approaches such as harvest tags or angler co-ops and were strongly opposed to regulation. Approximately 29% of anglers considered themselves "distressed" about the state of fisheries and were actively engaged in conservation, 57% of anglers identified themselves as concerned but not actively engaged in conservation, and 14% of anglers considered themselves "unconcerned", believing that fisheries are best managed through individual anglers with little or no involvement from the government. The survey indicated that the latter group was the most vocal but did not represent the majority.



Engaging anglers in fishery management

Literature suggests that anglers have the potential to greatly assist in the funding, planning, and implementation of fishery conservation strategies (Granek, Madin and Brown). However, three primary factors influence this opportunity: 1) the stakeholder degree of stewardship, 2) scale of the resource,

user group, or management structure (small to large), and 3) source of impacts on the fishery (internal, external or a combination). The ability for anglers to successfully work with managers and scientists depends on the coalescence of important factors: 1) when the fishery is threatened by external factors, fisher involvement is likely to be high 2) if local fisher knowledge and key stakeholders are incorporated into the program from the beginning, 3) if there is a high level of ecological awareness, and 4) if the resource is small, fishers may likely feel responsible for its conservation and may feel that their actions will affect change. The coalescence of these factors varies by region, however, and the impact of each of these incentives should be evaluated and considered for targeting the audience and designing an app, keeping in mind the size of the fishery, the stewardship of the anglers, and internal vs. external factors.

In marine recreational fisheries, some scientists have observed trends in which voluntary guidelines aligned perfectly with local fishery needs providing conservation value even when fishery managers were slow to react to these needs (Cooke, Suski and Arlinghaus). Indirect regulatory approaches have succeeded in situations where regular face-to-face interaction is occurring among stakeholders leading to peer pressure that motivates compliance with the voluntary regulations in a closely bounded fishery. Promoting an indirect regulatory approach utilizes an often overlooked tool of the fisheries management toolbox and could provide a significant opportunity to engage recreational fishermen in the management process. At the same time, this approach can be promoted via technology, as well. However, some anglers have adopted voluntary regulations despite any scientific evidence in support of the efficacy of these regulations, and these misunderstood regulations can lead to mismanagement and erosion of public support for mandatory or voluntary regulations or negate the intended effects of formal institutions. The study also suggests indirect management approaches are more effective in some environments where top-down regulatory approaches have been unpopular.

Cowx et al (2010) proposed an integration of various lessons learned in recreational fisheries into a framework for stakeholders and managers (Cowx, Arlinghaus and Cooke). Cowx suggests that

fishermen accept codes of practice that could foster a relationship between recreational fishers and conservation stakeholders, as well as provide a united front to combat environmentally damaging development projects. Cowx also suggests the use of risk assessment in evaluating management interventions. With these insights and those proposed by Granek, recreational angler engagement can be evaluated and customized for likely acceptance by region, scale, species, and targeted change.

Red Snapper in the Gulf of Mexico

Tensions are at an all-time high in the Gulf of Mexico, as recreational anglers are becoming increasingly frustrated with red snapper management which is threatening to undermine significant success in red snapper recovery. Anglers are angry at what some are calling “over-regulation” of red snapper. News reports indicate that the population of red snapper is so high that many anglers are forced to switch fishing strategy to target other fish because they are hitting their snapper quotas so quickly. There is also likely a race-to-fish mindset in the red snapper fishery, as anglers try to catch their year’s snapper catch within the alloted ten days (J. Dute). Furthermore, NOAA has openly acknowledged the shortcomings of its current Marine Recreational Information Program (MRIP) as having major gaps in knowledge and potential for significant biases. Organizations such as the Recreational Fishing Alliance are strongly opposed to any measure that restricts open access, specifically citing other pro-recreational fishery reform organizations on their website as restricting anglers’ access to fishing (Recreational Fishing Alliance). These groups are currently seeking refuge in Congress and distracting greatly needed funds and efforts away from the greater issues of the fishery to combating Congressional action (Lallo).

Historically, the Gulf of Mexico Fishery Management Council has estimated when the recreational sector will reach its quota before the season begins based on the previous year’s data (Gulf of Mexico Fishery Management Council). The managers announce the season length beforehand and attempt to estimate the number of snapper caught during the season with dockside interviews. However, as discussed previously, these estimates are rarely precise and are time consuming to analyze.

As a result, the recreational sector has been exceeding its quota consistently for the last 10 years, and the recreational season has gotten shorter in response. The 2014 season was a record 10 days but also a record high quota of over 7 million pounds allotted. In the 2014 lawsuit *Guindon v. Pritzker* (civil action No. 13-00988, D.C. 2014), the D.C. district court found that the Gulf of Mexico Fishery Management Council was failing to implement necessary accountability measures as required by the Magnuson-Stevens Act pursuant to 16 USC § 1853(a)(15). The recreational sector was consistently going over its allotted quota, thereby slowing the rebuilding timeline for the red snapper fishery and jeopardizing the commercial sector quota. The court ordered that the National Marine Fisheries Service had to include better accountability measures to ensure that the recreational sector stayed within its quota. The Gulf of Mexico Fishery Management Council responded by instituting a 20% quota buffer on the recreational sector. All following years beginning in 2015 must have a 20% buffer to the quota because of the difficulty in measuring when the recreational sector is hitting its quota.

Citizen Science

Citizen science projects are developed by scientists but use, at least in part, contributions from a range of participants that may or may not have any scientific background. The level of involvement can vary from simple observations reported via the internet to citizens trained to use scientific equipment to calling on the public to solve problems. Quality of data collected and the number of users acquired is often correlated with the level of involvement requested and the motivation of the reporters.

Lessons learned from citizen science

A detailed literature review of over 200 citizen science projects, conducted by Roy et al. in 2012, classified projects and conducted a meta-analysis to create guidelines for successful citizen science projects (Roy). The results classified citizen science initiatives into one of four categories: simple local projects, thorough local projects, simple mass participation projects and thorough mass participation projects. A great breadth of diversity existed in these projects, but all case studies highlighted the

utmost importance of providing feedback to the volunteers as a form of engagement, such as through social media. Risks of using technology included the inability or unwillingness for some participants to engage, too many projects creating fatigue or confusion from a flood of projects, and the financial costs and usefulness associated with the projects. The authors indicate that the most important factor in developing a citizen science project is an understanding that the willingness of people to participate varies widely. Furthermore, matching the data needs for users such as policy makers, scientists, and managers to meet the needs of the participants is very difficult and often unattainable. Intense data needs can put too great a demand on the volunteer, but what is realistic for the volunteer may be insufficient for the data users. Therefore, a one-size-fits-all approach is rarely realistic, and projects must have clearly identified project goals, needs, and participants. The review also points to the potential for a greater vision of a 'cyber-infrastructure' which sets data standards that can be applied across many systems and apps.

Nov et al (2013) describes the motivations of contributors to citizen science, which varies and can be influenced by factors such as improvement of skills, enhancement of status, enjoyment, reciprocity, identification with contributors' community, and group level factors. Nov et al. specifically looks at: collective motives, norm-oriented motives, intrinsic rewards and reputation, and their role in technology-mediated social participation (Nov, Arazy and Anderson). Their study indicates that the motivations that lead to higher quantity of contributions, which included all of the above motives, do not necessarily lead to a higher quality of contributions, and can actually detract from quality contributions. The authors argue that citizen science is context-specific and much thought must be put into determining why people would participate in the project. Authors suggest that projects should strive to increase volunteers' commitment to the project and its goals, such as through communicating project mission and achievement to volunteers. Finally, even intrinsic motivation did not lead to increased quality, which could be solved with more enjoyable, game-like participation mechanisms.

Also, mechanisms which use a social network or incorporate a social pressure may provide an incentive for better quality. Motivations could also be enhanced by creating a dynamic organization that allows volunteers to take on more responsibility and engagement, such as has been done with open source software and Wikipedia.

Technology for Behavior Change

Technology has been used to target behavior change, with some of the most significant examples occurring in energy use. These initiatives encourage users to be more energy-conscious using a variety of tools that alert the user to opportunities to reduce energy usage, apply social pressure to others through social media, or to provide feedback. One of these feedback forms, known as persuasive technology, is designed to nudge users into changing their behavior. It relies on six key features for effectiveness: usability, social norms, goal setting, considerations of scale and group dynamics, tapping into less rational motivational mechanisms, and combining approaches and addressing differences in motivation. In developing an effective feedback system, the information must be easy to access and comprehend while also giving the user the ability to easily act on the information. The results of the user's decision to act on the information must be immediately observable, such as through an indicator similar to gauges in a car. Normative social influence can harness the competitive and comparative nature of people by answering the two questions: "How am I doing now compared to how I have done in the past?" and "how am I doing relative to members of groups with whom I identify?" this approach has been much more effective in influencing behavior than environmental, financial or societal benefits. Goal setting, rewards and commitments can also be used for feedback, although reward-driven action alone has been shown to be short-lived once rewards are removed. Group motivation can also be used to promote conservation, although this has worked more effectively in cultures with strong a sense of community than those with a strong sense of the individual. Research has indicated that people tend to respond more strongly to emotional, habitual, or non-rational communication than to quantitative

information. For example, energy users who were chastised by a mechanical cat reduced their energy use more than users who were given their energy information in a straight-forward, quantitative manner. Tailored feedback can also tap into the different motivations of people. Research indicates that a combination of tailored feedback, goal setting, normative information, historical comparison, and incentives results in the most effective feedback mechanisms (Petersen and Franz).

Feedback in the form of normative comparisons has shown varying preferences for information depending on the scenario or project. A citizen-science project where users can report the location of trash in California showed that users were interested in the map-view of the app, showing where other users were finding trash, suggesting that the users were interested in the nature and location of other people's findings. However, a study of using social media to encourage a reduction in energy-use found that users were most interested in their own energy-use followed by that of their peers, but ability for peers to see user's energy-use discouraged use of the technology by those who did not want their peers judging them for their energy use (Lehrer and Vasudev).

Researchers advise managers interested in using technology for data collection to ensure that they avoid accidentally providing inherent bias within the app. Some forms of bias that can occur from design errors include difficulty in logging some locations or catches, or intentional selection to reveal or omit information. It is also important to ensure that the specific data needs and the analysis is included in the design to avoid creating a large amount of noise in the data. Scientists might initially focus on validating app-based data collections by comparing apps with other data collection methods such as creel or survey, and compare the app use demographics to other angler demographics. It is important that the design facilitate the ease and enjoyment of using the app. Creating value for the user may be helpful in reducing bias and error and should be considered an important aspect of app design (Gutowsky, Gobin and Burnett).

Marine Recreational Information Program

The current method by which MRIP estimates recreational catch effort is known as the Coastal Household Telephone Survey (CHTS – MRIP, 2015). The survey consists of random digit dialing to landlines within coastal communities and asking respondents about their fishing activity in the past year. MRIP conducted pilot studies of a mail-in dual frame survey that used addresses from the state databases of saltwater anglers and from residential address frames, known as the Fishing Effort Survey (FES). The mail-in surveys showed much higher response rates of anglers than the CHTS. MRIP is currently in a transition period, beginning in 2015, that will last for three years where the MRIP survey transitions from the CHTS to the FES. During this period, MRIP scientists will compare responses from both surveys and investigate differences in catch estimates. After three years, FES is expected to be the primary survey method. The final report for FES indicates that the previous CHTS may have been including bias that the FES removes (Andrews). Furthermore, houses in the FES were more likely to respond than those in the CHTS. Furthermore, the CHTS did not reach anglers outside of coastal regions. People are responding less and less frequently to telephone calls, and the CHTS was conducted through land line phones. Finally, the CHTS resulted in a higher recall bias, as respondents had to answer questions on the spot about past fishing activity. A report from the National Research Council indicated that the CHTS design further suffers from a low rate of saltwater angler participation among the general public and limits to the survey resulting from a dependence on landline-based telephone numbers restricted to coastal county residences. A decreasing response to phone based surveys is also resulting a higher nonresponse bias to the CHTS. The NRC recommends that survey methods come from a direct angler population, which MRIP has studied through phone surveys as well.

The Angler License Directory Telephone Survey (ALDS) was piloted in 2007, 2008 and most recently administered in 2012. It called numbers associated with state fishing licenses from Florida, Alabama, Mississippi and Louisiana, and did see a much higher rate of reaching anglers -46% as

compared to 6.5% with the CHTS. However, the ALDS suffered from missing anglers due to exemptions in state licensing resulting in under-coverage, estimated to be as high as 70% in some states. Furthermore 20% of anglers in the system may have been unreachable due to missing, nonworking, or wrong telephone number. Because of low telephone response rates in general, ALDS had only marginally higher response rates than CHTS. MRIP developed a dual-frame survey that includes both methods, but this still proved to be an unreliable survey.

Current State of Angler Self-Reporting

As of June 2015, almost 100 apps exist tailored to recreational anglers, with features ranging from social media fishing apps, solar, lunar and weather apps, catch log apps, fishing analytics, and local fishing regulations. NGOs and commercial fishery managers have presented electronic log books as a tool for commercial fishermen, and recently conservation groups and states have offered (or required the use of) these services to recreational fishermen. Availability of citizen science-based apps for fisheries remains limited, but several apps are continuing to develop pilot studies and new apps and ideas are emerging all the time. Most of the apps are being developed independently of one another, however, and level of communication between them varies. There are also challenges of housing and managing databases, as well as the ability for managers to use these databases and easily access them across apps.

How reliable is angler self-reported data?

Another important consideration that managers must examine is how reliable angler self-reported data will be. A recent Fisheries article by Papenfuss (2015) studied the voluntary use of an iPhone app for reporting catch in Canada, and found that the app was able to reveal preferences of anglers, especially their effort and movements. However, the study did find that, compared to creel survey data, apps underestimated total angler visits to some lakes by a factor of as much as 254, and

app data tended to overestimate the popularity of some lakes while underestimating the popularity of others. (Papenfuss, Phelps and Fulton).

In 2014, the Alabama Marine Resources Division began requiring that all for-hire captains and private anglers report their red snapper catch either through the app "Snapper Check" or by paper in order to obtain more accurate landings data for better management of the red snapper fishery (Alabama Department of Conservation and Natural Resources, Marine Resources Division). The Alabama Red Snapper Reporting Program estimated that 417,526 pounds of red snapper were landed in June, compared to the federal MRIP program estimate of 1,041,121 pounds of red snapper landed in June. Preliminary results indicate that 2,685 trips were made, with 60% being reported through the app. Compliance among charter captains was 85% and it was 45% among private anglers (J. Dute). The preliminary report claims that video data from cameras installed on docks to measure the number of trips taken confirms that Alabama Red Snapper Reporting is more accurate than federal MRIP estimates.

Electronic logbooks

Government organizations and NGOs have elaborated at length on the feasibility and practicality of using mobile apps for real time or near real time data collection for use in commercial fishery management, and lessons can be taken from these investigations. A West Coast Steering Committee and a stakeholder committee was formed in 2011 to bring together the interests of scientists, fishery managers, fishermen, seafood producers and other stakeholders to evaluate the feasibility of implementing mobile apps into commercial fishery reporting in the Northwest (Steinberg, Sylvia and Dresler). The committees recommended a bottom-up incentivized approach, as opposed to top-down mandated approach. Specifically, they recommended that government and industry should develop a "standard" to supports entrepreneurial development of eFIS systems, with flexibility and adaptability to avoid duplicative, inflexible and piecemeal development. The committees recognized

that organizational and administrative hurdles will be much more challenging than technical hurdles (including systems needs and objectives, privacy, legal issues, and budget constraints), and encouraged partnerships with technology providers. Panelists from the discussion agreed that a standard for data collection and a simple database, rather than trying to develop a single integrated system, would be more beneficial to the industry and other practitioners. Panelists recommended that data targets and needs, including data gaps, be identified for state, federal, and private organizations in order to create effective feedback loops. Furthermore, a standard framework on which specific applications can be built should be created. The panels also stressed the need for incentives for all stakeholders.

An overview of angler self-reporting apps

Two states in the Gulf of Mexico have already begun using mandatory angler self-reporting apps in an attempt to obtain better catch estimates than MRIP. Mississippi and Alabama are requiring that all private recreational anglers report their red snapper catch to their states' smartphone apps (or by phone, web). News reports indicated that the requirement for recreational anglers to report their red snapper catch using Outdoor Alabama has been well received, despite lower than hoped for compliance with private anglers. As the Montgomery Advertiser states,

> *"Red snapper anglers have expressed their intent to comply with the red snapper data collection program because they want accurate information to be used when seasons and bag limits are set. 'NMFS changed its data collecting program in 2013….We don't feel that program is accurately reflecting the red snapper that are being landed on the Gulf Coast.'"* (Rainer).

Alabama's Marine Resources Division Director, Chris Blankenship, indicated that Alabama's red snapper season could be extended if the landings are closer to those estimated by Snapper Check than by MRIP (J. Dute).

The iSnapper Report (2014) indicated that 2 large head boats, 9 private charters, and 5 small head boats participated in the Texas-based pilot study. Large head boat captains are already required to

log their catches via paper log books, and other for-hire vessels are required to provide effort information when contacted by MRIP. A survey indicates that captains greatly preferred using the app to pen and paper log books. Some captains did indicate that accurately submitting discard data was a struggle because of the nature of guiding a boat with charter guests (Stunz, Johnson and Yoskowtiz). Furthermore, surveys indicated that captains were not able to confirm exactly at what depth their anglers were fishing. For example, even if captains' depth finders indicated a specific depth, the captains had no way to confirm that their anglers were pulling up red snapper from that depth. This kind of error may skew discard data which is dependent on depth for accurate estimates. Although the pilot was a success among these captains, there is no indication that the platform would be readily adopted by private recreational anglers because the incentive structures for these groups differ.

iAngler is an app developed by Angler Action based out of South Florida as a citizen-science based app for Common Snook management. The Angler Action Program is a project of the Snook and Gamefish Foundation, who own the app and house the database. According to the Angler Action website, data collected by anglers was used for the 2011 Florida Fish and Wildlife Snook Stock Assessment and data continues to provide value for managers and scientists. The International Game Fish Association teamed up with Columbia University to provide another citizen science-based app for South Florida anglers. The IGFA CatchLog is currently conducting a pilot study of anglers in the Everglades National Park. The data is provided to the Everglades National Park and the Florida Fish and Wildlife Conservation Commission (International Game Fish Association). Chesapeake Catch is a citizen-science app and catch log for anglers in the Chesapeake Bay region.

Methods

Theoretical Framework

The citizen science review conducted by Roy et al. (2012) was collated into a framework and best practices guideline for UK Environmental Observation Framework. The foundation of a successful citizen project rests on thoroughly exploring fundamental questions and reflecting on the needs of the current project. The UK Environmental Observation Framework identified the conditions under which citizen science projects have been most successful, and I use this framework as my theoretical framework to guide questions and analysis. The components of the framework is described below.

It works for you and the user

Citizen science works well in a situation in which there is a benefit not only to the scientists, but some benefit received by the participant. There has been significant market research into user retention in apps, and a study by market research company Mixpanel found that apps that provide the user with value are the most successful. The trends indicate that customization (such as social apps and messaging) have higher retention rates than those with instant gratification, but users also spent a significant amount of time investing into those apps by building networks (MixPanel). Mixpanel advises that apps be designed to give customers value right at the start of their experience. Other citizen science apps have also stressed the importance of giving back to the user.

The participants are carefully targeted and supported

Understanding participant motivations is important for keeping users engaged. With the wide variety of apps on the marketplace targeting fishermen with varying degrees of popularity, it is clear that there are a variety of anglers who have preferences that range from logging catches to social media posts to predicting best fishing times.

The project aims are clearly defined and communicated from the outset

Clearly defining the data goals and project goals can help tailor the project to meet the needs of the citizens and the scientists, while providing for measurable targets to strive for.

The members of the development team have the appropriate expertise, not just in data collection and analysis, but also in communication and publicity

The review by Roy et al. stresses the importance of outreach and communication. This may require experience in marketing, branding and messaging. Understanding the needs of the project, the values of the users, and creating the appropriate message to bring these aspects together is important for reaching as many users as possible.

Evaluation is built into the project design and there is a willingness to listen and adapt as necessary

Conducting surveys and focus groups can provide valuable insight into challenges or successes, and how to adapt the app as necessary. It is also important that evaluation for data reliability and precision is monitored by project managers. The Appalachian Trail Conservancy found that its early citizen-science projects were not providing precise enough data, so the project was reconfigured and involved training of the volunteers to provide usable data (Cohn).

Small scale trials are undertaken to test the approach with potential participants

Pilot studies can prevent future headaches by letting users interact with the technology, provide feedback, and evaluate if scaling is feasible.

The motivations and skill-sets of all parties (development team and participants) are understood, because they may vary considerably

The motivations of volunteers and scientists to engage in citizen science vary, yet motivations of both stakeholders must be considered in the design of the project. One study indicates that volunteers' motivations are temporal in nature and change over time, with novelty initiating involvement and the feeling of community resulting in continued engagement (Rotman, Preece and Hammock). Scientists are interested in research and furthering their career, as well as aiding in the engagement and education of the community. Factors that can become catalysts for engagement include feedback, identifying

temporal changes in motivation for volunteers and engaging them at those points, and highlighting local interests.

Participants feel part of the team, understand the value and relevance of their roles and (especially for long-term projects) gain new skills

Feeling that their contributions are aiding science and conservation may be the satisfaction that some users seek. It is important to understand the motivations so that the app can be tailored to keep users engaged and provide satisfaction to users as appropriate. Volunteers from the National Zoo's Conservation and Research Center marine mammal citizen-science initiative have indicated that knowing how the scientists are using their data is intriguing and exciting, reinforcing the emphasis on providing feedback for volunteers (Cohn).

The project is an efficient and enjoyable way to gather and analyze the required dataset

If developing apps is cost-intensive but they do not have the desired outcomes, either in data or in angler engagement, than the projects may not be a realistic option for the objectives.

The quality of the scientific data generated in measurable

Quality of data is likely to vary by user type, motivation, and perhaps by data type. Ecologists leading citizen science-based projects recommends that projects develop protocols for citizen scientists in addition to testing citizen-science results for reliability.

Tradition of Inquiry

My tradition of inquiry is an exploratory case study to investigate how fishery scientists, NGOs, and app developers are creating and implementing their angler self-reporting programs. Because there is little background information on anger self-reported data at this time, an exploratory case study allows me to investigate how angler self-reported apps are emerging and how the data is being used. I conducted 10 semi-structured interviews that were approximately 20 minutes long, with some up to 45

minutes long. As described in O'Leary, I prepared semi-structured questions based on the theoretical framework chosen, avoiding leading questions or asking more-than-one questions, and probed where necessary (O'Leary). Because the theoretical framework may not apply to every situation, I chose to use semi-structured interviews in order to allow for other themes to emerge that may not have been included or anticipated in the theoretical framework. In addition to probing questions about the components of the theoretical framework, additional themes focused on goals, challenges, and data collection, listening for indicators that related to my theoretical framework.

The UK Observation Center framework based on the review by Roy et al. (2012) incorporates the lessons learned from numerous citizen science projects. The framework identifies the following primary considerations for a citizen science project:

1. It works for you and the user
2. The participants are carefully targeted and supported
3. The project aims are clearly defined and communicated from the outset
4. The members of the project team have the appropriate expertise, not just in data collection and analysis, but also in communication and publicity
5. Evaluation is built into the project design and there is a willingness to listen and adapt as necessary
6. Small scale trials are undertaken to test the approach with potential participants
7. The motivations and skill-sets of all parties (project team and participants) are understood, because they may vary considerably
8. Participants feel part of the team, understand the value and relevance of their roles and (especially for long-term projects) gain new skills
9. The project is an efficient and enjoyable way to gather and analyze the required dataset
10. The quality of the scientific data generated is measurable

The review and framework indicate that these best practices may not necessarily apply to every citizen science project. Project needs may vary based on the region, type of project, demands asked, and audience targeted. Furthermore, some of the components of the framework would have required interviews with anglers. I chose to remove these from my evaluation because my interviews would not

be able to evaluate the components of the framework that required the input from citizen science volunteers. Based on theses consideration, I removed numbers 1, 8, and 9 from my analysis.

Data Collection and Analysis

My data was collected by conducting interviews with fishery managers and angler self-reporting app managers. I conducted three interviews with apps and seven interviews with fishery managers at the federal and state levels. The apps included one for-profit app that recently began providing citizen science data on endangered species to federal managers. The other apps are citizen science angler self-reporting apps. I received verbal consent to interviews and to recording interviews. I recorded all but one interview (in which I took notes) and transcribed interviews. I use ID's for apps and fishery scientists for privacy.

I conducted thematic analysis using NVivo 9 to identify themes and trends across interviews. I visualized data using word frequency, text analysis and tree maps. I identified themes for challenges, methods, data, verification, etc. and code interviews to these nodes. I used matrix queries and charts to further visualize the data.

Limitations and Positionality

This study contains limitations due to the limited knowledge on angler self-reporting and potential biases that I encountered with interviewees. I chose not to interview mandatory angler self-reporting apps for the states of Alabama, Mississippi, and Louisiana. These apps and the state managers working with these apps may have different positionality than many of the fishery scientists and apps that I interviewed. The fishery scientists that I interviewed were not currently incorporating angler self-reported data in management, and the apps were volunteer based. Therefore, their attitudes may differ from scientists and app developers who are incorporating mandatory self-reported data in state fishery statistics.

I aimed to maintain objectivity throughout the interview process, although I am aware that I may have had some leaning positionality to the use of angler self-reported data, and this positionality changed throughout the process. Despite any biases I may have developed, I present my data in the most objective manner possible.

Results

My analysis first examined how the angler self-reporting apps were following the selected components of the framework proposed by Roy et al. (2012) and the UK Observation Network. I further observed the app goals and the ability for fishery scientists to use the self-reported data for management measures such as season length, bag limits, size limits, and other necessary measures. I considered and evaluated other themes as they emerged, which will be discussed in the results section.

App use of the theoretical framework

When analyzing the results of the use of the theoretical framework, it was clear that the framework did not apply to the for-profit app in many ways. Therefore, I removed this app from the analysis and focused on the other two angler self-reporting apps for analyzing the use of the theoretical framework. Figure 1 indicates responses in which app interviewees made statements positively indicating presence of the use of components of the framework. Figure 2 indicates responses in which the apps stated that they were specifically not following some aspects as outlined in the framework. It is important to note that the framework is not a hard and fast rule, but rather guidelines for citizen science. Furthermore, apps may not be at a phase in their development where they have implemented or experimented with some aspects of the framework. As a conclusion, though, apps consistently showed lack of marketing and outreach expertise or indicated that they struggled to reach their audience effectively.

2. Participants are carefully targeted and supported

I asked apps how they were targeting and/or supporting their anglers, specifically if apps were targeting a certain type of angler or person. The two angler self-reporting apps indicated in interviews that the apps were not directly targeting a certain behavior or angler type, but this may have been due to the relatively early stage of the angler self-reporting apps. One angler self-reporting app indicated that they were interested in starting to conduct surveys and focus groups to better understand their anglers, but were not currently reaching out to anglers in such a way.

The for-profit app indicated that they could target anglers given the user's location. For example, the app indicated they could theoretically provide regulation information for anglers based on their location, but they are not currently employing this approach. This app also indicated that it did not specifically target a type of person, but rather tried to build a platform that people enjoyed:

> *"You need to give people something they love- not just like. Like won't do anymore. You have to do something people truly love." –For profit app*

The app indicated that sustainability is a strong part of their brand, and something that their users respond positively to. This may be interpreted as understanding their audience, and therefore by including an opportunity for their audience to support conservation, they target participants and support them.

The angler self-reporting apps cited a lack of buy-in from anglers as a major challenge. One of the apps indicated that their pilot study was essentially an experiment in seeing if anglers would respond, and could be interpreted as not effectively targeting their audience. Another self-reporting app indicated that they are not marketing to a particular group; however, they do conduct informational sessions at boat shows and at fishing clubs for those audiences.

3. Project aims are clearly defined and communicated from the outset

Clear project aims varied by app. One of the angler self-reporting apps has clearly stated goals and objectives, and these goals include data collection, behavior change, habitat restoration, and involving anglers in the management process. The other angler self-reporting app indicated their major goal for launching the app was to get an idea for how well it was received and if it would work. The goals are less defined for this app, but the interviewee did indicate that behavior change was something they are hoping to achieve with their app. The for-profit app has for-profit goals; in this case including citizen science was a component of branding because the app and its users value sustainability.

4. Members of the team have the appropriate expertise, not just in data collection and analysis, but also communication and publicity

The for-profit app used a public relations firm to reach out to the US Fish and Wildlife Service to offer assistance. This app does not have expertise in data collection and analysis, but they have outsourced expertise in marketing and PR, which may be why the response from their users has been "overwhelmingly positive" to the new citizen science app feature. The interviewee indicated that they are continuing to reach out and connect with fishery managers and scientists to expand their citizen science component of the app.

The other two apps indicated that they do not have marketing expertise. One app indicated that it had done its own outreach campaign through newspaper ads, magazine ads, and social media, but were concerned that their message had not reached a wide audience. The other apps indicated that they did not have marketing expertise and did not have the resources to invest in marketing. One of these apps did indicate that they spend significant time going to face-to-face meetings and presenting their app platform in that way.

5. Evaluation is built into the project design and there is a willingness to listen and adapt as necessary

The only app that is attempting to evaluate a response to citizen science is the for-profit app. This app specifically looks at click-through rates (percentage of people clicking on relevant links for the citizen science feature) and other factors such as comments and submission of endangered species data to evaluate whether or not anglers are perceptive to this opportunity to provide citizen science data. The other angler self-reporting apps are aware of the lack of responses to their platforms, but do not appear to have evaluation built into their project, either in the form of surveys, focus groups, or other means or evaluating how useful the platform is for anglers.

6. Small scale trials are undertaken

The two angler self-reporting apps have conducted pilot studies but are struggling to take their operation to the next level. Surprisingly, the for-profit app did not conduct a pilot study, but rather opened up the possibility of citizen science to users, and describe a very positive response, with high click-through rates and high submission of endangered species information.

7. The motivations and skill sets of all parties are understood because they may vary considerably

This protocol can also be difficult to assess using an interview with one member of each team because the interviewee has to respond on behalf of others as to whether their skill sets and motivations are understood. Therefore, I infer based on the levels of expertise that the apps indicated. The interviews indicate that the for-profit app has a clear understanding of their skill sets as a team and the motivations of its users, but they are not skilled to conduct data collection and analysis in such a way that the fishery managers require for catch estimates.

The angler self-reported apps indicated in one or more ways that they are struggling to reach or to engage users. This could be attributed to not fully understanding the motivations of their users and/or they are missing key skill sets related to messaging, marketing, and outreach. This could be

because the app platform does not effectively target angler motivations or it does target angler motivations, but these anglers are unaware of the app due to marketing and outreach gaps. Either way, this evidence indicates that motivations and communication are key gaps missing in these initiatives.

10. The quality of the scientific data generated is measurable

The most common word coded to "Challenges" was the word "data" indicating that data management is by far one of the most-cited challenges for fishery managers. Two app managers cited uptake of data from fishery scientists as a challenge. Two fishery scientists suggested that the apps may be moving at a faster rate than fishery scientists are able to keep up. Interviews with apps and data managers indicate that there may be a disconnect between these two groups, which may be creating difficulties in implementing angler self-reporting.

App Challenges

A primary question asked of all respondents was the greatest challenge facing angler self-reported data. Figure 3 shows the greatest challenges for by respondent type. Two angler self-reported apps indicated that angler use of the app was the greatest challenge facing them. The for-profit app mentioned that they understood there were statistical challenges to using data from their platform in catch estimates, but this question did not apply to the for profit app in the way that it did for the angler self-reporting apps. Although the for-profit app indicated interest in promoting sustainability, their primary focus is profit and product satisfaction for their users, therefore the use of their data for scientific reasons is less of a focus. However, they did believe that their users supported sustainability, and therefore sustainability is a major part of their branding.

Two of the three angler self-reported apps indicated that increasing participation from anglers was a major challenge:

"That's definitely the biggest challenge-just getting everybody [anglers] to buy in." – App 1

"They [anglers] have to be interested in using the app…I think that is going to be the biggest hurdle to get over."- App 2

Angler self-reporting apps showed high responses to angler participation, while fishery scientists showed very high responses to statistical challenges as the greatest challenge for angler self-reporting

Statistical Challenges

In every interview with fishery scientists, interviewees indicated that there were statistical challenges to using angler self-reported data for catch estimates. Statistical challenge cited varied, but many related to self-selection or avidity bias (See Figure 4). The challenges cited by scientists indicate that the data provided by angler self-reporting may not be coming from an unbiased sampling frame, meaning that those who report may not be representative of the entire angling population.

Angler Self-Reporting Goals

I also asked respondents about the goals for angler self-reporting (See Figure 5). Fishery scientists cited data collection and angler involvement, but apps indicated other goals beyond data collection. Some apps indicated that behavior change or promoting conservation was a major goal for them:

"[The goal] is ultimately to get as many anglers engaged in the management process as we can and use that as a two-way communication tool to keep universal conservation messages in the front of their mind."- App 1

"We are really trying to change the behavior of the anglers." –App 2

"We try to promote that [sustainability] in any way we can. How do you encourage people to do catch and release? How do you make people aware of rules and regulations?...In all the ways we can, we try to promote [sustainability]." –App 3

Discussion

The angler self-reporting apps indicated consistently that angler participation was a challenge, and indicated that marketing and outreach was something that the team may not have expertise in, or

had not been used effectively to reach the target audience. Marketing and outreach may be a challenge if the apps do not fully understand the motivations of anglers and citizen scientists. As described in the citizen science literature, citizen scientist motivations vary and citizen science projects do not necessarily appeal to a wide audience (Roy; Rotman, Preece and Hammock). Therefore, it is important for angler self-reporting apps to conduct further qualitative or survey analysis in order to better understand motivations for anglers to participate in angler self-reporting. This can also greatly assist in fine-tuning messaging and marketing communications. However, the literature also indicates that it is paramount that citizen science practitioners provide feedback to volunteers, informing them of how their data is used (Grove-White). This keeps citizen scientists engaged in the project but obviously cannot be incorporated into angler self-reporting platforms unless the data is being used in management. Fishery scientists indicated in interviews that the use for angler self-reported data in other capacities, such as supplementary information, was valuable and currently being employed. However, fishery scientists indicated it may be several years before angler self-reported data can be used to estimate catch, if at all.

One fishery scientist described how angler self-reported data could be used, but would require that a sampling frame be built. A sampling frame, as defined by the Organization for Economic Co-operation and Development (OECD), is a list of all members from which a population can be sampled (The International Statistical Institute). As described by the OECD and by fishery scientists, samples lacking a sampling frame can contain biases that could misrepresent the data. There is a concern that scaling the data from the voluntary angler self-reporting apps to the entire population may either over or under estimate catches. One fishery scientist did indicate that if a sampling frame could be built for angler self-reported data, it would be possible to use the data without fear of self-selection bias. However, it will likely take several years to build the sampling frame. Developing new survey protocols to incorporate voluntary (or compulsory) angler self-reported data will require input from the larger scientific community and will have to go through the peer-review process. In addition, transitioning from

one survey method to another requires that both survey methods be conducted simultaneously in order to compare and uncover any discrepancies (Marine Recreational Information Program). The current transition from MRIP's Coastal Household Telephone Survey to the Fishing Effort Survey requires that both surveys be conducted for three years side by side. Due to these necessities, it is likely that any use of angler self-reported data will require extensive testing and input from the scientific community, and may take many years and significant resources to incorporate. Nonetheless, there is the potential for using angler self-reported data in catch estimates considering these requirements.

Two fishery scientists indicated that the more data points collected, the greater the precision and accuracy of catch estimates. These interviewees also indicated that low numbers of responses result in low precision and accuracy for catch estimates. For data to be used effectively by fishery managers, data collection must be substantial and must include additional verification methods. The self-reporting apps indicated a struggle to attract anglers for input, but this could be attributed to either lack of understanding motivation or a lack in expertise of marketing, messaging and outreach. Both apps indicated that they were conducting their own marketing and messaging, but at least one app indicated it did not have any marketing expertise. On the other hand, the for-profit app has spent resources in outsourcing marketing and public relations to increase the brand and visibility. This group has had success with attracting users for their citizen science feature. Apps and practitioners should consider if voluntary angler self-reporting can appeal to a wide enough audience to provide for precise estimates of catch. If voluntary angler self-reporting cannot provide for more precise estimates than the current MRIP, or if the data cannot be used reliably in fisheries management, other uses of angler self-reporting should be considered.

Nonresponse does not always result in a nonresponse bias, but the higher the nonresponse rate the more likely that nonresponse bias may be present in the sample (Groves). Nonresponse bias occurs when the population that is non-responsive is significantly different than the overall general population.

In interviews with fishery scientists, I discovered that self-selection, or avidity bias, is also a risk of using angler self-reported data. As such, the larger scientific community interviewed believes that angler self-reported data would need to be conducted in conjunction with other survey methods, such as those done with MRIP. Another potential pitfall of trying to use apps for catch estimates in congruence or in addition to other survey forms is potentially another type of gatekeeper effect: the person must actually download and use the app, and using the app may be more work than filling out the mail in survey or answering telephone surveys.

Apps indicated that they had goals beyond just data collection, including behavior change. After an extensive review of citizen science literature, I found no evidence in the literature that citizen science can result in behavior change. I did find that social platforms can nudge behavior (Lehrer and Vasudev), but even nudging behavior may not be the behavior change that these apps seek. A review of recreational management styles indicates that there are ways to change behavior in recreational management, but these management techniques are underutilized. However, the availability of smartphones may provide an opportunity to use technology to implement these recreational styles in a way that was not possible before the advent of smartphone apps.

Johnston et al (2015) argues for Optimal Social Yield (OSY), as opposed to Maximum Sustainable Yield, for use in recreational fisheries because OSY takes into account other factors integral for recreational fishery satisfaction other than pure catch rate and economic gain, which has also been indicated by anglers. In order to determine OSY, researchers have also studied angler behavior to derive preferences and attitudes to best manage recreational fisheries (Fenichel, Abbott and Huang). New management structures such as angling management organizations and harvest tags have been cited as having the potential to incorporate the optimum social yield for recreational anglers and reduce effort.

Harvest tags have been suggested as a means for providing weak ownership incentives for stock protection (Johnston, Holland and Maharj). Harvest tags consist of anglers being given or purchasing "tags" for individual fish or groups of fish for capture throughout the season. Tags have had the potential to reduce retained harvest, reduce the race to fish, and lengthen recreational season. Managers who have implemented tags have reported that tags fully or partially met their objectives. One major drawback for tags in fisheries, though, is the transaction cost in obtaining tags quickly and the cost on the managers for returning them. App technology could provide an option for immediately obtaining tags and updating managers on their use. However, implementing harvest tags may encounter challenges such as program acceptance and enforcement.

Angler Management Organizations could provide relief to the effects of a growing recreational sector by managing effort. Sutinen and Johnston (2003) propose seven principles to integrated management which include: 1) benefit-cost analysis of an AMO 2) allocation for catches sectors 3) high degree of control over fishing mortality 4) strong angling rights 5) consideration of angling rights for organizations as well as individuals 6) decentralized recreational fishery management shared with local organizations and governing institutions , and 7) some form of cost recovery (Sutinen and Johnston). The authors cite devolved management authority as an argument for establishing AMOs, since traditional management does not apply on a local level and can be removed from the state of the fishery and satisfaction of anglers. The authors also argue that an AMO will be self-enforcing, reducing costs of traditional enforcement. With collective rights for the health of the fishery, the AMOs will maximize sustainable use of the stock. The use of technology for engaging anglers in self-reporting could provide valuable insight into the feasibility of using technology for AMOs in the future.

Angler self-reporting has the potential to provide a significant amount of value to fisheries management, but it has limitations- the greatest being that a voluntary program may not appeal to a wide audience. Furthermore, more precise data may not necessarily result in higher angler satisfaction.

It is important that practitioners consider these limitations and aim to measure these limitations in their pursuit of angler self-reported data. Smartphone apps may present an opportunity to experiment with implementing other management structures that do target angler satisfaction, though, such as angling management organizations and harvest tags. Research into using smartphone applications for these management structures should be conducted.

Conclusion

Interviews with fishery scientists and with principals in fishery apps reveals two major challenges facing the implementation of angler self-reporting as a primary source of catch estimates: according to fishery scientists, the data collected must be verified with dockside surveys or other surveys to provide for a sampling frame with which to compare app data; two angler self-reporting apps cited difficulty in reaching and attracting anglers to using their platform.

In summary, understanding the motivations of users, communicating to them, and verifying the data are the most important steps in implementing angler self-reporting. One interesting aspect to note, though, is that the goals of the angler self-reporting apps may not be in line with the goals of data collection. Two angler self-reporting apps indicated that some of their goals are to engage the anglers in the fishery process and change angler behavior. If the ultimate goal of angler self-reporting is to facilitate behavior change, other incentive structures may be required to address behavior. For data collection purposes, understanding motivations of anglers through research, surveys, and focus groups, targeting those groups with messaging, marketing, and outreach, and incorporating sampling frames through dockside or intercept surveys may bring angler self-reporting to a place where it can be used for catch estimates in recreational fisheries. However, there is no indication that using these catch estimates will necessary cool the tensions in the Gulf of Mexico. If reducing these tensions is the primary goal of angler self-reporting, then angler self-reporting may not be the right vehicle to address these problems.

Practitioners should consider using technology to implement management structures that, up until this point, were logistically challenging and expensive. Although not proposed in the literature, I suggest that technology platforms could be used for electronic harvest tags in order to reduce the burden of mailing and processing physical tags. A system such as this may provide opportunities to increase angler satisfaction and manage the recreational sector more effectively than angler self-reporting.

Tables and Figures

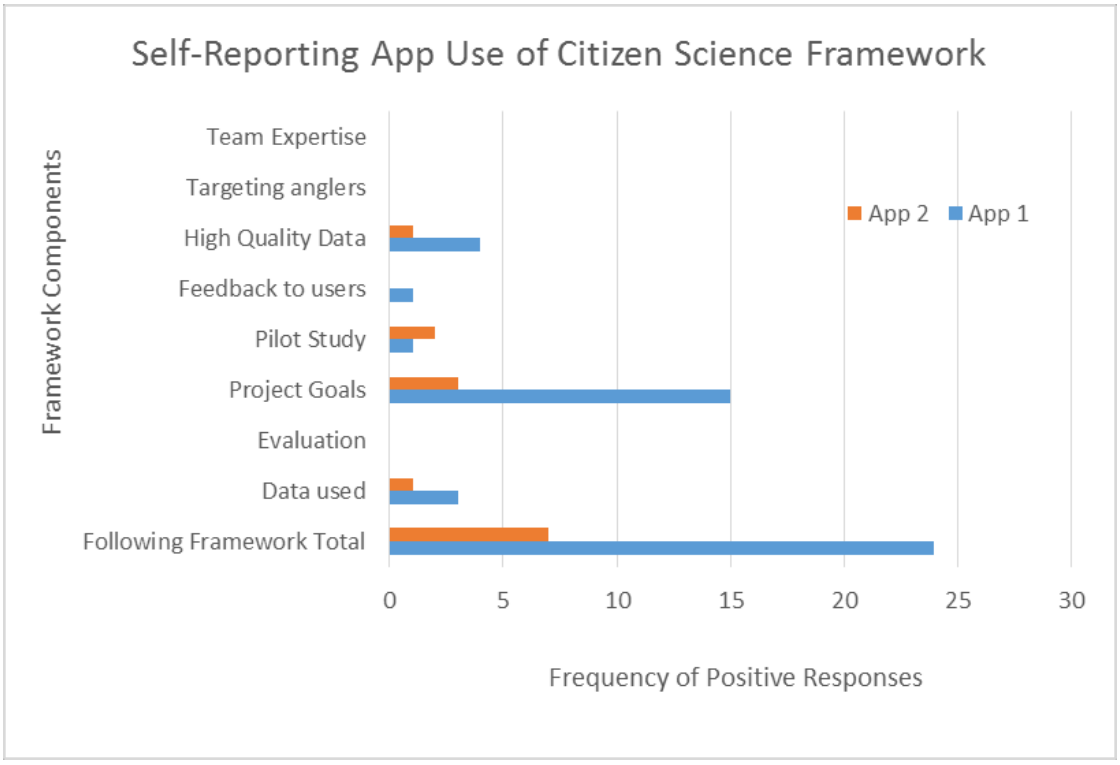


Figure 1. Angler self-reporting apps responses indicate areas where apps are following the framework as outlined by the UK Observation Network.

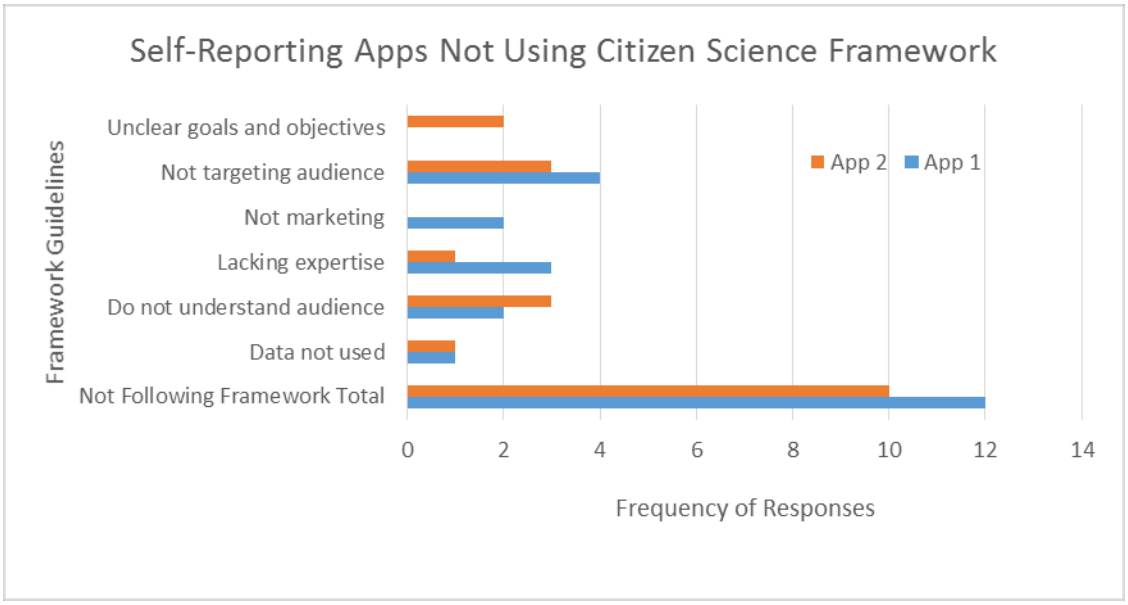


Figure 2. Angler self-reporting app responses indicate where apps are not following the framework. Note that not all aspects of framework apply to every citizen science project, but are guidelines.

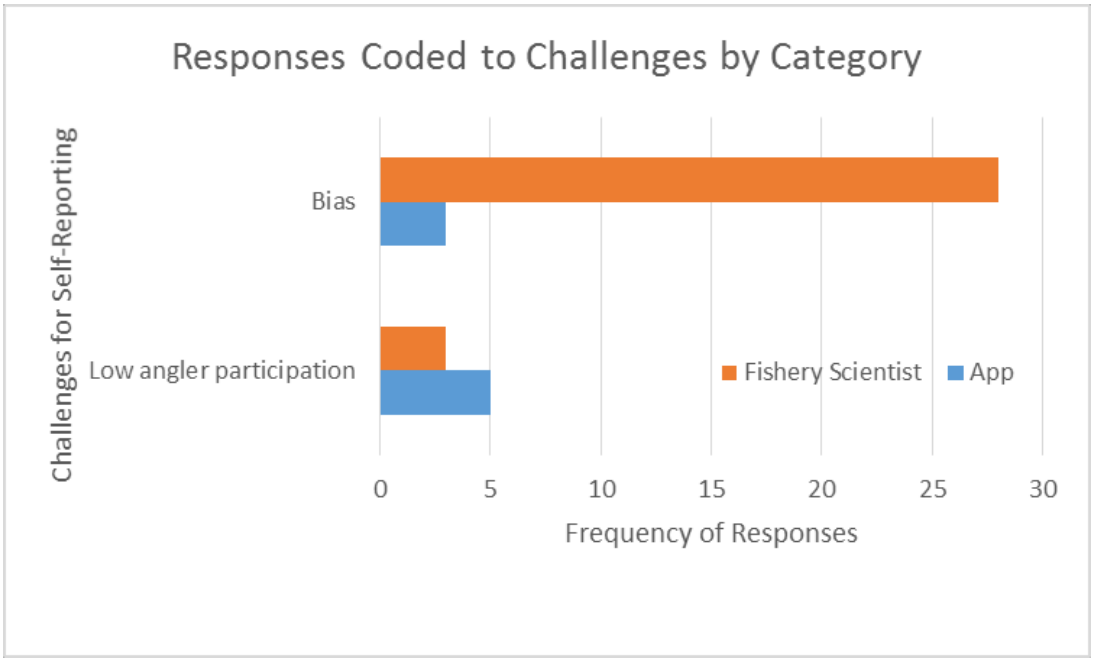


Figure 3. Challenges as cited by respondent type. Challenges most commonly cited were angler participation and statistical bias.

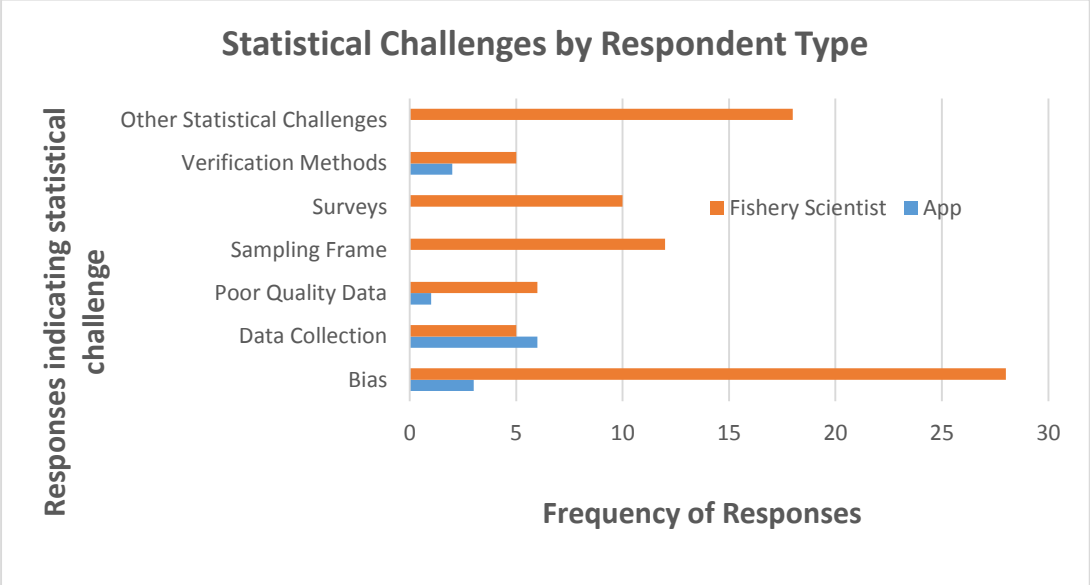


Figure 4. Responses related to types of statistical challenges, as cited by respondent type. Fishery scientists have high numbers of responses related to statistical challenges.

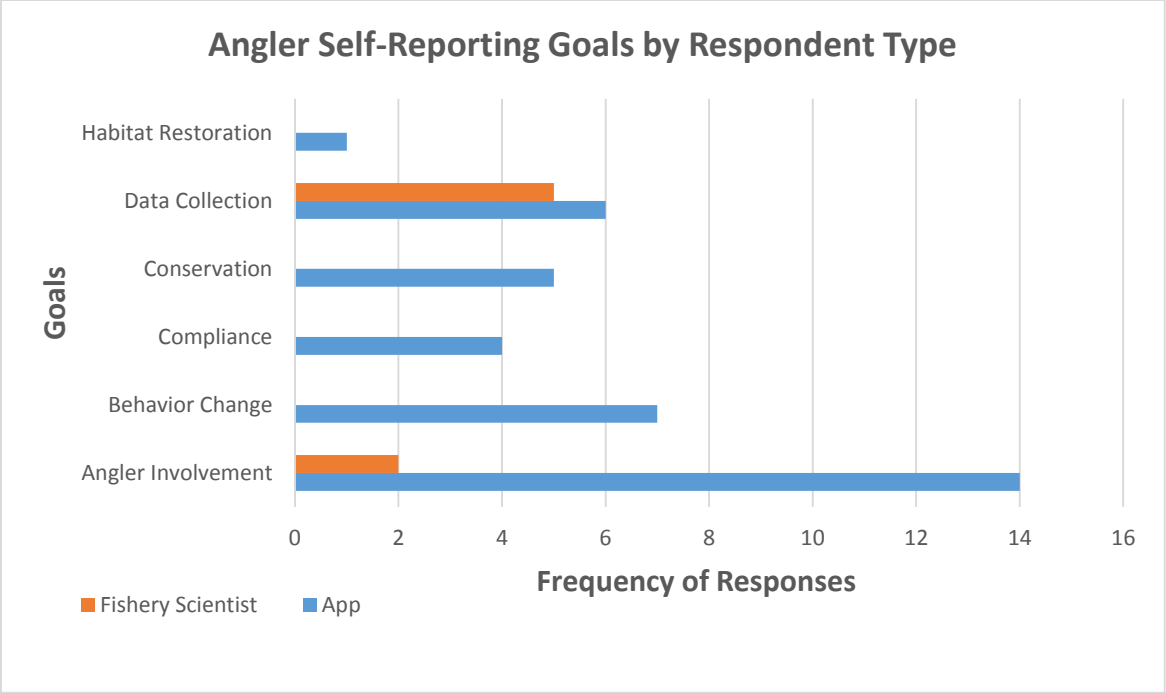


Figure 5. Goals for angler self-reported data by respondent type. Apps indicate a higher response rate of goals beyond data collection.

Appendix

Appendix 1: Survey questions

Fishery Scientist Questions:

1. Tell me how you or your department are approaching angler self reported data?
    a. Listen for whether or not they are directly dealing with ASR apps
    b. Do they have angler self reported data that they are managing right now?
2. What do you like about angler self reported data?
3. Why do you like it?
4. What do you dislike about angler self reported data?
5. Why?
    a. Listen for data standards…
    b. If not, ask about data standards here
    c. Do you have data standards for apps that are collecting angler self reported data? Why or why not? Benefits or disadvantages?
6. What are you doing to solve the problems for angler self reported data?
7. Why is that not a perfect solution?
8. How could the nonprofit/NGO or greater scientific community help?
9. Do you have anything to add?

App developer questions:

1. Tell me about your goals for your app?
    a. Listen for users engagement, listen for data uptake by managers, listen for marketing
    b. If they mention that they want to assist fishery management, ask what councils, scientists, groups, etc they are connected to
2. What are the challenges to reaching these goals?
    a. Listen for data management or transfer for fishery management
    b. Have you experienced challenges with sending data to fishery managers, scientists, etc.?
3. Why is this a challenge?
4. What are you doing to solve these challenges now?
5. Why is it not a perfect solution?
6. Do you have an opinion/idea of what the solution is?
7. How could the nonprofit/NGO community help reach your goals?
8. Do you have anything to add?

Appendix 2: Consent

"I am collecting research on technology in the environment. The information that I am collecting is confidential and private, will not be released to anyone and it is only for my use in my masters project. You are free to not answer any questions and we can move onto the next

question or stop the interview at any time. I would also like to ask if it is ok if I record the information for my own notes?”

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