

RESEARCH ARTICLE

From reels to research: Motivations and concerns of billfish citizen science participants

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Abstract

1. Citizen science facilitates cost-effective ecological data collection at much larger scales than would otherwise be feasible. This is particularly useful for the study of highly migratory species with broad distributions, such as billfishes.
2. Participants in citizen science benefit from an increase in scientific literacy, a sense of satisfaction and enhanced understanding. However, there are common challenges involved in citizen science projects, including the recruitment and long-term retention of participants. Applying knowledge about participant motivations and concerns is needed to overcome these barriers.
3. We conducted an anonymous online survey of 153 game fishers from across Australia, who were largely recruited through game fishing clubs. The survey investigated their perspectives on participating in citizen science on billfish, including their motivations and concerns.
4. Overall, those surveyed were highly motivated to participate in billfish citizen science programmes and reported few barriers to their engagement in research. Alongside wanting to contribute to billfish research and management, game fishers were motivated to participate to counteract potential negative perceptions of the sport. However, approximately one third of respondents had not participated in research. Therefore, opportunities for further recruitment exist as potential participants almost certainly exceed current participants. Impediments to participation included a lack of communication about opportunities and outcomes of citizen science research.
5. The survey highlighted a need to strengthen citizen science programmes to ensure participant retention and recruitment through targeted engagement and collaboration across organisations, which includes harnessing technology. Improved communication about the purpose and outcomes of research is key. We anticipate

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that our findings and recommendations are applicable to broader citizen science programmes, particularly those involving recreational fishers or a specialised pool of highly motivated participants.

6. Great opportunity exists for researchers, fisheries managers and fishing organisations to work together to expand citizen science programmes that strategically improve our knowledge of the biology and stocks of billfish and other recreationally important fish species.

KEYWORDS

Australia, billfish, citizen science, game fishing, migratory fish, recreational fisheries

1 | INTRODUCTION

1.1 | Benefits and challenges of citizen science

The term 'citizen science' (hereafter CS) refers to scientific work undertaken by members of the public, usually in collaboration with professional scientists and scientific institutions (Vohland et al., 2021). It was coined three decades ago, although the practice has been around for much longer (Bonney, 2021; Vohland et al., 2021). Many research programmes have benefitted from the growing involvement of citizen scientists, combined with the increasing use of digital platforms for sharing and accessing data (Bonney, 2021; Conrad & Hilchey, 2011). For example, eBird and iNaturalist are large online platforms that engage with many users on a global scale to collect biodiversity data (Bonney, 2021). Citizen science can facilitate cost-effective data collection on much larger spatial and temporal scales than would otherwise be feasible for many research projects, alleviating budgetary, time and staffing constraints that researchers often face (Bonney et al., 2021). Robust, long-term monitoring data are often needed to support resource management decisions, particularly in cases when there may be conflicts about resource use (Bonney et al., 2021).

Participants in CS often report a sense of well-being, satisfaction and community, enhanced understanding and increased scientific literacy (Bonney et al., 2016; Koss & Kingsley, 2010; Martin, Christidis, Lloyd, & Pecl, 2016; Pocock et al., 2023). CS projects where participants interact with nature have also been shown to increase both physical and mental health (Eichholtzer et al., 2024; Oh et al., 2024, 2025). In turn, the benefits gleaned from participating in CS can lead to a greater respect for and trust in scientific research by the public (Li et al., 2010; Lowry & Stepenuck, 2021). Participants in nature-related CS are more likely to bridge the knowledge-action gap by increasing their positive environmental behaviours (Day et al., 2022; Dean et al., 2018; Dean et al., 2019; Kelly et al., 2021; Pocock et al., 2023). Although there are many benefits to CS, there are some common challenges to its implementation. These include the development and maintenance of suitable data collection methods and platforms (Lotfian et al., 2020), and uncertainty regarding the skill levels of participants, which could impact the quality of data generated by CS programmes (Bonney, 2021). Additionally, the complexity and scope of a CS programme should be balanced against the time and resources

required for effective engagement to recruit, train and retain sufficient participants to meet the programme's objectives (Aceves-Bueno et al., 2015). Datasets generated by CS tend to be cumbersome and in need of quality checking, which requires expertise in data management (Burgess et al., 2017). The presumption by some scientists that CS-derived data are of low quality and deficient can lead to these datasets being underutilised by the scientific community (Aceves-Bueno et al., 2015; Bonney, 2021; Burgess et al., 2017).

1.2 | Recreational fishers are ideal citizen scientists

Nature and marine recreational activities can provide a basis for engaging in stewardship (Aschenbrand, 2024; Dean et al., 2024). Recreational fishers are ideal recruits for CS data collection (Bonney et al., 2021), as they can be meaningfully engaged in research and management of a resource that they use (McKinley et al., 2017). Their connection to nature, place-based learning and local ecological knowledge developed through recreational fishing can foster environmental values and stewardship (Shephard et al., 2023). Fishers can enhance CS programmes by providing their skills and local knowledge of fisheries, habitats and ocean conditions to not only support data collection but also assist with project design (Bonney et al., 2021; Calderwood et al., 2023). Fisheries managers and scientists are increasingly recognising the importance of integrating recreational fishing data with scientific data to provide insights into fish populations and fisher behaviour (Calderwood et al., 2023; Fowler et al., 2023; Jansen et al., 2013). In some cases, anglers have been attributed co-authorship in scientific publications (e.g. Arostegui et al., 2024; Buckmeier et al., 2016; Francis et al., 2019). Many fisheries agencies lead monitoring programmes that make use of catch and effort data and fish frames collected by recreational fishers to derive essential inputs for stock assessments and support management decisions (e.g. Fairclough et al. (2014), NOAA (2023)).

Globally, recreational fishers have contributed to CS programmes directly by providing catch information, fish samples and by tagging fish, and indirectly through sharing records such as catch diaries, tournament data, historic photographs and media articles (Gervasi et al., 2022; Gledhill et al., 2015; Pepperell et al., 2011). Widespread and popular CS angler programmes involve conventional

capture–tag–release–recapture programmes (hereafter conventional tagging programmes). These programmes have involved many thousands of participants worldwide who have tagged millions of fish, and their data have been used to explore questions regarding migration and movement patterns, distributions and abundance, site fidelity and age and growth (Brodie et al., 2018; Kohler & Turner, 2001; Merten et al., 2022; Ortiz et al., 2003). Recreational anglers have instigated or even operated their own tagging programmes, such as the Tindale Marine Research Charitable Trust in New Zealand and the Oceanographic Research Institute's (ORI, n.d.) Cooperative Fish Tagging Project in South Africa (Dunlop et al., 2013; Tindale Marine Research Charitable Trust, 2018).

For those seeking to use CS tools to garner information about recreational fisheries, understanding what motivates fishers is critical for leveraging their interests to recruit and retain them as CS volunteers (Clary et al., 1998; Lotfian et al., 2020). People can perform an action because it is inherently interesting or satisfying, known as *intrinsic motivations* (e.g. to benefit society), or because of what they receive in return, which is considered an *extrinsic motivation* (e.g. to further their career) (Finkelstien, 2009; Lotfian et al., 2020). The degree of participation in a CS programme can vary, with some being highly active and others becoming involved for a short time and then moving on (Fischer et al., 2021). A person's decision to stop volunteering may be because they are no longer motivated or receive insufficient benefit, or there may be personal or organisational reasons (Fischer et al., 2021). Understanding the organisational factors (e.g. difficult sampling protocols), personal situation factors (e.g. time commitment) and dispositional factors (e.g. concerns, values) that may present barriers to participation can allow programme managers to address them (Bonter et al., 2023).

1.3 | Game fishers and their role in billfish research

Marine game fishers are a relatively small community of skilled fishers who target large and challenging species such as billfish, tuna and sharks, often using specialised vessels and gear (Ward et al., 2012). Typically, they are highly committed recreational fishers who fish more frequently and have more fishing experience than other recreational marine fishers, and can afford both the time and financial expenditure required to target billfish (Ditton & Stoll, 2003; Ward et al., 2012). Game fishers predominantly practice catch-and-release of billfish rather than retaining them either for consumption or as trophies (Holland et al., 1998; Ward et al., 2012). Their engagement in research activities such as conventional tagging and tissue sampling is a cost-effective tool for gathering important information about these highly migratory fish that are difficult to access and catch in great numbers. Indeed, much of what we know about billfish has been derived in part from the game fishing community, who are strongly supportive of research, conservation, and education about species of interest (Ditton & Stoll, 2003; Ward et al., 2012). Organisations such as the International Game Fishing Association and The Billfish Foundation promote CS initiatives in several different countries,

and there is a long history of game fishers providing financial support to scientists as well as participating directly in research (Ditton & Stoll, 2003; Howard & Ueyanagi, 1965).

In Australia, the New South Wales (NSW) Department of Primary Industries Game Fish Tagging Program (NSW Department of Primary Industries, 2023) has operated continuously across the country since 1973 with over 500,000 game fish tagged as of 2022 for the dual purposes of sport and research (NSW Department of Primary Industries, 2023). The establishment and long-term success of conventional tagging programmes suggest that game fishers are motivated to be involved in research and conservation of a resource that they intrinsically value (Ortiz et al., 2003). More recently, electronic tagging programmes such as the Great Marlin Race have involved game fishers both sponsoring and deploying satellite tags on over 400 billfish across 21 countries (IGFA, 2021). Fishers have provided samples from landed fish and non-lethal fin clips (e.g. Arizmendi-Rodríguez et al., 2006; Williams et al., 2015). Non-lethal sampling is increasingly important to generate sufficient sample sizes for research on billfish species since the majority of recreational catches are released (Williams et al., 2015).

As several billfish stocks are in decline or data deficient, it is critical that we gather more data to inform accurate stock assessments (Collette et al., 2019, 2022). Citizen science can play an important role in addressing these knowledge gaps, for example, through combining conventional and satellite tagging data to inform stock structure (Arostegui et al., 2024). However, we need to understand the drivers and barriers for game fishers' participation in CS programmes in order to harness these opportunities more effectively. Therefore, in this study, we developed an online anonymous survey of game fishers fishing for billfish in Australia to: (1) characterise the diversity and level of their participation in CS research on billfish; (2) assess their motivations for participating in CS research; (3) identify barriers to their participation in research activities; and (4) examine their perceptions of and attitudes towards CS research on billfish. We present here the results of this survey and provide several recommendations for sustaining and growing game fishers' participation in CS programmes on billfish.

2 | METHODS

2.1 | Survey instrument

The survey instrument was developed by the authors, who have years of experience working with game fishers in Australia and researching participation in marine CS. The survey assessed factors influencing long-term participant engagement in CS in four broad categories (as suggested by Bonter et al. (2023)), including dispositional, organisational, personal situation and project-level factors. Respondent disposition was explored through questions about motivations and concerns, which included a series of statements about motivations (Table 1). The development of these statements was based on a classification of CS volunteer motivations by Lotfian et al. (2020), which is an expansion of the Volunteer Functions Inventory (Clary et al., 1998) (see Supporting Information—Appendix S2).

Statement	Level 1	Level 2	Definition
I want to win tournaments and prizes	Extrinsic	Future return Ego enhancement	Expect to achieve something in return Have a good reputation among others
I want to ensure game fishing has a good reputation in the wider community	Extrinsic	Community	Being part of a community with a shared goal
I want to have an activity to do while billfishing	Intrinsic	Enjoyment	Enjoy doing an activity other than profession
I want to spend more time billfishing	Intrinsic	Enjoyment	Enjoy doing an activity other than profession
I want to learn more about billfish	Intrinsic	Fulfilment	Interested in learning new knowledge and understanding the scientific process
I want to contribute to billfish research	Intrinsic	Altruism	Help scientists advance their research or contribute to a worthy cause
I want to contribute to billfish management	Intrinsic	Altruism	Help scientists advance their research or contribute to a worthy cause

TABLE 1 Classification of statements about motivation for participating in future research activities under Lotfian et al.'s (2020) framework of citizen science volunteers' motivation where Level 1 classifies motivations into intrinsic or extrinsic, and Level 2 breaks this down into six sub-categories.

Organisational factors that may affect participation were investigated, including asking participants whether their roles within the programme were clear, if they were satisfied with feedback provided and whether the tasks were simple enough to complete. Socio-demographic questions captured details about the range of people responding to the survey. Project-level factors were assessed through questions about the participants' perspectives on the nature and extent of their experience in previous research, as well as the perceived benefits. A measure of the intention to participate in future research activities was included to directly assess engagement (Ajzen, 1991). The survey instrument was programmed in the Qualtrics XM platform. The initial survey questions were pilot tested by six experienced game fishers who were identified by the Game Fishing Association of Australia (GFAA) to represent different states, with two representatives from NSW and one from each Queensland, Western Australia and Victoria. Following feedback from the pilot testing, the survey instrument was refined for clarity. The final survey instrument included 50 questions and is provided in Supporting Information (Appendix S1).

2.2 | Survey recruitment

Prior to survey distribution, the research was approved by the University of Queensland Science LRN Committee in the Research Ethics and Integrity Department on 16 November 2022 (project reference number 2021/HE002607). Game fishers aged 18years or over who fish for billfish in Australia were invited to participate through survey links that were distributed via email to clubs affiliated with the GFAA and to charter operators who target billfish across Australia. The survey was also shared via Facebook through relevant channels for the Australian game fishing audience, including game fishing community pages and groups. The survey was conducted over an 8-week period from February to April 2023.

A non-random convenience sampling method was used to recruit game fishers because they are a small, specialised and geographically dispersed group, representing only a small proportion (<1%) of the overall recreational fishing population (Ditton & Stoll, 2003; Ward et al., 2012).

2.3 | Data cleaning

Measures were put in place to identify low-quality responses, particularly those populated by computer bots. As suggested by Wardropper et al. (2021), questions were included in the survey to check the attention and logic of responses, including a consent check, commitment check and compulsory open-ended responses. These measures helped to identify that 63% of the 415 completed surveys received were fraudulent; therefore, only 153 survey responses were retained. The increasing prevalence of survey bots is a concern for social research, as they are now often present in large proportions of online survey responses (Johnson et al., 2023). The Qualtrics platform collected response metadata that aided in the detection of fraudulent responses, such as IP address and duplicate, fraud and reCAPTCHA scores. The most important variable for identifying fraudulent responses was location, as almost all suspicious responses were found to originate from outside of Australia. Logical checks were performed; for example, if years of fishing experience exceeded age or mismatches occurred between the state where the respondent was predominantly fishing, the state of residence, and the state of the fishing club. Fraudulent entries often had vague or identical open-ended responses and had selected they were members of multiple fishing clubs. Flagged responses were reviewed manually for irregularities, and those deemed to be fraudulent were excluded from the final dataset.

2.4 | Analyses

Responses to questions describing socio-demographics, fishing experience and past participation in research were summarised as frequency counts and percentages. A respondent's intention to participate in research activities over the next 2 years was measured on a 7-point rating scale (from 'strongly disagree' to 'strongly agree') and visualised using the *likert* package in R (Bryer, 2016). An ordinal logistic regression model with a logit link and an equidistant threshold was implemented in R using the *ordinal* package to explore the relationships between variables that predict intention to participate in future research activities (Christensen, 2023). Predictor variables included: age, gender, state or territory of residence, education level, club membership status, past participation in research, years' experience billfishing and whether participants were involved in a charter business. A likelihood ratio test was used to compare models with flexible, equidistant and symmetric thresholds. A Type II analysis of deviance with Wald chi-squared test was used to assess the significance of individual predictor variables. Respondents were asked to rank seven statements about their motivations for participating in future research activities on a 5-point rating scale (Table 1), and were asked to list any other motivations in an open-ended question (see Supporting Information—Appendix S1 for the questions). Differences in the seven motivation statements between those who had and had not participated in research activities were tested using a Mann–Whitney test.

Six statements about the benefits of participating in billfish research in the next 2 years were ranked on a 7-point rating scale by respondents, who were also asked to list any additional benefits (see Supporting Information—Appendix S1). An open-ended question asked whether they had concerns related to participation in future billfish research activities, and thematic analysis was used to group the answers, which were summarised with counts and percentages. Respondents who had participated in research activities in the past selected from lists of factors that helped their participation and factors that made it more difficult to participate (see Supporting Information—Appendix S1). Those who were willing to participate in research activities in the next 2 years were asked to list anything that might make it easier or more difficult to participate.

3 | RESULTS

3.1 | Respondent demographics and fishing experience

There were 153 legitimate survey responses received, including respondents from every state in Australia. Tables with count and percentage summaries of the responses are provided in Supporting Information (Appendix S3). Queensland (QLD) was most represented with 64 responses, followed by NSW with 43 and Western Australia (WA) with 24. There were 10 or fewer respondents from

other states. Most respondents were male (88%) and aged in their late 40s or older (mean age 48). Many respondents had a trade or professional certificate (42%), and some had completed undergraduate (21%) or postgraduate degrees (9%). Most were employed (57%) or self-employed (28%), and only 8% earned less than the Australian median income. Respondents had a mean of 41 years' experience in recreational fishing and a mean of 18 years' experience fishing for billfish. In addition, 8% were either owners or crew of charter operations, and the majority (84%) were current members of the GFAA. Most respondents had targeted billfish on at least 10 trips (median) over the previous 12 months.

3.2 | Participation in research

Nearly two-thirds of the respondents (63%) had been involved in billfish research activities in the past. Of these respondents, 96% had predominantly used conventional tags. Other activities included the provision of fish samples (55% of participants), provision of catch information (54%) and involvement in electronic tagging (26%). Most of those respondents (78%) had participated in research on more than one species, and most (78%) had participated in more than one type of research activity. Responses indicated that black marlin (*Istiompax indica*) was the most common focal species for past research activities (86%), with sailfish (*Istiophorus platypterus*) (60%), blue marlin (*Makaira nigricans*) (53%) and striped marlin (*Kajikia audax*) (52%) also popular. Fewer respondents had participated in research on spearfish (*Tetrapturus angustirostris*) (8%) and swordfish (*Xiphias gladius*) (5%). Just under a third (32%) of the respondents who had previously participated in research activities had undertaken more than 100 fishing trips for research, and over half (61%) had participated in a research activity in the past 6 months. The majority of respondents (88%) had participated in research in Australia only, with just 11% indicating that they had participated in research both within and outside of Australia. Half of the respondents had participated in research on species other than billfish. For these other species, most participants (88%) were involved in conventional tagging. Few respondents (5%) indicated that they did not intend to participate in future research. Past participation was shown to be a predictor of intention to participate in future research by the ordinal logistic regression model ($p=0.027$) with a positive coefficient estimate (0.84, SE=0.38); however, none of the other predictor variables were significant. The analysis of deviance with Wald chi-squared tested the significance of individual predictors and showed that only past participation was significant ($p=0.027$). Most respondents agreed that they intended to participate in future research regardless of whether they had participated previously, but those with previous experience had stronger intentions (Figure 1).

3.3 | Organisational factors

Most respondents (70%) who had participated in billfish research indicated that there were no factors that had made it more

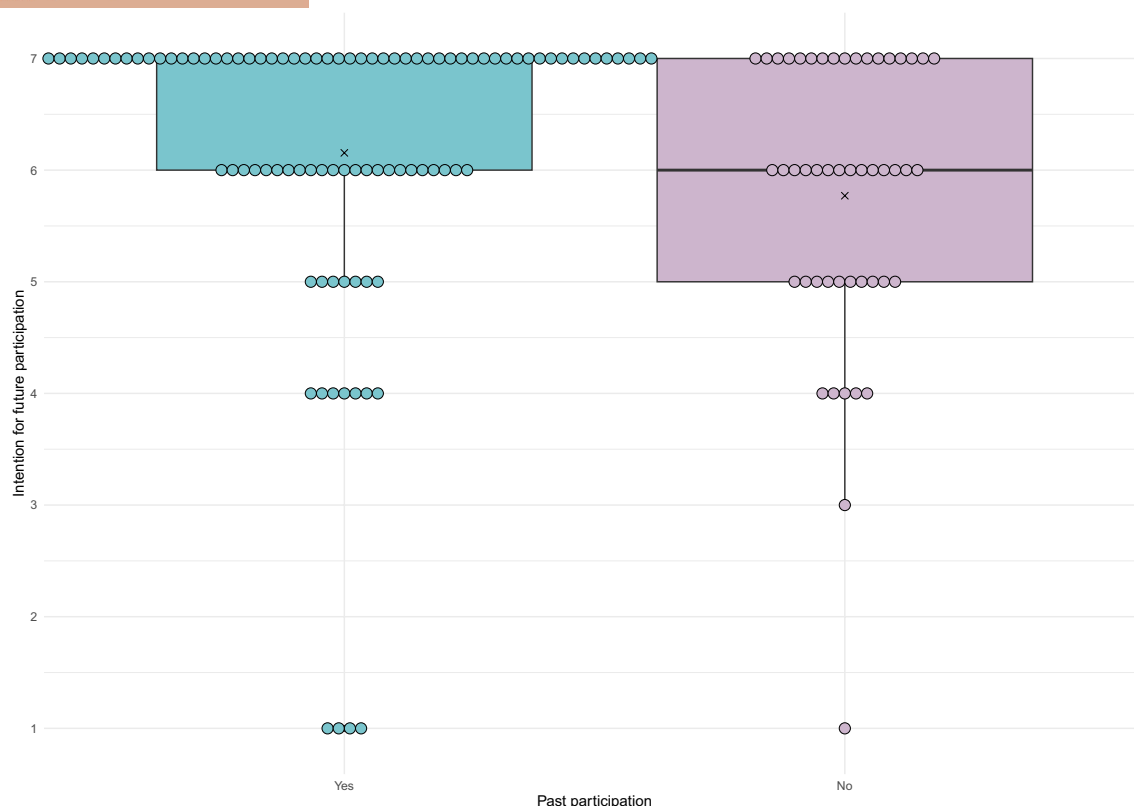


FIGURE 1 Boxplots overlaid with dot plots depicting the distribution of responses to a statement about intention to participate in research in activities over the next 2 years, where one is strongly disagree and seven is strongly agree, in relation to whether or not the respondent had previously participated in research activities (yes/no). Most respondents agreed with the statement and those who had participated in the past had stronger intentions.

difficult; however, 11% indicated that data submission was challenging and 7% indicated that lack of training made participation more difficult. Additional factors listed were predominantly related to the logistical challenges of fishing for billfish, although some cited access to information and equipment caused difficulty. Factors that facilitated participants' involvement in research included that data submission (63%) and sampling (45%) were simple tasks to complete, and that clear instructions were provided for the research activity (47%). Responses to statements regarding past participation in research were largely positive (Figure 2). Most participants agreed that they clearly understood their role in the research (96%), the reasons the research was being conducted (95%) and were satisfied with their participation (94%) (Figure 2). While most participants (71%) were satisfied that they had been informed of the outcomes or results of the research, 19% did not feel as though they had been adequately informed and 10% of the respondents were not satisfied with the communication from those leading the research activity (Figure 2). Just under a third of survey respondents (31%) had not participated in any research activities, with a further 5% uncertain whether they had participated before. The main reasons for non-participation included not being aware of research activities occurring (52%) and being aware of a research activity but unable to participate at the time (30%).

3.4 | Dispositional factors

The majority of respondents (88%) indicated that maintaining the good reputation of game fishing within the wider community was an important motivation for participating in research in the future, as was learning more about billfish (86%) (Figure 3). Contributing to billfish management (78%) and to billfish research (76%), as well as spending more time billfishing (74%) were also rated as important motivations by many respondents (Figure 3). Having an activity to do while billfishing (22%), and winning prizes and tournaments (18%) were less important motivators (Figure 3). Additional comments about motivations provided in open-text answers were reflective of answers in other parts of the survey and were considered in the overall interpretation of the perceptions and attitudes of game fishers towards research. Open-text responses are provided in Supporting Information (Appendix S4). Most respondents agreed that increasing scientific knowledge (96%) and their own knowledge (91%) about billfish were benefits of participating in billfish research in the next 2 years. Other benefits included improving the game fishing community as a whole (88% agreed), improving the management of billfish (87%), enhancing their enjoyment of billfishing (81%) and enhancing their involvement in the game fishing community (78%). Most respondents (79%) did not have any concerns about participating in research activities; however, the remaining comments were classified into five themes

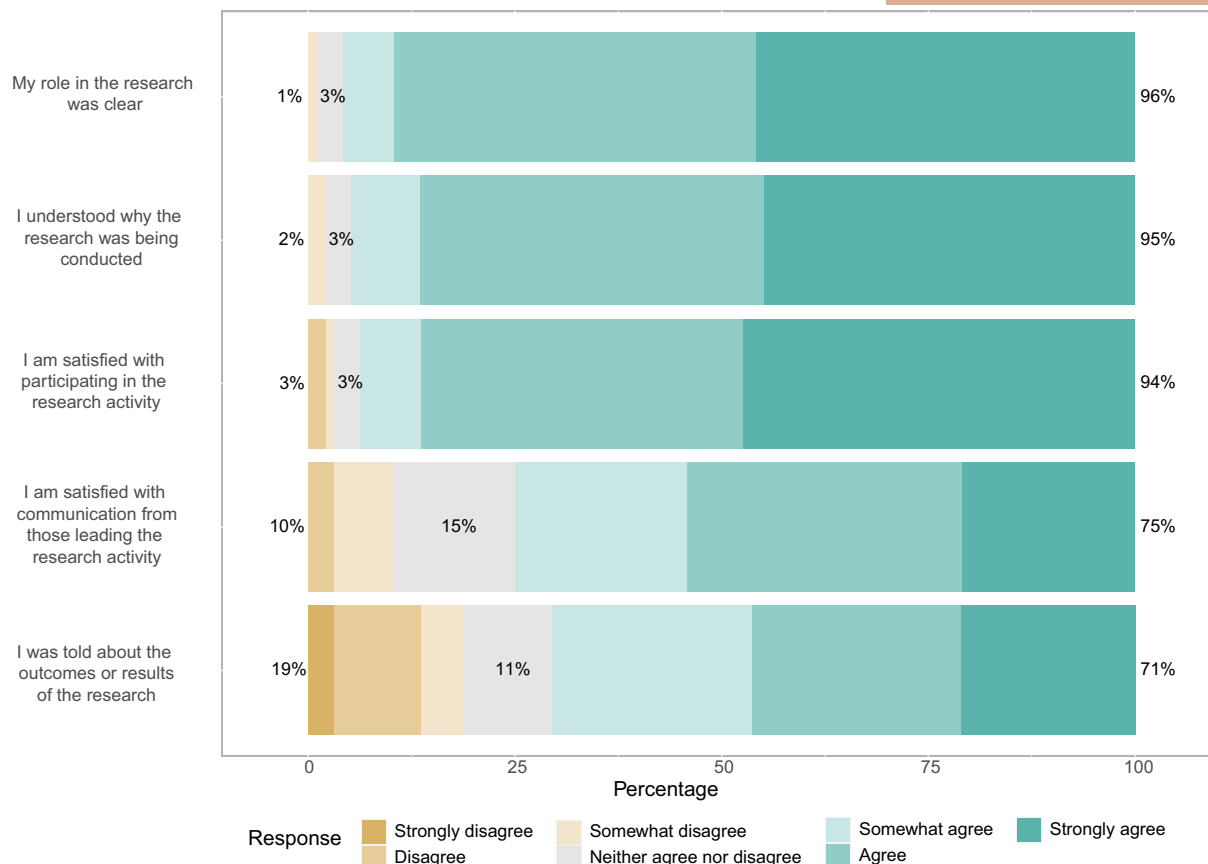


FIGURE 2 Stacked bar plot showing the level of agreement with statements about past experiences in participation in research activities. Most participants were very positive about their past experiences.

(Table 2). The most common concern was the possibility for data to be misused (9%), with comments either about restricting access to recreational fishers (6%) or increasing commercial exploitation of billfish (3%) (Table 2). Other concerns related to the logistical challenges of game fishing (5%) and to do with the welfare of billfish (4%) (Table 2).

4 | DISCUSSION

4.1 | Drivers for participation

Our study finds that game fishers in Australia are strongly motivated to participate in billfish research. This is important because there is a large pool of potential volunteers that could be recruited into both existing and new CS programmes on billfish to bolster data collection efforts. We identified that learning more about billfish was an important motivation for participation, as was contributing to billfish research and management. Previous studies on recreational fishers' engagement in CS programmes have identified similar drivers (Fairclough et al., 2014; Mann-Lang et al., 2022). Although CS projects increase the public's participation in science, this does not always translate into learning outcomes and this disconnect should be addressed to better meet the expectations of participants (Bela et al., 2016; Phillips et al., 2018). A review of several CS programmes

also found contributing to science and research to be a strong driver for participation (Lotfian et al., 2020), which suggests that motivations are broadly similar across various CS programmes. Respondents in our study indicated that they wanted to provide input on the type of research activities conducted on billfish, which is consistent with findings in another study on Australian recreational fishers (Martin, Christidis, & Pecl, 2016).

Recreational fishers often take part in research and stewardship actions because they want to maintain access to the fishery (Granek et al., 2008). Our study identified that for most game fishers, ensuring the sport maintains a good reputation within the wider community was important. A negative shift in public attitudes towards and social acceptance of game fishing could lead to increased limitations on this activity in the future (Arlinghaus et al., 2012). The results of our study suggest that one of the reasons that game fishers are motivated to participate in research activities is to counteract potential negative perceptions, as well as to play an active role in maintaining billfish stocks. In a previous study about a conventional tagging programme, participants expressed that the programme improved perceptions of game fishing and had beneficial welfare and conservation outcomes (Mann-Lang et al., 2022).

Survey respondents indicated that winning tournaments and prizes was a less important motivation for participating in CS, which was unexpected as many game fishers participate in tournaments

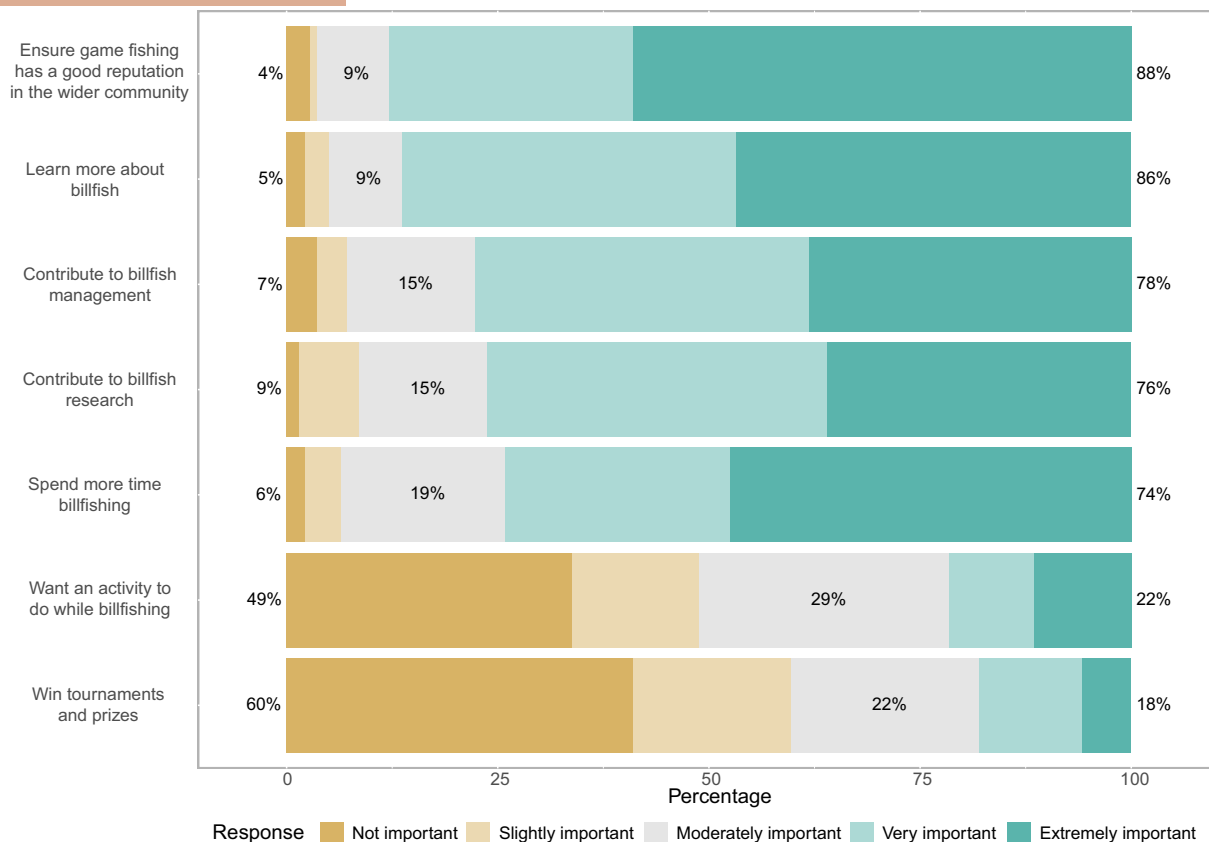


FIGURE 3 Stacked bar plot showing the level of importance for motivations for participation in future research activities.

Themes	Definition	Count	%
None	—	121	79
Misuse of data	Relating to the misuse of data gathered from research activities, particularly to restrict game fishing or for use by commercial fishers	14	9
Game fishing logistics	Relating to logistical challenges of game fishing	7	5
Welfare	Relating to the welfare of billfish	6	4
Project management	Relating to how the CS project is managed and any logistics, including its leadership, training, availability of equipment.	3	2
Feedback	Relating to receiving information about the project.	2	1
Total	—	153	100

TABLE 2 Classification of open-text responses about the concerns of participating in research activities into themes with definitions, counts and percentages.

that often have substantial prizes (Ward et al., 2012). A previous study found that 'trophy fishers' in Australia were motivated by the challenge and mastery of fishing and placed importance on catching large fish and meeting personal milestones (Magee et al., 2018). Conversely, recreational factors such as enjoyment of nature and perceived freedoms were most important for fishing trip satisfaction for members of a Texas sportfishing association (Holland & Ditton, 1992). Extrinsic motivations such as rewards and prizes have been shown in other studies to be less important for engaging participants in CS

programmes (Chacon et al., 2017; Fairclough et al., 2014; Lotfian et al., 2020; West et al., 2021).

Most survey respondents intended to participate in future research activities, and intention can predict behaviour (Ajzen, 1991). Past participation in research activities was a predictor of intention to participate in research activities in the near future, which is consistent with behavioural studies that show past behaviour is a good predictor of future behaviour (Ouellette & Wood, 1998). A subset of respondents could be considered highly committed citizen scientists.

An explanation for the strong participation in CS is that most survey respondents who undertook research activities had positive experiences. Positive experiences in CS programmes have been reported by recreational fishers in previous studies (Crandall et al., 2018; Mann-Lang et al., 2022; Martin, Christidis, & Pecl, 2016). Continued positive experiences in CS programmes rely on their appropriate management of the drivers and barriers identified in this study. In contrast, non-participation was largely owing to a lack of awareness of available opportunities. Improving awareness of CS programmes would therefore be very likely to increase recruitment of these willing volunteers in the future.

4.2 | Clear communication strengthens citizen science

The perceived success of a CS programme can be an important factor in maintaining participant motivation (Bonter et al., 2023). The results of our survey indicated that communication about both the purpose and outcomes of the research from CS programme leaders needs improvement. Respondents stated they would like more communication, particularly digitally, such as over social media or through an app. A study of marine users in Australia showed that they placed a high importance on feedback from scientists about CS projects (Martin, Christidis, & Pecl, 2016). If participants are not aware of the results of CS programmes, then they are unlikely to consider it successful, nor a valuable use of their time. Game fishing is a time-consuming and expensive activity that requires specialised skill, equipment and resources, which in itself is a barrier to participation in research activities on billfish. It is important that CS programme leaders keep these factors in mind, such as time and cost commitments and weather and boating constraints, although they are beyond their control. Clearly communicating the benefits of participating in CS, keeping requirements simple, demonstrating the value for research and management, and providing feedback to participants of CS programmes can help to counteract these factors and improve participant retention (Bonter et al., 2023; Dedual et al., 2013).

Respondents in our survey identified that a lack of access to information from CS programmes was a factor that made it more difficult to participate. Previous studies have shown that recreational fishers have limited access to scientific information, and there are barriers to communication between scientists, managers and fishers, including the technical language barriers and the inaccessibility of peer-reviewed publications (Calderwood et al., 2023; Dedual et al., 2013; Li et al., 2010). Researchers predominantly share their findings through peer-reviewed publications or conference proceedings, which are aimed at an academic audience and tend to spend little time on public outreach (Nguyen et al., 2019). Researchers involved in CS programmes should look to increase communication, engagement and collaboration from aspects of programme design through to sharing outcomes with participants. The benefits of CS data to researchers and managers are often far greater compared to the cost of

independent sampling and can be improved with investment in engagement (Fairclough et al., 2014).

Our survey identified that the potential misuse of information collected for CS to restrict game fishing was the most common concern, although most respondents did not identify any concerns. The recreational fishing sector has expressed similar concerns about access limitations through the creation or expansion of marine parks or changes to fisheries legislation in previous studies (Dedual et al., 2013; Gledhill et al., 2015; Magee et al., 2018; Martin, Christidis, Lloyd, & Pecl, 2016). Species with high social value, such as billfish, can garner substantial political debate about their management, and therefore these concerns are not unsubstantiated (Fairclough et al., 2014; Kadagi et al., 2020). Respondents also raised concerns about the potential for commercial fishers to use data from CS programmes to increase commercial catch of billfish or their prey. Tension between the interests of recreational and commercial fishers is a common theme in fisheries management (Bower et al., 2020; Dedual et al., 2013; Kadagi et al., 2020). There is a general concern that emerging technologies that allow anglers to collect and share information could lead to exploitation of fisheries (Cooke et al., 2021; Holder et al., 2020). As such, recreational fishers may be reluctant to share information through CS programmes that they feel could be used to exploit their target species or fishing grounds. If CS programmes fail to acknowledge the concerns of game fishers around potential misuse of data, it is possible that we will see decreasing levels of trust in researchers and managers within the game fishing community. To address these concerns, monitoring data, particularly location data, should be managed responsibly and consideration should be given as to who owns the data, how it is stored and with whom it is shared (Calderwood et al., 2023; Pecl et al., 2019; Sandbrook et al., 2021; Young et al., 2022). If engagement is done poorly, then there is a real risk to the future of CS programmes on billfish because the game fishing community from which these CS programmes draw is comparatively small and specialised.

4.3 | Mechanisms to improve engagement with game fishers

Ensuring there is a good relationship between the organisations leading CS programmes and the game fishing community is vital to the success of billfish research. Greater engagement with game fishers and collaboration across organisations can address some of the barriers to and enhance drivers for participating in CS programmes that were raised in this study. Collaboration helps build trust, which is fundamental to effective management (Bonney et al., 2021; Gilfedder et al., 2019). A previous study found that researchers who are more involved in fisheries management processes and public engagement often see greater uptake of their research findings, along with increased public trust (Nguyen et al., 2019). Greater involvement of both game fishers and the fishing associations that represent them

in CS programmes is likely to increase the agency of these groups and enhance their stewardship of the billfish species that they target (Arlinghaus et al., 2019; Shephard et al., 2023). Fishing associations are well placed to help increase fisher participation in CS programmes (Martin, Christidis, & Pecl, 2016; Voyer et al., 2015). These associations can provide support for research and conservation measures through advocacy, funding or in-kind contributions (Granek et al., 2008; Vohland et al., 2021). Collaboration can strengthen and diversify support and ensure continuity for long-term CS programmes, which can be threatened by fluctuations in funding and staffing.

The delivery of CS programmes and engagement with participants can be improved by better harnessing existing technologies. Several survey respondents called for digital data collection, indicating that digital tools were underutilised. Digital methods can increase accuracy and timeliness of records, and allow for two-way information exchange, such as to provide feedback and recognise participant contributions (Dedual et al., 2013; Taylor et al., 2022; Venturelli et al., 2017). Multiple respondents in our survey wanted to receive recognition for participating. Information about participation, such as recapture reports, summary statistics and leaderboards, can provide recognition and feedback about CS efforts. Training and resources for research activities, such as fish handling, tagging, and sampling techniques, can be widely disseminated using online learning tools, and can enhance satisfaction of participants and raise awareness of CS programmes (Mann-Lang et al., 2022). As digital technologies that allow fishers to share their fishing experiences grow, so will the opportunities for CS programmes (Cooke et al., 2021). The type and resolution of data that we can feasibly collect about billfish through CS programmes has evolved in recent decades, which creates new opportunities for CS programmes. This includes improvements in video and photo quality, as well as innovations in how cameras are deployed, developments in electronic tagging equipment and improved accuracy and availability of instruments that measure real-time location and in-situ environmental conditions (Bonney et al., 2021; Cooke et al., 2021).

Ensuring the consistency of information across a broad geographic area is a challenge for CS programmes involving migratory species, because the communication channels, demographics and peaks in fishing and animal activity can vary. CS programmes should engage with participants across multiple pathways for data reporting and communication, as different channels have different advantages and different user demographics (Mann-Lang et al., 2022; Taylor et al., 2022; Venturelli et al., 2017). Several tagging programmes provide regular communication through online newsletters (e.g. Hawaii Community Tagging Program, n.d. and ORI Cooperative Fish Tagging Project (ORI, n.d.)). Our study indicated that many of the respondents gained information from fishing clubs. Game fishing clubs in Australia provide information to their members through regular meetings, tournament events, via email and increasingly through social media. Peer-to-peer communication can be particularly effective and can take place at club or association meetings, through tackle shops or through ambassadors that have influence in fishing communities, such as fishing guides or media personalities (Dedual et al., 2013; Mann-Lang et al., 2022).

4.4 | Limitations

It was not possible to determine the degree to which our sample is representative of adult Australian game fishers who fish for billfish. This is, in part, due to the limited information about the size and demographics of the population of game fishers in Australia (Ditton & Stoll, 2003; Ward et al., 2012). We can compare the respondents in this study to membership information from the GFAA, which has similar proportions of men and women but differences across states, for example, a higher proportion of respondents from QLD and Northern Territory (see [Supporting Information—Appendix S5](#)). However, this information does not include fishers who are not members of clubs nor charter operations that target billfish, and therefore these differences do not mean the study is not representative.

The high response rate from avid game fishers who are involved in research is likely a result of self-selection bias and non-response error common to online surveys (Bethlehem, 2010). However, these avid respondents are ideal candidates to explore motivations and concerns about participation because they are most likely to be recruited to new CS programmes. Many such respondents remain as participants of existing programmes, so it is helpful to understand their experiences of CS to date. Importantly, perspectives from non-participants were also included since approximately one third of respondents had never participated in billfish research activities before. This study highlights the barriers and motivations for the recruitment of new participants into CS programmes, which is not commonly addressed in previous studies on CS motivations as these typically focus on existing participants.

Another limitation of this study is that the total population of Australian fishers who fish for billfish is unknown; therefore, determining an adequate sample size was not possible. In the absence of such data, we assumed a population of 10,000 game fishers to assess the overall power of the study and the impact of sample size on the reliability of results. Given a sample size of 153 respondents, the standard error was 0.04, and the corresponding margin of error was $\pm 7.9\%$ at the 95% confidence level for this study. The population estimate is based on the reported 7832 GFAA members for 2023/2024 and also allowed for a reasonable number of additional fishers not affiliated with a club. While this means the results should be interpreted with some caution, this exploratory study with an undefined target population provides sufficient data to progress the field and gain an understanding of what is important for game fishers participating in citizen science.

5 | CONCLUSION AND RECOMMENDATIONS

The results of our study have provided useful insight into the drivers and barriers of game fishers' participation in CS, which can be used to support the recruitment and retention of recreational fishers in CS programmes. Overall, game fishers in Australia are highly motivated to participate in citizen science programmes on billfish, and there are few

barriers to engaging them in research activities. However, our results indicate that communication about CS programmes needs to improve to not only recruit more participants but also to fulfil their motivations and address their concerns about participation. The disconnect between the willingness to participate in CS programmes and insufficient awareness of these programmes is broadly applicable in other CS contexts, where the number of potential participants almost certainly exceeds current participants. Our findings are particularly relevant for CS programmes where participants are highly motivated because recruitment and retention of participants from a small, specialised pool requires a different approach than for large-scale contributory CS programmes targeting the general public. Our survey highlighted the main motivations and concerns of game fishers as CS participants. We suggest that future research could explore the challenges in creating and managing CS programmes for billfish research and barriers to the integration of these CS data into fisheries science through the lenses of fisheries researchers, managers and CS programme leaders.

We present three key recommendations for CS programmes on billfish in Australia. Our recommendations are also pertinent to increasing recruitment and retention of participants in CS programmes more broadly, particularly where these participants include fishers. These include the following: (i) increasing collaboration between government, research and fishing organisations; (ii) improving communication with and engagement of participants in CS programmes; and (iii) employing more current and emerging technologies to deliver CS programmes.

New technologies can increase the type, scale and resolution of CS data collected to fill knowledge gaps for billfish in Australia. Addressing these gaps should be shaped by the management needs of government agencies, the stakeholder interests of fishing associations and the expertise of scientific researchers. Regular and quality communication is needed both through collaboration across these sectors and by engaging directly with participants in CS programmes. Communication and engagement plans are useful tools for CS programmes that can engage with participants through multiple pathways, both digitally and in person. These plans should aim to cover off on the following areas: advertising opportunities to become involved in CS activities; providing information and training about how to undertake CS activities; disseminating information about science and management; explaining how data are being used and with whom it will be shared; demonstrating the value of the CS programme to research and management; delivering feedback about the outcomes and results; recognising the contributions of participants; and collecting feedback from participants. Strategic engagement is needed to increase retention and recruitment of game fishers as citizen scientists into the future, without whom it would be difficult to carry out billfish research. As the opportunities for CS increase into the future, many eyes on the seas might allow us to make new and exciting discoveries about these seldom-sighted pelagic fish.

AUTHOR CONTRIBUTIONS

Laura M. Smith, Samuel M. Williams and Julian G. Pepperell developed the concept with assistance from Victoria Y. Martin, Bonnie J.

Holmes and Ian R. Tibbetts. Laura M. Smith and Victoria Y. Martin designed the methodology with support from Samuel M. Williams, Julian G. Pepperell and Bonnie J. Holmes. Laura M. Smith and Victoria Y. Martin analysed and interpreted the data with support from Sheridan Rabbitt. Laura M. Smith led the writing of the manuscript, which was substantively revised and reviewed by all authors.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Summarised survey data are available in the [Supporting Information](#). Raw survey data cannot be stored in any publicly available database due to the conditions of approval from the University of Queensland's Office of Research Ethics. Anonymised survey data can be made available upon request.

INCLUSION

Our study includes authors based in the country where the study was carried out. We engaged with local stakeholders from the game fishing community and the NSW GFTP to seek their feedback, which was incorporated into the study. Literature from relevant Australian studies is cited alongside studies from a broad range of regions, which demonstrates the global relevance of our work.

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REFERENCES

- Aceves-Bueno, E., Adeleye, A. S., Bradley, D., Tyler Brandt, W., Callery, P., Feraud, M., Garner, K. L., Gentry, R., Huang, Y., McCullough, I., Pearlman, I., Sutherland, S. A., Wilkinson, W., Yang, Y., Zink, T., Anderson, S. E., & Tague, C. (2015). Citizen science as an approach for overcoming insufficient monitoring and inadequate stakeholder buy-in in adaptive management: Criteria and evidence. *Ecosystems*, 18(3), 493–506. <https://doi.org/10.1007/s10021-015-9842-4>
- Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, 50(2), 179–211. [https://doi.org/10.1016/0749-5978\(91\)90020-T](https://doi.org/10.1016/0749-5978(91)90020-T)
- Arizmendi-Rodríguez, D. I., Abitia-Cárdenas, L. A., Galván-Magaña, F., & Trejo-Escamilla, I. (2006). Food habits of sailfish *Istiophorus*

- platypterus* off Mazatlán, Sinaloa, Mexico. *Bulletin of Marine Science*, 79(3), 777–791.
- Arlinghaus, R., Abbott, J. K., Fenichel, E. P., Carpenter, S. R., Hunt, L. M., Alós, J., Klefoth, T., Cooke, S. J., Hilborn, R., Jensen, O. P., Wilberg, M. J., Post, J. R., & Manfredo, M. J. (2019). Governing the recreational dimension of global fisheries. *Proceedings of the National Academy of Sciences of the United States of America*, 116(12), 5209–5213. <https://doi.org/10.1073/pnas.1902796116>
- Arlinghaus, R., Schwab, A., Riepe, C., & Teel, T. (2012). A primer on anti-angling philosophy and its relevance for recreational fisheries in urbanized societies. *Fisheries*, 37(4), 153–164. <https://doi.org/10.1080/03632415.2012.666472>
- Arostegui, M. C., Gaube, P., Bowman, M., Nakamaru, K., & Braun, C. D. (2024). Fishery-independent and -dependent movement data aid in defining the stock structure of a data-deficient billfish. *Fisheries Research*, 271, 106923. <https://doi.org/10.1016/j.fishres.2023.106923>
- Aschenbrand, E. (2024). How urbanization is shifting the context of nature experiences from economic to recreational. *People and Nature*, 6(2), 703–711. <https://doi.org/10.1002/pan3.10594>
- Bela, G., Peltola, T., Young, J. C., Balazs, B., Arpin, I., Pataki, G., Hauck, J., Kelemen, E., Kopperoinen, L., Van Herzele, A., Keune, H., Hecker, S., Suskevics, M., Roy, H. E., Itkonen, P., Kulvik, M., Laszlo, M., Basnou, C., Pino, J., & Bonn, A. (2016). Learning and the transformative potential of citizen science. *Conservation Biology*, 30(5), 990–999. <https://doi.org/10.1111/cobi.12762>
- Bethlehem, J. (2010). Selection bias in web surveys. *International Statistical Review*, 78(2), 161–188. <https://doi.org/10.1111/j.1751-5823.2010.00112.x>
- Bonney, R. (2021). Expanding the impact of citizen science. *Bioscience*, 71(5), 448–451. <https://doi.org/10.1093/biosci/biab041>
- Bonney, R., Byrd, J., Carmichael, J. T., Cunningham, L., Oremland, L., Shirk, J., & Von Harten, A. (2021). Sea change: Using citizen science to inform fisheries management. *Bioscience*, 71(5), 519–530. <https://doi.org/10.1093/biosci/biab016>
- Bonney, R., Phillips, T. B., Ballard, H. L., & Enck, J. W. (2016). Can citizen science enhance public understanding of science? *Public Understanding of Science*, 25(1), 2–16. <https://doi.org/10.1177/096362515607406>
- Bonter, D. N., Martin, V. Y., Greig, E. I., & Phillips, T. B. (2023). Participant retention in a continental-scale citizen science project increases with the diversity of species detected. *Bioscience*, 73(6), 433–440. <https://doi.org/10.1093/biosci/biad041>
- Bower, S. D., Aas, Ø., Arlinghaus, R., Douglas Beard, T., Cowx, I. G., Danylchuk, A. J., Freire, K. M. F., Potts, W. M., Sutton, S. G., & Cooke, S. J. (2020). Knowledge gaps and management priorities for recreational fisheries in the developing world. *Reviews in Fisheries Science & Aquaculture*, 28(4), 518–535. <https://doi.org/10.1080/23308249.2020.1770689>
- Brodie, S., Litherland, L., Stewart, J., Schilling, H. T., Pepperell, J. G., & Suthers, I. M. (2018). Citizen science records describe the distribution and migratory behaviour of a piscivorous predator, *Pomatomus saltatrix*. *ICES Journal of Marine Science*, 75(5), 1573–1582. <https://doi.org/10.1093/icesjms/fsy057>
- Bryer, J. (2016). *Analysis and visualization Likert items*, 1.3.5 edn, CRAN, R Package. <https://github.com/jbryer/likert>
- Buckmeier, D. L., Ferrara, A. M., Schlechte, J. W., Kirkland, K., & Smith, N. G. (2016). Characteristics and conservation of a trophy alligator gar population in the middle Trinity River, Texas. *Journal of the Southeastern Association of Fish and Wildlife Agencies*, 3(402021), 33–38.
- Burgess, H. K., Debey, L. B., Froehlich, H. E., Schmidt, N., Theobald, E. J., Ettinger, A. K., Hillerislambers, J., Tewksbury, J., & Parrish, J. K. (2017). The science of citizen science: Exploring barriers to use as a primary research tool. *Biological Conservation*, 208, 113–120. <https://doi.org/10.1016/j.biocon.2016.05.014>
- Calderwood, J., ten Brink, T., & Steins, N. A. (2023). Identifying best practice to integrate fisher's experiential knowledge into marine science and management. *ICES Journal of Marine Science*, 82, fsad166. <https://doi.org/10.1093/icesjms/fsad166>
- Chacon, F., Gutierrez, G., Sauto, V., Vecina, M. L., & Perez, A. (2017). Volunteer functions inventory: A systematic review. *Psicothema*, 3, 306–316. <https://doi.org/10.7334/psicothema2016.371>
- Christensen, R. H. B. (2023). Regression models for ordinal data, 2023.12-4 edn, CRAN, R Package. <https://github.com/runehaubo/ordinal>
- Clary, E. G., Snyder, M., Ridge, R. D., Copeland, J., Stukas, A. A., Haugen, J., & Miene, P. (1998). Understanding and assessing the motivations of volunteers: A functional approach. *Journal of Personality and Social Psychology*, 74(6), 1516–1530. <https://doi.org/10.1037//0022-3514.74.6.1516>
- Collette, B. B., Di Natale, A., Fox, W., Graves, J., Juan Jorda, M., Pohlot, B., Restrepo, V., & Schratwieser, J. (2022). *Istiophorus platypterus*, IUCN, 23/08/2022. <https://doi.org/10.2305/IUCN.UK.2022-1.RLTS.T170338A46649664.en>
- Collette, B. B., Graves, J., & Kells, V. A. (2019). *Tunas and billfishes of the world*. Johns Hopkins University Press.
- Conrad, C. C., & Hilchey, K. G. (2011). A review of citizen science and community-based environmental monitoring: Issues and opportunities. *Environmental Monitoring and Assessment*, 176(1–4), 273–291. <https://doi.org/10.1007/s10661-010-1582-5>
- Cooke, S. J., Venturelli, P., Twardek, W. M., Lennox, R. J., Brownscombe, J. W., Skov, C., Hyder, K., Suski, C. D., Diggles, B. K., Arlinghaus, R., & Danylchuk, A. J. (2021). Technological innovations in the recreational fishing sector: Implications for fisheries management and policy. *Reviews in Fish Biology and Fisheries*, 31, 253–288. <https://doi.org/10.1007/s11160-021-09643-1>
- Crandall, C. A., Monroe, M., Dutka-Gianelli, J., Fitzgerald, B., & Lorenzen, K. (2018). How to bait the hook: Identifying what motivates anglers to participate in a volunteer angler data program. *Fisheries*, 43(11), 517–526. <https://doi.org/10.1002/fsh.10156>
- Day, G., Fuller, R. A., Nichols, C., & Dean, A. J. (2022). Characteristics of immersive citizen science experiences that drive conservation engagement. *People and Nature*, 4(4), 983–995. <https://doi.org/10.1002/pan3.10332>
- Dean, A. J., Barnett, A. G., Wilson, K. A., & Turrell, G. (2019). Beyond the 'extinction of experience'—Novel pathways between nature experience and support for nature conservation. *Global Environmental Change*, 55, 48–57. <https://doi.org/10.1016/j.gloenvcha.2019.02.002>
- Dean, A. J., Church, E. K., Loder, J., Fielding, K. S., & Wilson, K. A. (2018). How do marine and coastal citizen science experiences foster environmental engagement? *Journal of Environmental Management*, 213, 409–416. <https://doi.org/10.1016/j.jenvman.2018.02.080>
- Dean, A. J., Uebel, K., Schultz, T., Fielding, K. S., Saeck, E., Ross, H., & Martin, V. (2024). Community stewardship to protect coastal and freshwater ecosystems—pathways between recreation and stewardship intentions. *People and Nature*, 6(4), 1452–1468. <https://doi.org/10.1002/pan3.10658>
- Dedual, M., Sague Pla, O., Arlinghaus, R., Clarke, A., Ferter, K., Geertz Hansen, P., Gerdeaux, D., Hames, F., Kennelly, S. J., Kleiven, A. R., Meraner, A., & Ueberschär, B. (2013). Communication between scientists, fishery managers and recreational fishers: Lessons learned from a comparative analysis of international case studies. *Fisheries Management and Ecology*, 20(2–3), 234–246. <https://doi.org/10.1111/fme.12001>
- Ditton, R. B., & Stoll, J. R. (2003). Social and economic perspective on recreational billfish fisheries. *Marine and Freshwater Research*, 54(4), 545. <https://doi.org/10.1071/mf01279>
- Dunlop, S., Mann, B., & Van Der Elst, R. (2013). A review of the oceanographic research institute's cooperative fish tagging project: 27 years down the line. *African Journal of Marine Science*, 35(2), 209–221. <https://doi.org/10.2989/1814232x.2013.769909>

- Eichholtzer, A. C., Driscoll, D. A., Patrick, R., Galletta, L., & Lawson, J. (2024). The co-benefits of biodiversity citizen science for well-being and nature relatedness. *Applied Psychology. Health and Well-Being*, 16(2), 515–536. <https://doi.org/10.1111/aphw.12502>
- Fairclough, D. V., Brown, J. I., Carlish, B. J., Crisafulli, B. M., & Keay, I. S. (2014). Breathing life into fisheries stock assessments with citizen science. *Scientific Reports*, 4(1), 7249. <https://doi.org/10.1038/srep07249>
- Finkelstien, M. A. (2009). Intrinsic vs. extrinsic motivational orientations and the volunteer process. *Personality and Individual Differences*, 46(5), 653–658. <https://doi.org/10.1016/j.paid.2009.01.010>
- Fischer, H., Cho, H., & Storksdieck, M. (2021). Going beyond hooked participants: The nibble-and-drop framework for classifying citizen science participation. *Citizen Science: Theory and Practice*, 6(1), 10. <https://doi.org/10.5334/cstp.350>
- Fowler, A. M., Dowling, N. A., Lyle, J. M., Alós, J., Anderson, L. E., Cooke, S. J., Danylchuk, A. J., Ferter, K., Folpp, H., Hutt, C., Hyder, K., Lew, D. K., Lowry, M. B., Lynch, T. P., Meadows, N., Mugerza, E., Nedreaas, K., Garrone-Neto, D., Ochwada-Doyle, F. A., ... Chick, R. C. (2023). Toward sustainable harvest strategies for marine fisheries that include recreational fishing. *Fish and Fisheries*, 24(6), 1003–1019. <https://doi.org/10.1111/faf.12781>
- Francis, M. P., Shivji, M. S., Duffy, C. A. J., Rogers, P. J., Byrne, M. E., Wetherbee, B. M., Tindale, S. C., Lyon, W. S., & Meyers, M. M. (2019). Oceanic nomad or coastal resident? Behavioural switching in the shortfin mako shark (*Isurus oxyrinchus*). *Marine Biology*, 166(1), 5. <https://doi.org/10.1007/s00227-018-3453-5>
- Gervasi, C. L., Massie, J. A., Rodemann, J., Trabelsi, S., Santos, R. O., & Rehage, J. S. (2022). Recreational angler contributions to fisheries management are varied and valuable: Case studies from south Florida. *Fisheries*, 47(11), 469–477. <https://doi.org/10.1002/fsh.10823>
- Gilfedder, M., Robinson, C. J., Watson, J. E. M., Campbell, T. G., Sullivan, B. L., & Possingham, H. P. (2019). Brokering trust in citizen science. *Society & Natural Resources*, 32(3), 292–302. <https://doi.org/10.1080/08941920.2018.1518507>
- Gledhill, D. C., Hobday, A. J., Welch, D. J., Sutton, S. G., Lansdell, M. J., Koopman, M., Jeloudev, A., Smith, A., & Last, P. R. (2015). Collaborative approaches to accessing and utilising historical citizen science data: A case-study with spearfishers from eastern Australia. *Marine and Freshwater Research*, 66(3), 195–201. <https://doi.org/10.1071/Mf14071>
- Granek, E. F., Madin, E. M., Brown, M. A., Figueira, W., Cameron, D. S., Hogan, Z., Kristianson, G., de Villiers, P., Williams, J. E., Post, J., Zahn, S., & Arlinghaus, R. (2008). Engaging recreational fishers in management and conservation: Global case studies. *Conservation Biology*, 22(5), 1125–1134. <https://doi.org/10.1111/j.1523-1739.2008.00977.x>
- Hawaii Community Tagging Program. <https://www.sharktagger.org/>
- Holder, P. E., Jeanson, A. L., Lennox, R. J., Brownscombe, J. W., Arlinghaus, R., Danylchuk, A. J., Bower, S. D., Hyder, K., Hunt, L. M., Fenichel, E. P., Venturelli, P. A., Thorstad, E. B., Allen, M. S., Potts, W. M., Clark-Danylchuk, S., Claussen, J. E., Lyle, J. M., Tsuboi, J.-I., Brummett, R., ... Cooke, S. J. (2020). Preparing for a changing future in recreational fisheries: 100 research questions for global consideration emerging from a horizon scan. *Reviews in Fish Biology and Fisheries*, 30(1), 137–151. <https://doi.org/10.1007/s11160-020-09595-y>
- Holland, S. M., & Ditton, R. B. (1992). Fishing trip satisfaction: A typology of anglers. *North American Journal of Fisheries Management*, 12, 28–33. <https://doi.org/10.1577/1548-8675>
- Holland, S. M., Ditton, R. B., & Graefe, A. R. (1998). An ecotourism perspective on billfish fisheries. *Journal of Sustainable Tourism*, 6(2), 97–116. <https://doi.org/10.1080/09669589808667305>
- Howard, J. K., & Ueyanagi, S. (1965). Distribution and relative abundance of billfishes (Istiophoridae) of the Pacific Ocean. *Studies in Tropical Oceanography*, 2, 1–134.
- IGFA. (2021). *What is the IGFA great marlin race?* International Game Fishing Association (IGFA). <https://igfa.org/igmr-program-overview/>
- Jansen, T., Arlinghaus, R., Als, T. D., & Skov, C. (2013). Voluntary angler logbooks reveal long-term changes in a lentic pike, *Esox lucius*, population. *Fisheries Management and Ecology*, 20(2–3), 125–136. <https://doi.org/10.1111/j.1365-2400.2012.00866.x>
- Johnson, M. S., Adams, V. M., & Byrne, J. (2023). Addressing fraudulent responses in online surveys: Insights from a web-based participatory mapping study. *People and Nature*, 6(1), 147–164. <https://doi.org/10.1002/pan3.10557>
- Kadagi, N. I., Wambiji, N., & Swisher, M. E. (2020). Potential for conflicts in recreational and artisanal billfish fisheries on the coast of Kenya. *Marine Policy*, 117, 103960. <https://doi.org/10.1016/j.marpol.2020.103960>
- Kelly, R., Evans, K., Alexander, K., Bettiol, S., Corney, S., Cullen-Knox, C., Cvitanovic, C., de Salas, K., Emad, G. R., Fullbrook, L., Garcia, C., Ison, S., Ling, S., Macleod, C., Meyer, A., Murray, L., Murunga, M., Nash, K. L., Norris, K., ... Pecl, G. T. (2021). Connecting to the oceans: Supporting ocean literacy and public engagement. *Reviews in Fish Biology and Fisheries*, 32(1), 123–143. <https://doi.org/10.1007/s11160-020-09625-9>
- Kohler, N. E., & Turner, P. A. (2001). Shark tagging: A review of conventional methods and studies. *Environmental Biology of Fishes*, 60(1–3), 191–224. https://doi.org/10.1007/978-94-017-3245-1_12
- Koss, R. S., & Kingsley, J. Y. (2010). Volunteer health and emotional well-being in marine protected areas. *Ocean & Coastal Management*, 53(8), 447–453. <https://doi.org/10.1016/j.ocecoaman.2010.06.002>
- Li, O., Sutton, S. G., & Tynan, L. (2010). Communicating scientific information to recreational fishers. *Human Dimensions of Wildlife*, 15(2), 106–118. <https://doi.org/10.1080/10871200903366939>
- Lotfian, M., Ingensand, J., & Brovelli, M. A. (2020). A framework for classifying participant motivation that considers the typology of citizen science projects. *ISPRS International Journal of Geo-Information*, 9(12), 704. <https://doi.org/10.3390/ijgi9120704>
- Lowry, C. S., & Stepenuck, K. F. (2021). Is citizen science dead? *Environmental Science & Technology*, 55(8), 4194–4196. <https://doi.org/10.1021/acs.est.0c07873>
- Magee, C., Voyer, M., McIlgorm, A., & Li, O. (2018). Chasing the thrill or just passing the time? Trialing a new mixed methods approach to understanding heterogeneity amongst recreational fishers based on motivations. *Fisheries Research*, 199, 107–118. <https://doi.org/10.1016/j.fishres.2017.11.026>
- Mann-Lang, J. B., Mann, B. Q., Jordaan, G. L., & Daly, R. (2022). An assessment of the impact of participation in the Oceanographic Research Institute's Cooperative Fish Tagging Project on angler attitudes and behaviour. *African Journal of Marine Science*, 44(4), 299–309. <https://doi.org/10.2989/1814232x.2022.2126525>
- Martin, V. Y., Christidis, L., Lloyd, D. J., & Pecl, G. (2016). Understanding drivers, barriers and information sources for public participation in marine citizen science. *Journal of Science Communication*, 15(2), A02. <https://doi.org/10.22323/2.15020202>
- Martin, V. Y., Christidis, L., & Pecl, G. T. (2016). Public interest in marine citizen science: Is there potential for growth? *Bioscience*, 66(8), 683–692. <https://doi.org/10.1093/biosci/biw070>
- McKinley, D. C., Miller-Rushing, A. J., Ballard, H. L., Bonney, R., Brown, H., Cook-Patton, S. C., Evans, D. M., French, R. A., Parrish, J. K., Phillips, T. B., Ryan, S. F., Shanley, L. A., Shirk, J. L., Stepenuck, K. F., Weltzin, J. F., Wiggins, A., Boyle, O. D., Briggs, R. D., Chapin, S. F., ... Soukup, M. A. (2017). Citizen science can improve conservation science, natural resource management, and environmental protection. *Biological Conservation*, 208, 15–28. <https://doi.org/10.1016/j.biocon.2016.05.015>
- Merten, W., Appeldoorn, R., Grove, A., Aguilar-Perera, A., Arocha, F., & Rivera, R. (2022). Condition of the international fisheries, catch and effort trends, and fishery data gaps for dolphinfish (*Coryphaena hippurus*) from 1950 to 2018 in the Western Central Atlantic Ocean.

- Marine Policy, 143, 105189. <https://doi.org/10.1016/j.marpol.2022.105189>
- Nguyen, V. M., Young, N., Brownscombe, J. W., & Cooke, S. J. (2019). Collaboration and engagement produce more actionable science: Quantitatively analyzing uptake of fish tracking studies. *Ecological Applications*, 29(6), e01943. <https://doi.org/10.1002/eap.1943>
- NOAA. (2023). *About the marine recreational information program*. National Oceanic and Atmospheric Administration. <https://www.fisheries.noaa.gov/recreational-fishing-data/about-marine-recreational-information-program>
- NSW Department of Primary Industries. (2023). *NSW DPI Game Fish Tagging Program Annual Report 2020–2021*, by Pepperell, J. G. https://www.dpi.nsw.gov.au/_data/assets/pdf_file/0007/14146/63/GFT-Report-2020-21.pdf
- Oh, R. R. Y., Fuller, R. A., Peters, B., Dean, A. J., Pachana, N. A., Callaghan, C. T., Sockhill, N. J., Bonn, A., & Suarez-Castro, A. F. (2024). Enhancing the health and wellbeing benefits of biodiversity citizen science. *Frontiers in Environmental Science*, 12, 1444161. <https://doi.org/10.3389/fenvs.2024.1444161>
- Oh, R. R. Y., Suarez-Castro, A. F., Fuller, R. A., Tervo, M., Rozario, K., Peters, B., Chowdhury, S., von Gönner, J., Friedrichs-Manthey, M., Berger, A., Schultz, T., Dean, A. J., Tulloch, A., & Bonn, A. (2025). Using nature-based citizen science initiatives to enhance nature connection and mental health. *Frontiers in Environmental Science*, 13, 1461601. <https://doi.org/10.3389/fenvs.2025.1461601>
- ORI. (n.d.). *Oceanographic Research Institute's (ORI) Cooperative Fish Tagging Project*. <https://www.oritag.org.za/>
- Ortiz, M., Prince, E. D., Serafy, J. E., Holts, D. B., Davy, K. B., Pepperell, J. G., Lowry, M. B., & Holdsworth, J. C. (2003). Global overview of the major constituent-based billfish tagging programs and their results since 1954. *Marine and Freshwater Research*, 54(4), 489–507. <https://doi.org/10.1071/mf02028>
- Ouellette, J. A., & Wood, W. (1998). Habit and intention in everyday life: The multiple processes by which past behavior predicts future behavior. *Psychological Bulletin*, 124(1), 54–74. <https://doi.org/10.1037/0033-2909.124.1.54>
- Pecl, G. T., Stuart-Smith, J., Walsh, P., Bray, D. J., Kusetic, M., Burgess, M., Frusher, S. D., Gledhill, D. C., George, O., Jackson, G., Keane, J., Martin, V. Y., Nursey-Bray, M., Pender, A., Robinson, L. M., Rowling, K., Sheaves, M., & Moltschanivskyj, N. (2019). Redmap Australia: Challenges and successes with a large-scale citizen science-based approach to ecological monitoring and community engagement on climate change. *Frontiers in Marine Science*, 6, 349. <https://doi.org/10.3389/fmars.2019.00349>
- Pepperell, J., Kopf, R., & Malseed, B. E. (2011). Use of historic fisheries data to determine trends in relative abundance and body size of sailfish, *Istiophorus platypterus*, off northwestern Australia. *Royal Society of Western Australia*, 94(2), 333–344.
- Phillips, T., Porticella, N., Constan, M., & Bonney, R. (2018). A framework for articulating and measuring individual learning outcomes from participation in citizen science. *Citizen Science: Theory and Practice*, 3(2), 3. <https://doi.org/10.5334/cstp.126>
- Pocock, M. J. O., Hamlin, I., Christelow, J., Passmore, H. A., & Richardson, M. (2023). The benefits of citizen science and nature-noticing activities for well-being, nature connectedness and pro-nature conservation behaviours. *People and Nature*, 5(2), 591–606. <https://doi.org/10.1002/pan3.10432>
- Sandbrook, C., Clark, D., Toivonen, T., Simlai, T., O'Donnell, S., Cobbe, J., & Adams, W. (2021). Principles for the socially responsible use of conservation monitoring technology and data. *Conservation Science and Practice*, 3(5), e374. <https://doi.org/10.1111/csp2.374>
- Shephard, S., List, C. J., & Arlinghaus, R. (2023). Reviving the unique potential of recreational fishers as environmental stewards of aquatic ecosystems. *Fish and Fisheries*, 24(2), 339–351. <https://doi.org/10.1111/faf.12723>
- Taylor, A. T., Peeper, A. M., Chapagain, B., Joshi, O., & Long, J. M. (2022). Modern reporting methods for angler tag-return studies: Trends in data quality, choice of method, and future considerations. *North American Journal of Fisheries Management*, 42(1), 189–199. <https://doi.org/10.1002/nafm.10738>
- Tindale Marine Research Charitable Trust. (2018). *Tindale Marine Research Charitable Trust*. <https://tindaleresearch.org.nz/>
- Venturelli, P. A., Hyder, K., & Skov, C. (2017). Angler apps as a source of recreational fisheries data: Opportunities, challenges and proposed standards. *Fish and Fisheries*, 18(3), 578–595. <https://doi.org/10.1111/faf.12189>
- Vohland, K., Land-Zandstra, A., Ceccaroni, L., Lemmens, R., Perelló, J., Ponti, M., Samson, R., & Wagenknecht, K. (2021). *The science of citizen science*. Springer. <https://doi.org/10.1007/978-3-030-58278-4>
- Voyer, M., Gollan, N., Barclay, K., & Gladstone, W. (2015). 'It's part of me': understanding the values, images and principles of coastal users and their influence on the social acceptability of MPAs. *Marine Policy*, 52, 93–102. <https://doi.org/10.1016/j.marpol.2014.10.027>
- Ward, P., Mazur, K., Stenekes, N., Kancans, R., Curtotti, R., Summerson, R., Gibbs, C., Marton, N., Moore, A., & Roach, J. (2012). *A socioeconomic evaluation of three eastern Australian game-fishing regions*, ABARES report to client prepared for the Fisheries Research and Development Corporation, Canberra. http://www.rqys.com.au/newsletters/20121011/images/Game_fishing_report.pdf
- Wardropper, C. B., Dayer, A. A., Goebel, M. S., & Martin, V. Y. (2021). Conducting conservation social science surveys online. *Conservation Biology*, 35(5), 1650–1658. <https://doi.org/10.1111/cobi.13747>
- West, S., Dyke, A., & Pateman, R. (2021). Variations in the motivations of environmental citizen scientists. *Citizen Science: Theory and Practice*, 6(1), 1–18. <https://doi.org/10.5334/cstp.370>
- Williams, S. M., Holmes, B. J., & Pepperell, J. G. (2015). The novel application of non-lethal citizen science tissue sampling in recreational fisheries. *PLoS One*, 10(9), e0135743. <https://doi.org/10.1371/journal.pone.0135743>
- Young, N., Roche, D. G., Lennox, R. J., Bennett, J. R., & Cooke, S. J. (2022). Ethical ecosurveillance: Mitigating the potential impacts on humans of widespread environmental monitoring. *People and Nature*, 4(4), 830–840. <https://doi.org/10.1002/pan3.10327>

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

Appendix S1. Survey instrument.

Appendix S2. Framework of motivations for volunteering in citizen science.

Appendix S3. Summary tables of survey responses.

Table S1. Socio-demographic variables of the survey population showing the number (N) and percentage (%) of respondents for each category out of 153 total respondents.

Table S2. Fishing experience of the survey population showing the number (N) and percentage (%) of respondents for each category out of 153 total respondents.

Table S3. Experience participating in research by the survey population, showing the frequency count (N) and percentage (%) of responses for each category. The number of respondents is also included as can vary depending on their previous answers. An asterisk (*) denotes multiple choice questions.

Table S4. Factors that have helped or hindered participation in research from 97 respondents that have participated in the past showing the frequency count (N) and percentage (%) of respondents

for each factor (multiple choice).

Table S5. Benefits of participating in future research on billfish showing percentage of respondents ($n=153$) for each rank on a scale of 1 to 7, where 1 is strongly disagree, 4 is neither agree nor disagree and 7 is strongly agree.

Appendix S4. Open-text comments.

Appendix S5. Australian game fisher demographics.

Appendix S6. Ordinal regression model.

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