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Evaluation of an app-based recreational fishing survey against population benchmarks from a traditional probability-based survey

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Abbreviations

ABS	Australian Bureau of Statistics
AI	Artificial Intelligence
API	Application programming interface
App	Smartphone application
FRDC	Fisheries Research and Development Corporation
HREC	Human Research Ethics Committee
ICT	Information and communications technology
IMAS	Institute for Marine and Antarctic Sciences
PIRSA	Department of Primary Industries and Regions (South Australia)
SA	South Australia
SARDI	South Australian Research and Development Institute
UTAS	University of Tasmania

Executive Summary

Overview

Information on recreational catch and effort is becoming increasingly important to inform fishery stock assessment and the sustainable management of fisheries resources. As smartphone applications ('apps') become more sophisticated and widely available, they are increasingly being used to record recreational fishing activity, presenting an opportunity to collect non-probability data. However, the self-selected nature of data collection through apps introduces potential biases, necessitating comparative studies with traditional probability-based surveys to assess these biases as well as the accuracy and precision of app-based data. This study aims to compare a traditional probability-based survey with app-based data collection to compare estimates, assess bias and utility, and provide guidance for the future development of app-based data collection methods.

This study was a collaborative effort between the South Australian Research and Development Institute (SARDI) and the Department of Primary Industries and Regions (PIRSA) and conducted under the University of Adelaide affiliate agreement. It was undertaken in partnership with the University of Tasmania (UTAS), Institute of Marine and Antarctic Sciences (IMAS). To ensure comprehensive project development, a project steering committee comprising stakeholders from the Commercial and Recreational Fishing sectors was established.

Background

The lack of regularly collected recreational catch data that can provide a precise estimate of catch and effort for a range of species caught by recreational fishing presents significant challenges for fishery stock assessment and management. Traditional probability-based methods, such as stratified phone surveys, are regarded as providing the most robust estimates of catch and effort for recreational fisheries. However, these surveys are often expensive, conducted infrequently, and may not provide the species-specific information at the spatial and temporal scales required to inform stock assessment and effective management. Smartphone apps may provide a complementary option for data collection due to their ability to gather large volumes of information in real-time. However, challenges exist regarding representativeness of the data, low participation due to technological barriers, engagement issues, quality control, and privacy and security concerns. This study aims to explore the effectiveness and suitability of a smartphone application for collecting data on recreational catch and effort, offering an innovative approach while considering the associated advantages and disadvantages.

Objectives

The objectives of this study were as follows:

1. Design and implement a probabilistic phone-diary survey of South Australian recreational fishers to determine participation levels, as well as quantify catch and effort for key species.
2. Assess the effectiveness and suitability of a smartphone app as a means of collecting data on recreational catch and effort and comparing the data to that collected through the probability-based survey method.
3. Explore the feasibility of integrating smartphone apps into future recreational fishing surveys, investigating their potential as reliable and practical data collection tools.

Methodology

To understand the current state of knowledge relating to the use of phone apps for data collection for fisheries, a review of existing technologies and knowledge assets, nationally and internationally, was undertaken prior to commencement of this project. A subsequent stakeholder survey was conducted to gather qualitative information on perceptions around the utility of phone apps to collect recreational fishing data. The survey targeted fisheries scientists, managers, and

recreational fishing stakeholder representatives who had experience in using or an intention to implement smartphone apps for the collection of data from the recreational fishing sector. Stakeholders were then invited to participate in an online workshop which served as a platform to investigate strategies for targeting recreational fishers, developing purposeful apps for collecting catch, effort, and participation data, as well as identifying the minimum requirements for sustainable fisheries management and utilising catch and/or effort data. By incorporating these steps, the study ensured a broad understanding of the current state of knowledge and benefited from the expertise and experiences of various stakeholders in the field.

To assess the use of smart-phone apps as a method for collecting information on recreational fishing participation, catch and effort, two separate studies were conducted. The first study utilised probability-based methods to assess the State-wide participation, catch and effort (multi-phase phone survey supported by opportunistic on-site sampling), and catch and effort of Pipi (*Donax deltoides)* at Goolwa (on-site survey). These probability-based surveys implemented stratified, random sampling to enable estimates to be expanded to represent the broader population. The screening phase of the State-wide survey involved a sample of 4,925 households, while the longitudinal phase (1 March 2021 to 28 February 2022) involved a sample of 1,019 households (2,751 individuals) who reported 5,551 fishing events. This survey provided population benchmarks for recreational fishing participation, catch, and effort in South Australia during the 2021–22 survey period.

The second study utilised a non-probability app-based data collection approach hosted on the Qualtrics survey platform which was integrated into the “SA Fishing app”. The survey was promoted using a range of strategies including in-app reminders, push notifications, print and digital media, social media, e-newsletters, and by approaching fishers during on-site sampling to support the State-wide survey. During the comparative survey period (i.e., 1 March 2021 to 28 February 2022), the app-based approach included 1,559 individuals who logged 2,249 fishing events. Participants in the longitudinal survey were self-selected and provided information on their fishing activity and demographic profile. Recruitment, retention, and participation patterns were examined, and a wash-up survey was conducted to examine data quality and barriers, and drivers to participation. Participant demographic profile information, such as gender, age, education, country of birth, residential location, and avidity, were compared to the State-wide survey to assess representativeness and identify potential biases.

The comparative study aimed to evaluate the accuracy and representativeness of catch and effort estimates derived from app-based data collection by comparing them to the State-wide survey. To correct for any discrepancies in reporting behaviours, such as smaller numbers of zero catch day reporting and lower retention in the app-based data, coefficient q derived from a non-parametric bootstrap was used to adjust the app-based data for catch rate per event (i.e. the ratio of fish caught to the total number of fishing events reported) and number of events reported per fisher. Additionally, expansion methods such as raking, propensity scores, statistical matching, and model-based approaches were examined to generate species-specific expansions of catch and effort estimates that could be benchmarked against estimates from the State-wide study. This approach allowed evaluation of the temporal variability of catch rates and fishing events to inform the expansion of catch and effort estimates.

For all surveys conducted, potential ethical issues were considered, including ensuring data privacy, obtaining informed consent from participants, and following ethical guidelines for research involving human subjects. The South Australian Goolwa Pipi (*Donax deltoides)* Survey, on-site sampling to support the 2021–22 Recreational Fishing Survey, and the 2021–22 South Australian Recreational Fishing Smartphone App Survey were reviewed and approved by the University of Adelaide Human Research Ethics Committee (HREC) H-2021–034, H-2020–238, and H-2021-025. The State-wide Survey of Recreational Fishing in South Australia was reviewed and approved by the University of Tasmania HREC H0023757.

Results/key findings

The review of existing technologies and knowledge assets highlighted some of the challenges faced by probability-based surveys due to changing communication practices and sampling limitations. Although smartphone apps are recognised for their potential to engage users and collect recreational fishing data, they have limitations such as participant non-response and possible unknown biases that may affect reported catch rates and data quality. It was acknowledged that recruiting participants without a license frame is challenging, requires substantial communication investment, and that private companies may be able to advance app technology for broader user appeal. While app-based data collection is likely to complement probability-based methods, successful implementation requires validation, bias control, user-friendly design, transparency, and measures to ensure adequate recruitment and retention. Key to this is addressing concerns around privacy, security, and representativeness to encourage app adoption, which has the potential to promote the collection of near real-time data to inform fisheries assessment and management.

The comparison between app-based and probability-based samples revealed differences in catch rates and reported events, highlighting the importance of considering self-selection bias and under-reporting when analysing app-based data. The app-based data collection trial showed high survey engagement among existing SA Fishing app users, with participants primarily using the SA Fishing app as it was intended for information on regulations. Push notification open rates were low but correlated with increased survey participation and app activity. Retention rates in the app-based survey declined over time, highlighting the need for sustained engagement strategies. Factors like age, sex, and education had no significant influence on retention rates, and avid fishers were over-represented in the survey sample. To address issues identified in this study, future strategies should focus on targeted promotion, improved functionality and design, tailored interventions, and further research on factors influencing engagement and retention.

Because of the differences in catch rates and reported events between the two survey methods, along with variations observed across different species and fisher avidity groups, adjustments based on coefficient q were necessary to correct for these differences. It is important to note that expanding the app-based data without adjustments would lead to over-estimation of catch per event and under-estimation of total catch. The raking expansion method, combined with coefficient q adjustments, provided comparable harvest estimates with the State-wide survey for most species but tended to overestimate the number of days fished. The propensity scores method, statistical matching, and the model-based approach showed promise in improving accuracy, with each method outperforming others for specific species. Adjusting for biases and using appropriate expansion methods are crucial for reliable estimates of catch and effort. When the best-performing expansion models were compared to the State-wide survey results, differences between catch estimates ranged from 2% for Southern Calamari (*Sepioteuthis australis*) to 63% for Yellowfin Whiting (*Silago schomburgkii*) (using model-based expansion), while effort displayed a larger range from 4% for Southern Calamari to 115% for Australian Herring (*Arripis georgianus*) (using statistical matching). Further research is needed to investigate and compare app-based estimates with those from probability-based surveys to improve the adjustment accuracy, with particular consideration for the turnover of app-based participants and how this may affect the consistency of the application of correction factors through time.

Implications for relevant Stakeholders

The study's findings have several implications for fisheries managers, scientists, and policymakers. Firstly, the study highlights the potential for using a combination of app-based data and probability-based survey data to obtain reliable and comprehensive information about the recreational fishing community. While app-based data collection offers a source of real-time data and has the potential to generate a large number of responses, the study demonstrates that apps also attract a selective group of fishers and may result in biased catch rate and reported event estimates. As the user base of app-based surveys expands, there is potential for increased coverage and wider representation of the fishing population. Additionally, longer-term data

collection would enable the identification and assessment of temporal trends or changes in biases, helping to refine correction factors and improve the reliability of the data. Therefore, while apps may not currently be a substitute for probability-based surveys, there is value in persisting with their use and continuously monitoring and improving their methodologies. Over time, with increasing user participation and longer time series of data, the biases associated with app-based data are likely to reduce, making them a more attractive option for obtaining comprehensive and representative information about the recreational fishing community. Stakeholders should continue to prioritise rigorous approaches (e.g., probability-based surveys), which are necessary to validate app-based estimates. It is also important to acknowledge the challenges associated with sampling frames across probability and non-probability data collection. Non-exempt registration systems and targeted species-specific sample frames could improve the cost efficiency of surveys and, thereby, the accuracy and precision of the collected data. Exploring different sample frame approaches, would contribute to a more representative understanding of recreational fishing and improve the overall effectiveness of surveys.

Secondly, stakeholders should view app-based data collection as a complementary approach to probability-based surveys. Apps can offer valuable insights into fishing activity and catch rates, especially for popular species. Enhancing app design and promotion through user feedback and addressing reporting rate challenges is of critical importance. This involves improving user interfaces, simplifying data entry, and providing participation incentives. Engaging with users and actively seeking their feedback will drive continuous improvement of app-based data collection methods. Additionally, incorporating educational materials and compliance reminders within the app can incentivise regulation adherence, making the app an effective tool for education and rule compliance in the recreational fishing community.

Thirdly, there is a need to increase the number of participants in app-based data collection to improve the accuracy of results. By reaching a wider audience and encouraging more fishers to participate in the surveys, the representativeness of app-based data can be enhanced. This could be achieved through effective promotional strategies, such as digital and media campaigns, targeted advertising, and collaboration with fishing clubs and organisations. Larger sample sizes would enable more accurate and precise estimation of catch rates and reported events, improving the overall reliability of the data collected. Stakeholders should focus on addressing adoption barriers and enhancing user engagement within the app. This should include addressing concerns related to data privacy, ensuring user-friendly interfaces, and providing incentives for participation, such as rewards or access to additional fishing-related resources. By enhancing user engagement, stakeholders can encourage more frequent and accurate reporting of fishing activity, contributing to a more extensive understanding of recreational fishing practices.

Recognising the importance of accurate and comprehensive information on recreational catch and effort, fishery managers and scientists have the potential to provide more reliable determinations of fishery stock status, monitor changes over time, and make informed decisions regarding fishing regulations, bag limits, and seasonal restrictions by incorporating both app-based and probability-based surveys. This forward-thinking approach to data collection holds the potential to better inform fisheries management decisions that aim to ensure the long-term sustainability of fisheries resources. While immediate implementation may not be feasible, this holistic approach provides a pathway to enhance the quality and reliability of fisheries data. In summary, the study's findings highlight the need for stakeholders to employ a combination of non-probability app-based data collection and traditional probability-based surveys, where regular probability-based surveys are prioritised for obtaining demographic information and app-based data collection is conducted to obtain complementary data. By addressing adoption barriers, enhancing user engagement, and increasing the sample size, stakeholders can improve the reliability and representativeness of app-based survey data. These efforts will have significant implications for fisheries management.

Recommendations for further work or follow-up actions

Based on the study's findings, several recommendations can be made:

1. **Improve accuracy and representativeness of app-based catch and effort estimates:** To improve the accuracy of app-based catch and effort estimates, it is recommended to focus on collecting species-specific catch rate data. By gathering independent information on catch rates for individual species to calibrate app-based estimates, stakeholders can obtain more precise estimates and better understand the dynamics of different fish populations and those who access them. App-based catch and effort estimates should be derived by selecting suitable expansion methods which have been assessed against population benchmarks. Ongoing research is required to refine techniques to address biases and uncertainties. This can contribute to more effective fisheries management strategies and resource allocation. Conducting comparative analyses between future app-based approaches, integrating suggested enhancements, and probability-based methods could provide valuable insights into the potential of app-based approaches to yield results comparable to those obtained through probability-based methods.
2. **Assessing and incorporating reporting quality:** It is crucial to develop mechanisms that assess and incorporate the quality of reporting into app-based estimates. This can involve implementing validation checks, data verification processes, or data quality indicators within app-based data collection. App design should also be enhanced to improve user experience, features should be implemented that promote data accuracy and completeness, significant investment is required for effective promotion and outreach, reporting processes should be streamlined, and technological advancements should be leveraged. By considering the reliability and accuracy of reported data, stakeholders can minimise biases and improve the quality of estimates derived from apps.
3. **Exploring the human dimensions of fishing behaviour:** While the study examined the influence of fisher avidity on catch rates, it is recommended that other factors that may affect fishing behaviour are investigated. Factors such as skill level, experience, and fishing techniques can significantly impact catch rates and reported events. Understanding these additional aspects of fisher behaviour can provide valuable insights for refining data collection methods, developing targeted outreach strategies, and tailoring management approaches to different segments of the recreational fishing community.
4. **Regular evaluation and refinement of data collection methods:** To ensure the continuous improvement of data collection methods and tools, stakeholders should prioritise regular evaluation and refinement based on user feedback, pilot studies, and emerging best practices. This can involve conducting user surveys, usability testing, and engaging with stakeholders through workshops or focus groups to gather insights and identify areas for improvement. By incorporating ongoing collaboration between stakeholders and scientists, data collection methods can be refined, leading to more accurate and reliable data.

In conclusion, this study provides recommendations for further work to improve recreational fishing data collection methods. Emphasising the importance of ongoing collaboration between stakeholders and scientists to improve the tools and techniques used to collect data. By implementing these recommendations, stakeholders can strive for more accurate, representative, and reliable data, leading to better-informed decisions concerning the sustainable management of recreational fisheries resources.

Keywords: Recreational fishing, catch and effort, smartphone applications, apps, probability-based survey, non-probability survey, data collection, fishery management, bias, survey methodology, stakeholder perspectives

1. Introduction

Recreational catch and effort data is important for informing fishery stock assessment and ensuring the sustainable harvest of community owned fisheries resources. In many jurisdictions, including South Australia, there is no requirement to register as a recreational fisher or to report recreational fishing activity. The lack of enforced reporting creates significant challenges when estimating recreational harvests, particularly given the diverse and dispersed behaviour of recreational fishers. Traditionally, participation rates, catch, and effort have been estimated at a broad scale using probability-based survey methods, where a sample is randomly selected such that it is representative of and inferences can be drawn for the broader population (Lyle *et al.* 2010). While these surveys generally provide the best available estimates, they are not without significant challenges. Declining response rates and limitations around the available sampling frames (i.e., contact details for the population of interest) adversely impact the robustness of survey estimates (Callegaro et al. 2014). However, future growth of commercially available data sets with contact details is expected to alleviate sampling frame challenges, surpassing traditional phone directories. In addition, targeted license-frame surveys (Lyle *et al.* 2021, Trinnie *et al.* 2021), offshore fishing surveys utilising boat registration sample frames (Tate *et al.* 2020), and gear-based surveys on license frames (e.g., gillnets and set lines) (Lyle and Tracey 2016) can provide specific and localised data.

In 2018, a workshop was held to discuss the 'best practice' approach in design, execution, and analysis of recreational fishing surveys (Beckmann et al. 2019). The workshop recognised the need to investigate cost-effective methods for surveying a large number of fishers over broad spatial and temporal scales. At the national level, research had already begun to investigate online surveys for understanding the social and economic contributions of recreational fishing (Moore et al. 2023). While this study provided some insight into the use of non-probabilistic data collection to estimate participation rates and fishing effort, it focused on socio-economics, and was not designed to provide species-specific catch estimates, which are required by state jurisdictions responsible for managing recreational fisheries. Smartphone applications (hereafter abbreviated as 'apps') have been identified as a potential tool for collecting data on recreational catch (and effort) (Venturelli *et al.* 2017). However, while many stakeholders are enthusiastic about using apps for data collection and the capacity exists to collect these data, there are clear challenges to be overcome to use the data for fisheries assessment (discussed in Chapter 4).

Despite the challenges of data collection, apps are increasingly being adopted by recreational fishers with options available for checking rules and regulations, identifying species captured, and recording or sharing information about trips (Lu and Thabtah 2017). In addition to the many smaller-scale Government-managed apps, privately run apps such as "Fishbrain" can have large global reach and provide an online platform for recreational anglers to communicate and report their catch. Apps provide an opportunity to reach participants virtually anywhere, at any time, facilitating data collection from hard-to-reach segments of the population. Despite many tools existing to collect recreational fishing information, recruitment and retention of participants in voluntary studies (including apps, angler diaries or logbook programs (Venturelli *et al.* 2017) remains a key barrier to research efforts, as well as biases against less avid fishers and those that do not use smartphones (e.g., older individuals).

The lack of a structured sampling framework or statistical survey approach also poses barriers to the utility of app-based data. It is well recognised that reporting rates are likely to be low unless apps are well designed and effectively promoted, particularly in relation to how the data are likely to be used (Gundelund et al. 2020). The need for updated information on recreational fishing activity in South Australia, provided an opportunity to trial app-based data collection (discussed in Chapter 5). This study provided an opportunity to estimate recreational catch and effort; investigate some of the barriers to participation and the quality of data reporting

(through the wash-up survey of app-based participants); and compare data from the app to that from a probability-based survey.

While collecting or harvesting app-based recreational fishing data is a critical first step, one of the primary challenges scientists can encounter is devising rigorous scientific methods to generate associated estimates of catch and effort, which are strongly influenced by angler behaviour. Unlike probability-based surveys (which use random, stratified sampling), app-based data collection relies on a non-probability design. As app participants are self-selected, the data collected is unlikely to be representative of the entire population, resulting in a range of potential biases. Initial studies of app-based data (e.g., Jiorle et al. 2016) indicated similarities with probability-based catch data for more common species, however, limited information is often available on user demographics and behaviours which are likely to be critical to evaluating the potential biases. This is due to privacy concerns, user reluctance, and the potential complexity it adds to apps, resulting in its limited availability. Sample size limitations, sampling bias (e.g., spatial and behavioural) are also commonly cited as key barriers to extrapolating estimates to the population level from app-based data (Papenfuss et al. 2015, Collier et al. 2019, Marks et al. 2020, Johnston et al. 2022). In particular, fisher behaviour is key to understanding differences in reported catch and effort, as specialisation (e.g., dedicating more time and resources to fishing) often results in biased (higher) catch rates (Gundelund et al. 2020). However, catch rates reported in app-based data may not significantly differ from those in recall survey respondents (Gundelund et al. 2020). This indicates that despite inherent biases in both methods, app-based data can still provide valuable insights when used complementarily with probability-based surveys.

For app-based data collection to inform stock assessment and fishery management decisions, comparative studies are necessary to evaluate potential bias and compare estimates with probability-based benchmarks (Brick et al. 2022). The present study aims to evaluate data requirements and suitability of statistical methods for expanding species-specific catch and effort estimates from app-based data collection (see Chapter 6). The methods range from simple post-stratification techniques to complex model-based approaches. Estimates of species-specific catch and effort are then evaluated against comparable probability-based estimates. The accuracy of app-based data is important because, while both survey methods rely on participant-reported data, the probability-based survey ensures data quality through structured collection and regular contact. In contrast, app-based data collection relies on self-reporting, increasing the potential for misreporting. This is explored in analysing the results of the app-based wash-up survey.

This report presents an evaluation of app-based recreational fishing data collection approaches. First, the objectives of the study are summarised (Chapter 2), followed by the methods used (Chapter 3). The results are presented and discussed across several chapters:

1. Effectiveness of smart-phone apps to collect information on recreational fishing (Chapter 4).
2. Findings of the South Australian app-based trial (Chapter 5).
3. Exploration of methods to expand catch and effort estimates from app-based data (Chapter 6); and
4. Recommendations for the implementation of app-based data collection into future surveys (Chapter 7).

Other documents arising from this project include the '*Survey of Recreational Fishing in South Australia 2021-22*', (Appendix 2) and the '*On-site survey of recreational fishing for Pipi in Goolwa, South Australia 2020-21'* (Appendix 3).

Improving the reliability of recreational catch and participation estimates was one of the key recommendations in the recent Commonwealth Productivity Commission enquiry into

regulation of the Australian marine fisheries and aquaculture sectors. The outcomes of this research will support development of novel survey methods to inform future recreational fishing surveys, the results of which will inform sustainable fisheries management.

2. Objectives

The objectives of this project were to:

1. Design and implement a survey of South Australian recreational fishers to determine participation and catch and effort levels for key species.
2. Assess the use of a smart-phone app as a method for collecting recreational catch and effort information; and
3. Explore whether smart-phone apps can be feasibly integrated into future recreational fishing surveys.

This report focusses on objectives 2 and 3, with detailed reporting on objective 1 available in Appendix 2 and Appendix 3.

3. Method

This project was strategically aligned with the commencement of the 2021/22 State-wide recreational fishing survey in South Australia, which encompassed a dedicated on-site survey for Goolwa Pipi (*Donax deltoides)*. Leveraging these planned surveys provided crucial baseline data for comparative analysis. Further details, including methods, for these related projects can be found in separate reports, available in Appendix 2 and Appendix 3.

3.1 Introduction

This chapter describes the methods used to collect data on stakeholder perspectives from an online survey and workshop, data on recreational fishing activity from an app-based data collection platform, and the assessment of data quality and barriers to adoption through the associated app-based wash-up survey. The methods used to undertake statistical analysis in this report are also detailed.

The development phase of this project commenced in June 2020 with the formation of a project steering committee to reach an agreement that the use of a smart-phone app should be trialled in South Australia to be benchmarked against traditional phone surveys. The first phase of the project commenced in November 2020 with the on-site access point survey of the Goolwa Pipi recreational fishery. Development of the second phase of the survey also commenced at this time. During development, key stakeholders were consulted, via a survey and subsequent online workshop, to build a better understanding of how smartphone apps can be used to effectively collect information on recreational fishing activity for the purpose of fisheries management. The State-wide survey and on-site sampling then commenced in February 2021. The final phase was the app-based data collection approach which commenced in March 2023, at the same time as the commencement of the 12-month diary period for the State-wide survey.

The South Australian Goolwa Pipi Survey, on-site sampling to support the 2021–22 Recreational Fishing Survey, and the 2021–22 South Australian Recreational Fishing Smartphone App trial were reviewed and approved by the University of Adelaide Human Research Ethics Committee (HREC) H-2021–034, H-2020–238, and H-2021-025. The State-wide Survey of Recreational Fishing in South Australia was reviewed and approved by the University of Tasmania HREC H0023757.

3.2 Stakeholder consultation

Stakeholder consultation was initially undertaken in the form of an online survey (Appendix 4) to gather qualitative information on the experiences of scientists, managers, technical and communications experts in implementing or planning to implement smart phone apps targeting the recreational fishing sector. The online survey was reviewed and approved by the University of Tasmania HREC H0023766.

The first part of the stakeholder survey collected personal information (i.e., name, jurisdiction, role) to allow examination of responses relative to the range of knowledge and experience across jurisdictions and roles. The second part of the stakeholder survey probed participants knowledge about regulations (licencing), smart phone app functionality and capability and jurisdictional priorities.

Following from the stakeholder survey, five key topics were selected to guide discussions in an online workshop:

1. App functionality and availability.

2. Jurisdictional priorities relative to app use and development.
3. Effectiveness of apps for conveying and/or collecting information.
4. Recruitment and retention of participants; and
5. Using recreational data to inform science and management.

The workshop was split into three sessions. The technical session focussed on what works and what does not when it comes to targeting recreational fishers (points 1, 3 and 4). While the science workshop focussed on how to develop an app that is fit for purpose to collect information on catch, effort and participation (points 3, 4 and 5). The management workshop focused on the minimum requirements to manage a stock and how catch and/or effort data could be used (points 2, 3 and 5).

Overall, 33 stakeholders attended the workshop across the three sessions, representing 12 different organisations from around Australia (Table 3.1).

Table 3.1 List of organisations who participated in the online workshop.

Organisation
University of Tasmania
South Australian Research and Development Institute
Western Australian Department of Primary Industries and Regional Development
Queensland Department of Agriculture and Fisheries
Tasmania Department of Primary Industries, Parks, Water and Environment
New South Wales Department of Primary Industries
Australian Recreational Fishing Foundation
Fisheries Research and Development Corporation
Victorian Fisheries Authority
Australian Department of Agriculture Water and the Environment
Northern Territory Department of Primary Industries and Resources
Department of Primary Industries and Regions (South Australia)

3.3 Probability-based surveys

3.3.1 Goolwa Pipi

Due to the limited geographical distribution of the largest proportion of the recreational Pipi fishery, a specific on-site access point survey was conducted to estimate the recreational catch and effort. The survey of recreational catch and effort for Pipi was undertaken on Goolwa Beach from the Murray mouth, extending to Middleton Beach over the 2020/21 season (November 2020 to May 2022). A detailed description of the on-site survey for Goolwa Pipi is available in Appendix 3.

3.3.2 State-wide survey

The State-wide survey utilised a probability-based design to ensure comparability with the previous three surveys (Henry and Lyle 2003, Jones 2009, Giri and Hall 2015). A detailed description of this method is provided in Henry & Lyle (2003) and Lyle et al. (2002). Data analyses are described in detail by Lyle et al. (2010) and were generated using the statistical computing language R (R Development Core Team 2022).

Briefly, the first phase of the multi-phase telephone survey involved regionally stratified, random sampling of phone numbers drawn from a commercial database. The screening phase commenced in February 2021 and gathered profiling information for a sample of the population to inform the State-wide participation rate. Subsequently, eligible respondents were recruited to undertake a 12-month longitudinal panel survey commencing in March 2021 (referred to as the phone diary phase). Participants were encouraged to complete a memory-jogger (diary) to record key fishing data and were contacted by survey interviewers who were responsible for collecting this information. Contact from the interviewers was regular and guided by how often the diarist was fishing. In most cases the contact was on at least a monthly basis with interviewers only holding off in cases where the diarist indicated they would not fish until a specified date/period. This approach aimed to minimise respondent burden and maximising response and data quality, whether the diary was used or not.

At the conclusion of the diary phase of the survey, a wash-up survey was conducted with a sub-sample of diarists to assess awareness and attitude and detect differences among respondents. In addition, call backs were made to a subsample of non-intending fishers (identified at screening) to account for any unexpected fishing activity. Call backs refers to the act of contacting or reaching out to a subset of individuals who were initially identified as non-intending fishers during the screening process. This follow-up communication is conducted to assess whether any unexpected fishing activity occurred among this subgroup, allowing for a more comprehensive understanding of fishing behaviour and its potential impact on the study's results.

On-site sampling (separate to the on-site Pipi survey) was also conducted at key fishing locations in parallel to the longitudinal panel survey to provide ancillary information on the size distribution of the recreational catch. The on-site sampling program was designed to target peak periods of recreational fishing activity to maximise the number of fish measured. This data was used to convert the catch numbers estimated by the phone-diary survey into weight estimates.

A detailed description of the State-wide survey is available in Appendix 2.

3.4 Non-probability-survey

3.4.1 Survey design

Two options were considered for the design of the app-based data collection trial to enable comparisons with the longitudinal State-wide survey. The first was developing a standalone app. While this option would provide the most flexibility in terms of design, it was considered unfavourable as there was limited time available to develop and promote the app prior to the launch of the survey, which needed to commence at the same time as the phone diary phase of the State-wide survey to undertake the comparative analysis.

The second option was to integrate app-based data collection into the existing South Australian Government “SA Fishing Guide,” which has been available for free download since 2013. This app underwent a major upgrade in 2020 and was re-launched as “SA Fishing”. The SA Fishing app includes the latest fishing rules and regulations and provides a platform to

report illegal activity, shark sightings and Snapper (*Chrysophrys auratus)* catches for the South-East Fishery, which are subject to mandatory catch reporting. In comparison to a new app which would require significant recruitment efforts, the SA Fishing app already had approximately 13,000 users (November 2020–January 2021), based on Google Firebase analytics data. This is equivalent to approximately 4% of the 356,708 estimated recreational fishers in South Australia (Beckmann *et al.* 2023). After considering the available information and following consultation with PIRSA's Strategic Communications and Information Computer Technology (ICT) departments, the chosen option was to integrate the survey into the existing SA Fishing App.

To integrate the survey within the SA Fishing app, two options were considered. The first was developing the survey as part of the existing app framework. While this would support some desirable features for app-based data collection (e.g., adding fishing locations from a map), there were several constraints that need to be overcome. In particular, there was no existing reporting system and survey outputs would need to have been sent individually and then manually compiled into a database. In addition, developing the survey into the existing app framework would increase app installation size, would require substantial development time and on-going support, and survey reporting and metrics would be unavailable.

The second option was to use a survey service integration (e.g., Qualtrics survey platform). The main disadvantages of this approach were the lack of fully customisable features and that the survey could not be completed when offline. However, this approach had several key advantages including (i) the ability to develop the survey in-house with the ability to make modifications on demand, (ii) the survey platform had the capacity to use complex scenarios/workflows, (iii) the access to the survey would be seamless (i.e., to the user it would appear that they were still in the app), (iv) the survey data could be accessed in real-time and the database exported in multiple formats, and (v) data on survey metrics and their use would be easily accessible. After considering the available information and following consultation with PIRSA's Strategic Communications and ICT departments, the chosen option was to use a survey service integration approach.

This was a longitudinal, opt-in survey developed using the Qualtrics platform (see screenshots provided in Appendix 5) and available via a link in the SA Fishing app from March 1, 2021, to December 15, 2022. Users who downloaded the app were sent periodic reminders to participate in the survey by submitting data anytime they went fishing during the survey period. When users clicked the survey link, they were redirected to a web interface within the app. The survey captured embedded data, including device ID and location (if enabled). After providing consent, participants answered an initial profiling section with questions about contact preferences, gender, postcode, ethnicity, age, and fishing avidity (Table 3.2). An autocomplete API improved postcode accuracy by suggesting matching suburbs. Crucially, after completing the first survey, each participant's profile was stored against their device ID. To increase efficiency and improve retention rates, this device ID was then detected on future survey entries, allowing the introductory section to be skipped. The device IDs enabled tracking of the same users over time, facilitating the longitudinal survey design. By storing profiles and using device IDs to identify returning participants, this method aimed to increase efficiency and retention rates throughout the longitudinal study period. Reminders encouraged participants to regularly submit data on their recent fishing activity soon after the events, rather than recalling an entire previous year. The survey collected data on both when the fishing activity occurred and when it was reported, allowing examination of any potential recall bias. Other data collected included when/where fishing occurred, fishing platform, group size, catch details like species (kept/released numbers) (Table 3.2). An interactive calendar API was provided for selection of fishing date, while a Google Maps API allowed for selection of pinpointed fishing locations. Autocomplete APIs assisted species entry from a comprehensive list with images to aid identification.

Table 3.2 Summary of the app-based data collected.

Section	Description	Options/data collected
Screening	Consent	• Agree • Disagree
Participant information	Location	• GPS co-ordinates at time of survey submission
	Device ID	• Device ID linked to download of the SA Fishing App
	Contact information	• Phone number • Email
Profiling	Days fished in previous 12 months	• Zero • 1 to 4 days • 5 to 9 days • 10 to 14 days • 15 to 19 days • 20+ days • Unsure • Prefer not to answer
	Gender	• Male • Female • Other • Prefer not to answer
	Age	• Under 15 years • 15 to 29 years • 30 to 44 years • 45 to 59 years • 60 to 74 years • 75+ years • Prefer not to answer
	Birthplace	• Country of birth (searchable)
	Residential location	• Postcode and associated suburb (searchable)
	Education level	• Bachelor or postgraduate • Year 12 or above • Year 10 or above • Year 9 or below • Did not go to school • Prefer not to answer
Fishing activity	Fishing date	• Date (selected from calendar)
	Fishing location	• Map pin (latitude, longitude)
	Platform fished	• Shore – beach/rocks • Shore – jetty/marina/wharf • Boat – private • Boat – hire • Boat – charter • Prefer not to answer
Fishing activity	Group size	• On my own • In a group • Prefer not to answer
	Whose activity was reported	• Just mine • Everyone in my group • Prefer not to answer
	Number of fishers in group (excl. reporting participant)	• Free answer (numeric)
	Catch event	• Yes • No • Prefer not to answer
	Species caught	• Select from list (searchable or scroll)
	Catch by species	• Kept number • Retained number
Finalisation	Comments	• Free answer

3.4.2 Survey promotion

The key strategies used to promote the app-based survey are summarised in Table 3.3. Examples of the materials developed are available in Appendix 6.

Table 3.3 Summary of promotional strategies used.

Category	Description	Detail
Digital	App Store/Google Play	App available for download.
	SA Fishing app	Links to participate in the research displayed prominently. An information sheet was made available (via consent page) prior to commencing the survey.
	Project website	Described the survey's purpose and how to get involved (including embedded promotional video). Note that the text was later updated to focus on project results.
	YouTube	Video promoting the project
	Social Media (Facebook/ Twitter/Instagram)	Various posts across PIRSA pages (e.g., https://www.facebook.com/PrimaryIndustriesAndRegionsSA https://twitter.com/SA_PIRSA https://www.instagram.com/sa_pirsa) and a dedicated page to promote the survey https://www.facebook.com/SARecFishingSurvey
	Push Notifications	Small, pop-up messages programmed to be sent to a user's device by the SA Fishing app that appear regardless of whether the app is open or not.
	Pop Up Reminders	Small, pop-up messages programmed to be sent to a user's device by the SA Fishing app that appear only when users have opened the app.
	Newsletters	Project updates emailed to survey participants. Articles in newsletters (e.g., PIRSA FishFacts, PIRSA news, FRDC).
Media	Magazine	Articles in SA Fishing and SA Angler.
	Newspaper	Media release resulting in articles in the Advertiser, Victor Harbor Times, and Stock Journal. Advertisements (including QR code) in the Yorke Peninsula Country Times, Border Watch, Port Lincoln Times.
	Radio/ Podcast	Interviews featuring the project on ABC Regional Drive and Rowey's Fishing Show (5AA), All the gear no idea podcast.
Printed collateral	Flyers/brochures	Information provided to tackle shops, visitor information centres, caravan parks, council offices etc. Also provided to fishers during on-site sampling at key fishing locations.
In person	Word of mouth	Conversations with recreational anglers during on-site sampling and patrols by FishCare Volunteers. Presentations also provided to stakeholder groups (e.g., the Minister's Recreational Fishing Council, FishCare Volunteers, commercial fishery executive officers, various fishery management committees). Presentations at the World Recreational Fishing Conference in Melbourne, February 2023.

3.4.3 Wash-up survey of app participants

During the app-based data collection period, contact details were collected for those participants who agreed to be contacted for a follow-up or 'wash-up' survey. A randomly selected sub-sample of these participants were offered a structured questionnaire (Appendix 5) administered by telephone between March 2022 and June 2022. Firstly, the interviews aimed to confirm that fishing information recorded on the database for each participant was complete (e.g., water body, platform, estimate of days fished), and to further profile fisher behaviour (e.g., importance of fishing, years of experience, hours spent researching or viewing fishing content, perceived skill level, group membership). The secondary aim was to explore participants experience using the SA Fishing App including constraints and barriers to participation (recruitment/retention), and level of non-response (e.g., how often fishing activity was reported relative to actual level of fishing activity). This survey was conducted with respondents aged 18 years and older. A summary of responses to key questions are presented in Chapter 5, noting that data from the 'wash-up' survey are not extrapolated to account for fishers not included in the survey.

3.4.4 Statistical analysis

Statistical analyses were conducted using R version 4.2.2 (R Core Team 2023) using the r package *Survival* (Bewick et al. 2004) and *NonProbEst* (Martín et al. 2022). Additional packages employed included *ggplot2* and lattice for data visualisation; *readxl*, *writexl*, *openxlsx*, and *excel.link* for reading and writing Excel files; *dplyr* and *tidyr* for data manipulation; *cowplot* for plot annotations and arranging; *RColorBrewer* for color palettes; *plotrix* for additional plotting utilities; *RODBC* for database connections; scales for scientific data visualisation; lubridate for handling dates; *ggsurvfit* for enhancing survival plots; *gtsummary* for generating summary tables; *ggfortify* for visualising diagnostics; *broom* for providing a tidy representation of model outputs; *rstatix* for statistical analysis; and *boot* for bootstrap methods.

Survival

A survival modelling approach was used to assess participants' retention in the study (Bewick et al. 2004). In this analysis, an 'event' was defined as a participant dropping out, and 'elapsed time' referred to their participation duration. We evaluated data submission during the diary phase of the State-wide survey (1 March 2021 to 28 February 2022) and whether participants remained in the study until 14 December 2022. Right censoring (Clark et al. 2003) minimised the influence of periodic disengagement, considering participants engaged if they submitted fishing activity during and after the study period. Data collection was extended to 14 December 2022, with communication promoting this extension.

Kaplan-Meier curves were used to measure the overall participant retention rates (Rich et al. 2010, Zhang et al. 2023). The effect of multiple variables of interest (i.e., age, sex, avidity, stratum, education, country of birth) on participant retention was assessed using the Cox Proportional-Hazard (CoxPH) model which provides an estimate of the hazard ratio (HR) for each predictor variable (Kumar and Klefsjö 1994). Higher HRs (i.e., >1) indicate that variables are associated with lower retention. The Cox Proportional-Hazards model assumes that the hazard ratio for any predictor variable is constant over time, known as the proportional hazards assumption. This assumption states that the ratio of hazards for any two individuals with different values of a predictor variable should remain constant over the entire study period. The assumption of CoxPH regression was tested using the scaled Schoenfeld residuals (Grambsch and Therneau 1994). Scaled Schoenfeld residuals measure the difference between the expected and observed values of the predictor variables at each event time, after adjusting for all other predictor variables.

Fishing activity adjustments

To undertake comparative analysis of the datasets, it was first ensured that fishing data from the app were within the same temporal period as the phone diary phase of the State-wide survey period (i.e., 1 March 2021 to 28 February 2022) and that participants resided in South Australia to align with the State-wide (probability-based) survey sampling frame. Interstate residents (n = 141) were excluded from the analysis.

The data collected by the app-based approach were obtained from a self-selected population, in contrast to the State-wide survey that utilised probability-based sampling techniques (i.e., randomly selected participants). To understand the biases in the app-based data that could affect the expansion of fishing effort and catch, catch numbers per fishing event and total number of fishing events reported per fisher were compared between datasets. This comparison is particularly important when using data from a self-selected app, as it is expected that a higher proportion of avid fishers would contribute. Additionally, app-based participants may be more inclined to report successful fishing days with higher catch rates than low or zero catch events, though this potential bias requires further investigation specific to angling app users as opposed to generalisations from social media data (Papenfuss *et al.* 2015, Venturelli *et al.* 2017).

Due to the non-probabilistic nature of the app-based data, traditional hypothesis testing might not be representative of the differences between that dataset and the probabilistic State-wide survey. Instead, a non-parametric bootstrap approach was applied, where a mean estimate of each variable was calculated by bootstrap sampling E (Hartill and Edwards 2015, Gundelund et al. 2021) and compared among surveys using their coefficient q (Equation 1). This procedure was repeated 1,000 times to obtain the distribution of the coefficient q.

$$q = \frac{E_{App-based}}{E_{\text{State-wide}}} \qquad \text{Equation 1}$$

When the value of one was within the 95% percentile of the bootstrap distribution of q, no difference among datasets was deemed. Where the 2.5th percentile fell above one, variable values in the app-based data were considered significantly larger than in the State-wide survey. Where the 97.5th percentile fell below one, variable values in the app-based data were considered significantly smaller than in the State-wide survey. This approach is comparable to using a $\alpha = 0.05$ level of significance during parametric tests (Lehdonvirta et al. 2020). The comparisons were done for each species separately, as well as for each level of different covariates used in the expansion.

Due to the discrepancies in catch rate and number of events reported between datasets, the coefficient q was applied as a scalar to the raw app-based data as adjustments, firstly to the catch rate per event, then to the number of events reported in the app-based data. Coefficient q was calculated for each species and avidity group and the mean value used as adjustments for each of these groups separately. Avidity was used to perform adjustments because this variable is directly linked to the expected number of events a fisher should report if there was no underreporting. All adjustments were applied, even when the value of one fell within the 95% distribution of q.

Because all events in the scope of analysis were included in the calculation of q, the coefficient provides an adjustment for the most challenging biases to overcome when comparing both datasets: the differences in (1) catch rates, (2) amount of reporting, (3) no catch events reported and (4) lack of information from important groups (such as high avid fishers). To evaluate the temporal variability of the adjustments in the last 15 years, coefficient q of catch rate and fishing events reported per species and avidity group were also calculated between the State-wide probabilistic surveys of 2021-22 and 2007-08.

Expansion

Different expansion methods were applied to the app-based data to obtain estimates of harvested catch and effort for the whole fishing population of South Australia, i.e., equivalent to estimates from the 2021-22 recreational fishing survey (Beckmann *et al.* 2023).

NonProbEst was used to expand the non-probability survey data using raking, propensity score adjustment, statistical matching and a model-based approach. Details on each one of these methods (including their advantages and disadvantages) can be found in Table 3.4 and each is briefly described below. The covariates used in the non-probability expansions were gender, age, education, country of birth and geographic stratum, matching those used in the probability State-wide survey expansion (Beckmann *et al.* 2023). When available, avidity was also included in the set of covariates due to its importance after coefficient q adjustments. When algorithms needed to be selected for analyses, K-nearest neighbour or generalised linear models were chosen over bagging algorithms, due to their simplicity and the better prediction of outcomes (Castro-Martín et al. 2020). For comparison, expansions were calculated using both raw and *q*-adjusted data from the app-based data (see previous section). All estimates were compared to results from the State-wide survey (Beckmann *et al.* 2023).

Raking: Raking calculates and assigns weights to each fisher in the app-based data so the sum of the multiplication (fisher times weight) reproduces the known marginal counts for all covariates (Deville et al. 1993). This approach is also called incomplete post-stratification and is useful when no detailed information about the population totals is known, i.e., a cross-tabulated cell count is not available for all covariates and only total counts are known. Raking also produces a more reliable calibration when zero or small sample sizes for combinations of covariates occur (Deville and Särndal 1992). Weights were calculated using the *calib_weights* function with *initial_weights* set to one (no initial sampling design). The expanded screening results for each covariate from the State-wide survey were used as marginal counts, as they represent the best estimate of total number of fishers in the State when the app-based survey was conducted. Results compiled from the Australian Bureau of Statistics 2021 Census data (as described in Beckmann et al. 2023) were also used as marginal counts for each covariate. Avidity was not included as a covariate when running the expansion using Census data due to the absence of avidity information in that dataset.

Propensity score adjustment: There is a need to correct for the bias in the app-based data caused by the self-selection of participants. If a probability sample from the fisher population is available (such as the State-wide screening survey which collects), the propensity score adjustment calculates the likelihood that each fisher in the app-based dataset is in the screening dataset from the diary survey (*ps_convenience*) and vice versa (*ps_reference*) using information from the covariates provided (Terhanian et al. 2001). Propensity scores were calculated using the *propensities* function with a K-nearest neighbour algorithm and parameter optimisation for K within all odd values between three and the square root of sample size (40). Propensity scores were sorted by value and allocated to 10 different strata. Weights were calculated by dividing the proportion number of individuals in *ps_reference by* the proportion number of individuals in *ps_convenience in each stratum* after Lee (2006), which were applied in the expansion of harvested catch to the whole fisher population.

Statistical matching: Similarly to propensity score adjustments, statistical matching attempts to correct the selection bias present in the non-probability dataset using a probability sample from the population (such as the State-wide screening survey). The statistical matching method models the relationship between the variable (catch or effort) and covariates in the app-based dataset and uses that to predict the variable estimated response in the screening dataset, which is later expanded to population totals (Rivers 2007). Responses were estimated using the *matching* function with a K-nearest neighbour algorithm and parameter optimisation for K within all odd values between three and 11 (a smaller range of K was used to avoid too

many ties in the algorithm). Screening weights, calculated through calibration and response propensity modelling of the State-wide survey, were then applied to each fisher to obtain expanded estimates of harvested catch by the total fishing population.

Model-based: In contrast to the previous approaches, this method fits a linear model that explains the relationship between the variable of interest and selected covariates in the app-based data. Our approach was a generalised linear model with an elastic net model (GLMnet) that includes two penalised regression models, ridge, and Lasso. Choosing a penalisation alpha value of 0.5 allowed the model to combine both penalties, resulting in models that are easier to generalise (Friedman et al. 2010). The model assumes a gaussian distribution between covariates and variable of interest with lambda values varying from 0.001 to 0.1, centring and scaling predictors using the function *model_based.* The model is then used to predict harvested catch and effort for the total number of fishers in the State using cross-tabulated totals for covariates available from the screening phase of the State-wide survey (Beckmann *et al.* 2023).

Table 3.4 Data requirements for the expansion of recreational fishery app data to population estimates, including essential and desirable requirements and their advantages and disadvantages.

Expansion method	**Data requirements**		**Comparison**	
	Essential	**Desirable**	**Advantages**	**Disadvantages**
Raking	Marginal totals of each covariate from Census. Participation rate in recreational fisheries.	Marginal totals of each covariate for the fisher population. Expansion weights from App survey design.	Datasets are generally available for expansions.	Large expansion weights can result in large errors.
Propensity score	Probability sample of general population.	Probability sample of fisher population.	Screening surveys are cheaper and easier to run than probability surveys and can be used in expansions. Propensity weights can be applied to Raking expansions.	Sample of fisher population needs to be large enough for expansion of catch and effort of specific species.
Statistical Matching	Probability sample of fisher population.	Probability sample of fisher population. Expansion weights from sample design of fisher population.	Screening surveys are cheaper and easier to run than a probability survey and can be used in expansions.	Sample of fisher population needs to be large enough for expansion of catch and effort of specific species.
Model-based	Cell counts of each covariate of fisher population.		Independent of survey design and expansion weights.	Large amount of data needed for expansions are not usually available.

Data variability: Error bars for all four methods were calculated using a jackknife variance estimator (Quenouille 1956, Friedl and Stampfer 2001). Raking allowed the re-calculation of the expansion weights, and new model fits for the model-based approach, at every jackknife interaction. However, due to long run times (Rueda et al. 2020), re-weighting the propensity score adjustments and statistical matching methods was not possible for each jackknife sample.

4. Effectiveness of smart-phone apps to collect information on recreational fishing

4.1 Introduction

This chapter examines the results of the development phase of the project and is divided into three main sections, exploring:

- **Review of existing relevant technologies and knowledge assets both nationally and internationally:** literature review conducted prior to commencement of the project (undertaken in September 2020)
- **Stakeholder survey:** to gather qualitative information on the experiences of key stakeholders in implementing smart phone apps targeting the recreational fishing sector (undertaken in December 2020)
- **Online workshop:** what works and what does not when it comes to targeting recreational fishers, how to develop an app that is fit for purpose to collect information of catch, effort and participation and the minimum requirements to manage a stock and how catch and/or effort data could be used (undertaken in December 2020)

4.2 Review of existing relevant technologies and knowledge assets

In 2018, a workshop was held to discuss the 'best practice' approach in design, execution, and analysis of recreational fishing surveys (FRDC 2017-198; (Beckmann et al. 2019). Challenges in undertaking traditional probability-based surveys were identified due to changes in the way people communicate and the availability of appropriate sampling frames, particularly where a licence-frame or registry was not available. The workshop identified a need to investigate cost-effective methods to survey a large number of fishers over broad spatial and temporal scales. Smartphone apps and/or the internet were identified as one potential tool to collect supplementary data on recreational catch, however, limitations such as non-response and selection bias were likely to impact on the accuracy and precision of estimates and their representativeness. To develop apps as a method for recreational fishing surveys, there is a need to better understand how factors such as transiency (short-term use), avoidance (lack of trust or reluctance to share) and design issues influence the data collected from app users compared to data collected using probability-based surveys (Papenfuss et al. 2015).

To investigate the potential for apps as a tool in recreational fishing surveys, a pilot study was undertaken in Western Australia, where licence holders from the south-west Freshwater Angling licensed fishery were invited to a 12-month trial of an app to compare this survey with a simultaneous State-wide survey (probability-based) (Marks et al. 2020). The study found that eligible respondents (smart phone owners likely to fish in the next season) were younger and more avid than ineligible respondents. In the Western Australian study, approximately 6% of eligible fishers who accepted an invitation to participate in the app-based survey recorded at least one fishing event over the 12-month trial period, and similar catch and release estimates were recorded from the app-based data and the State-wide survey. Overall, the low number of app users prevented estimates being extrapolated to the population level. This indicated that there will be significant challenges in recruiting participants from the general population where a licence frame does not exist, emphasising the need for significant

investment in communications activity or ideally, the development of appropriate sample frames through licensing or registration systems.

Several international studies have also been undertaken to compare on-site surveys with app-based data collection. A pilot study undertaken in the Gulf of Mexico Red Snapper (*Lutjanus campechanus*) fishery found that the data from the iSnapper app was useful for management purposes at a small scale, however, broader application would require a carefully considered validation procedure (Stunz et al. 2016). Similarly, an analysis of three years of app-data from the iFish app in Alberta identified opportunities to investigate long-term and broad spatial trends in angler demographics, behaviour and harvest (Papenfuss et al. 2015). However, Papenfuss et al. (2015), specified that app-based data is likely to complement conventional surveys, rather than replace them, due to the range of biases and limitations to consider.

In Florida, analysis of the iAngler app identified a high degree of similarity between on-site survey data and app-based data, particularly for the more common species (Jiorle *et al.* 2016). Sample size limitations and spatial biases were identified for app-based data, however, with further data on user demographics required to investigate user patterns and behaviours (Jiorle *et al.* 2016). Similarly, in Alberta, data from the MyCatch app indicated that apps have the potential to capture regional fishing patterns, providing catch rates that are similar to conventional surveys, however, urban biases and sample size limitations need to be addressed (Johnston et al. 2022). Differences between on-site survey estimates and those from the MyFishCount app were also observed in the South Atlantic Red Snapper Fishery which are likely due to avidity bias, over reporting, higher reporting in hot spot areas and/or user error (Collier et al. 2019). These studies demonstrate the need to collect a wide range of demographic data to compare across different surveys.

Behavioural biases were investigated in more detail during a recent study in Denmark using the Fangstjournalen citizen science app (Gundelund et al. 2020). This study indicated that a user's level of specialisation resulted in biased (higher) catch rates, indicating their greater commitment to the fishery. While relatively high retention rates were observed generally, apps were found to be more appealing to older users over time (Gundelund et al. 2020). A key aspect when seeking to recruit and retain participants within an app-based data collection platform is ensuring that apps are well-designed, allow for user feedback and transparency with respect to data use (Venturelli et al. 2017). It is unlikely that one app will appeal to all anglers, as a result there is a need for data collection standards and guidelines to be developed to enable apps to be incorporated into fisheries research (Venturelli et al. 2017). Part of this conversation with app developers will be about the minimum data set that they are willing to share and developing standards for meta data and activity data collection.

To assess the current state of technology, we also undertook a review of the key design features of 42 individual apps (Table 4.1). Of the apps reviewed, 60% are run by private companies, 24% by Government bodies, 10% by associations (e.g., peak bodies) and 7% by university groups. Most apps (69%) require users to register, indicating the potential for individual data to be tracked. Most apps were free (83%), however 10% had optional features which could be purchased in-app and another 7% of apps required an upfront payment to access them. Most apps were voluntary (93%). Mandatory reporting features were available in three Government run apps including the SA Fishing app which hosts mandatory reporting capability for Snapper in South Australia, the VicRTag app where Southern Rock Lobster (*Jasus edwardsii*) tags can be purchased and reported on in Victoria and the Tail n' Scales app which is an electronic reporting system in Mississippi. About half (52%) of the apps reviewed did have some functionality to report trip-based data, although it was often unclear whether this data was submitted or stored only on the device. A large number of apps (76%) also collated fishing data into some kind of personal logbook.

Most apps (69%) included information on rules and regulations and information of the types of species in the area (57%). A small number of apps offered features related to tournaments or competitions (29%). Most apps (71%) had some form of mapping interface, however, the purpose varied from providing static information (e.g., where to find species, marine park boundaries) to feeding back data collected via the app (e.g., personal fishing data or amalgamated data). Approximately half of all apps had some functionality to encourage sharing on social media (e.g., brag posts). Third party information (e.g., tides, weather) was also built into 50% of the apps reviewed.

There are clearly a wide-range of potential features that can be built into apps to promote recruitment and retention. Many of the privately-run apps have had significant capital investment and already have a large number of participants, for example Fishbrain has over 13 million users worldwide. As such, software developers are well placed to continue to advance the technology behind apps to make them more attractive to a broad range of different user groups. Generating useable data, however, remains a key challenge. Even with good participation and spatial coverage, behavioural biases such as avidity are likely to result in unreliable estimates. Further comparative studies are required to determine whether data can be adjusted to account for any biases. If this can be achieved, apps could potentially provide complementary data to large-scale probability-based surveys. Apps could provide near real-time data which could be used to develop catch proxies in intervening years between large scale surveys.

Table 4.1 Summary of recreational fishing apps reviewed. U = unknown, O = optional. Note: current as of September 2021.

Name	Type	Registration	Cost	Mandatory	Rules/regs	Species info	Tournaments	Trip reports	Logbook	Mapping	Social shares	3rd party info.
AFANT Research App	Association	✓	×	×	×	×	×	×	✓	✓	×	×
CarpiLog	Private	U	✓	×	×	×	×	×	✓	×	×	×
Catchability	Private	✓	×	×	✓	✓	✓	✓	✓	✓	✓	✓
Fangstjournalen	University	✓	×	✓	✓	✓	×	✓	✓	✓	×	✓
Fish iReports	Private	✓	O	×	×	×	×	✓	✓	×	✓	×
Fish Ranger	Private	O	×	×	×	×	×	×	✓	×	×	✓
FishAngler	Private	✓	×	×	×	✓	×	✓	✓	✓	✓	✓
Fishbox	Private	✓	O	×	×	×	×	×	✓	✓	✓	✓
Fishbrain	Private	✓	O	×	×	✓	×	×	✓	✓	✓	✓
Fishing point - FishingTAG	Private	✓	O	×	×	✓	✓	×	✓	✓	✓	✓
FishOn-Angler map, fish app	Private	✓	×	×	×	×	×	×	✓	✓	✓	×
GoFishVic	Government	✓	×	×	×	×	×	✓	✓	✓	✓	✓
Gone Fishing Day	Private	✓	×	×	×	×	✓	✓	✓	×	✓	×
iAngler tournament	Private	✓	×	×	×	×	✓	×	✓	×	✓	✓
iDfish	Private	✓	×	×	✓	✓	×	✓	✓	×	✓	✓
IGFA catch log	Association	✓	×	×	×	✓	×	✓	✓	×	✓	✓
Iki Jime Tool extreme	Private	O	✓	×	×	✓	×	×	✓	×	✓	×
isnapper	University	✓	×	×	×	×	×	✓	✓	✓	×	×
Movtan Fishing	Private	✓	×	×	×	×	×	×	✓	✓	✓	×
My Fishing Mate Australia	Private	×	×	×	✓	✓	×	×	×	×	×	×
MyCatch by Angler's Atlas	Private	O	×	×	✓	×	✓	✓	✓	✓	×	×
Myfishcount	Private	✓	×	×	×	×	×	✓	✓	✓	×	×
FishSmart NSW	Government	×	×	×	✓	✓	×	×	×	✓	×	✓
Nt Fishing Mate	Government	×	×	×	✓	✓	×	✓	×	✓	×	✓
ProAngler	Private	×	×	×	✓	✓	×	×	×	✓	✓	✓
QLD Fishing 2.0	Government	×	×	×	✓	✓	×	×	×	✓	×	✓
recfishwest	Government	×	×	×	✓	✓	×	×	×	✓	×	×
RedMap	University	✓	×	×	×	✓	×	×	✓	✓	×	×
REEL IT IN	Private	✓	×	×	×	×	✓	✓	✓	✓	×	×
Reel it in	Private	×	×	×	×	×	×	✓	✓	✓	×	×
SA Fishing	Government	×	×	✓	✓	✓	×	✓	✓	✓	✓	✓
Salmon Slam	Association	✓	×	×	×	×	✓	×	✓	✓	✓	×
SCF Australia	Private	✓	×	×	×	×	✓	✓	✓	×	×	×
Score Fishing	Private	✓	✓	×	×	×	✓	✓	✓	✓	✓	×
Tacklebox	Association	✓	×	×	×	×	✓	✓	✓	✓	×	✓
Tails n' scales	Government	✓	×	✓	×	×	×	✓	×	×	×	×
Tasmanian Sea Fishing Guide App	Government	✓	×	×	✓	✓	×	×	×	✓	×	✓
Track My Fish Citizen Science	Private	✓	×	×	×	×	×	✓	✓	✓	✓	×
Track My Fish Tournament Edition	Private	✓	×	×	×	×	✓	✓	✓	✓	✓	×
Vic Fishing	Government	×	×	×	✓	✓	×	×	×	✓	×	✓
VicRLTag	Government	✓	×	✓	×	×	×	✓	×	×	×	✓

4.3 Stakeholder survey

4.3.1 Overview

Smartphones are owned by 83% of adult Australians (ACMA 2020) providing access to a broad suite of apps. These apps can be used for a range of purposes, including communication, entertainment and data collection. There has been significant interest over the last decade in the potential for apps as a means of conveying information to, as well as, collecting information from, the recreational fishing sector. In particular, apps have been proposed as a complementary tool to probability-based off-site and on-site survey methods, collecting information on participation, catch and effort from recreational fisheries, and in some cases, socio-economic information.

One of the fundamental questions to resolve regarding the use of apps to collect fisheries information is 'what can/will the data be used for?.' The answer to this question will drive the design and implementation of an app and determine whether the technology is 'fit for purpose.' Further consideration is needed around potential barriers to adoption that are common to many smartphone apps. While there is exciting potential for the use of apps in the recreational fishing space in the future, both for conveying and collecting information, it is important that there is a clear understanding of their roles and that they are closely aligned with the needs of management agencies and stakeholder groups.

Key stakeholders from around Australia involved in the management, research, technical, or communications aspects of recreational fishing data collection were identified. These stakeholders were invited to participate in a voluntary stakeholder survey aimed at improving our understanding of the potential usefulness of smartphone apps for recreational fishing and identifying research and management needs. A total of 31 responses were received, representing all states and territories in Australia.

4.3.2 Participant background, experience and awareness

Most stakeholder survey participants had a background in fisheries research (48%) or resource management (35%), while a smaller proportion were recreational stakeholder representatives (16%). The participants were highly experienced, with 58% having worked in the recreational fishing space for over 10 years. However, there were also some less experienced participants, with 19% working for one to four years and 23% working for five to nine years. Many of the participants were regular recreational fishers (48%), while 19% fished occasionally,16% fished rarely and 16% did not fish at all. Most participants were aged between 41 and 50 years old (55%), with a further 23% aged 31–40, 16% aged 51–60, 3% aged 61–70, and 3% aged 20–30.

Stakeholder survey participants indicated that based on their personal experience, they had demonstrated varying levels of consistency in voluntarily entering any activity data on their smart phones, with many reporting intermittent or no data entry (Figure 4.1). Of those who reported using apps for tracking activity, fishing was the most popular category, with 64% of respondents having used a fishing app compared to 52% for sport and exercise, and 33% for diet and health. However, a higher percentage of fishing app users (50%) reported never manually entering data compared to diet and health (22%) and sport and exercise (44%) app users. Furthermore, few fishing app users reported regularly entering data (27% reporting for more than one month), while 38% of diet and health and 56% of sport and exercise app users did so (Figure 4.2). The findings suggest that there may be unique barriers or challenges preventing app users from consistently manually entering activity data, which could limit the accuracy and usefulness of the data collected by these apps. Additionally, a considerable proportion of fishing app users recorded activity data for only a brief period of time, with 40%

recording for a day or so (similar to diet and health users at 38%), indicating a need to address factors that affect user retention and long-term engagement.

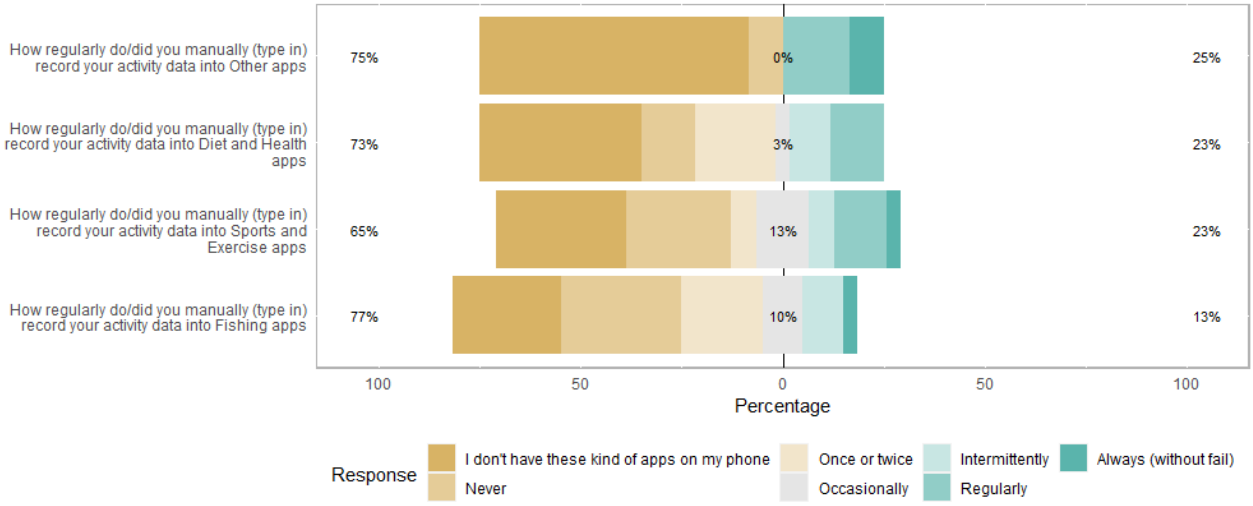

Figure 4.1 Summary of responses (% of total) when stakeholder survey participants were asked “if you have ever had any of the following categories of smartphone apps on your phone (i.e., Diet and Health, Sport and Exercise, Fishing), how regularly did you manually (type in) record your activity data. Select a response under each category [i.e., I don’t have these kinds of apps on my phone, never, once or twice, occasionally, intermittently, regularly, always (without fail)].”

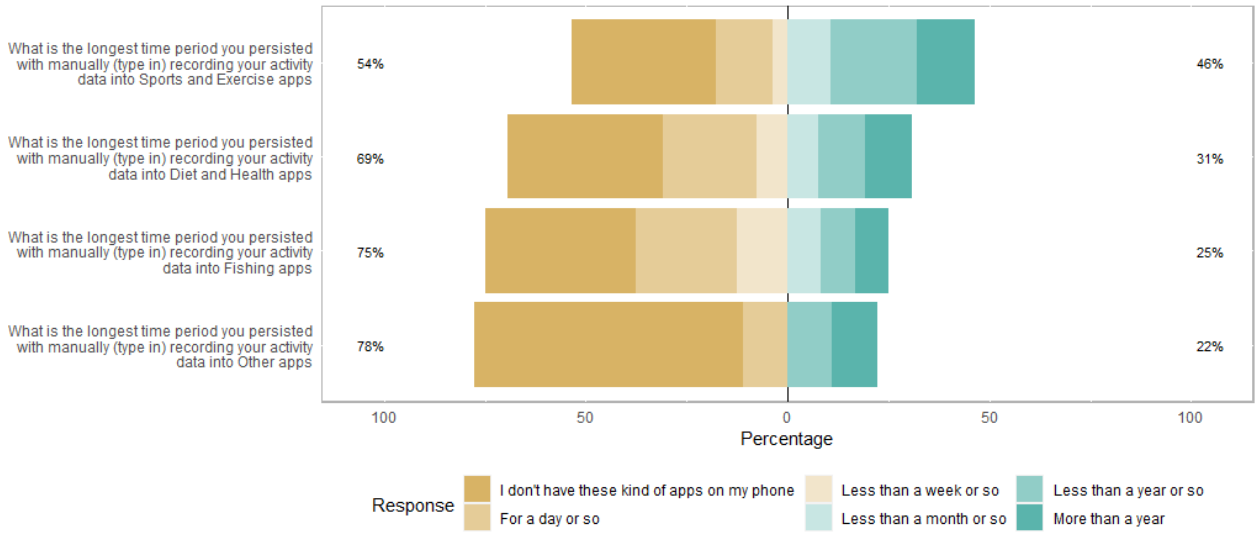

Figure 4.2 Summary of responses (% of total) when stakeholder survey participants were asked “if you have ever had any of the following categories of smartphone apps on your phone (i.e., Diet and Health, Sport and Exercise, Fishing), what is the longest time period you persisted with manually (type in) recording your activity data. Select a response under each category (i.e., I don’t have these kinds of apps on my phone, for a day or so, less than a week or so, less than a month or so, less than a year or so, more than a year.”

Regarding the methods used to collect information on recreational fishing activity, most fisheries managers, scientists and recreational stakeholders (66%) reported being very familiar with off-site, probabilistic survey methods, which typically involve State-wide or focused surveys targeting specific species or license holders (Figure 4.3). Similarly, 66% were

also very familiar with on-site (creel) probabilistic survey methods, which involve State-wide surveys conducted directly at fishing locations. In contrast, 31% of participants reported being very familiar with non-probability surveys, which include respondent-driven or self-selecting surveys, as well as opportunistic on-site surveys. Additionally, 52% were very familiar with citizen science programs such as angler diary/logbook programs and fish frames (skeleton) collection programs, which rely on the active participation of recreational fishers. Only a small percentage of participants (3%) expressed uncertainty or lack of familiarity with the different survey methods. Overall, the findings suggest that the surveyed participants generally had a high level of familiarity with off-site and on-site probabilistic survey methods, while their familiarity varied for non-probability surveys and citizen science programs.

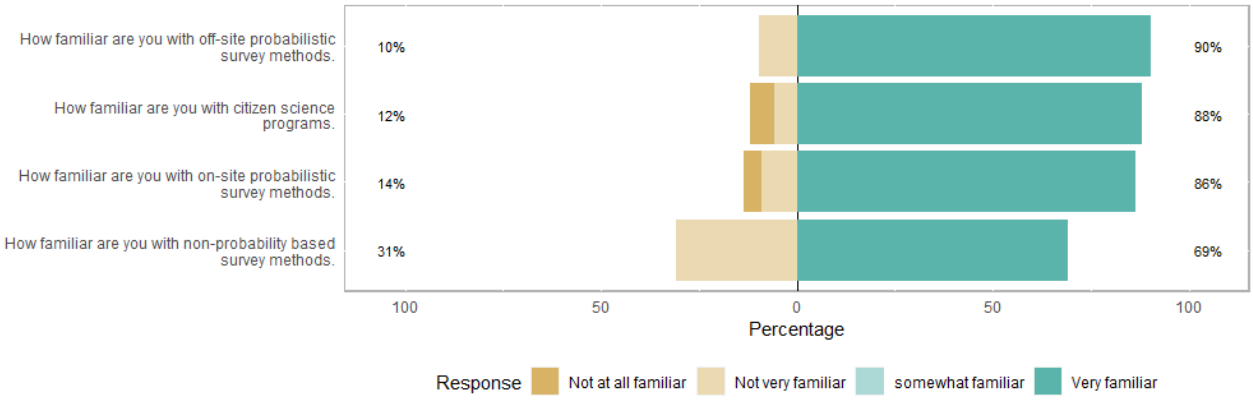

Figure 4.3 Summary of responses (% of total) when stakeholder survey participants were asked "Generally, how familiar are you with each of the following (non-app) data collection methods? (not familiar at all, not very familiar, somewhat familiar, very familiar, unsure)."

Among the fisheries managers, scientists, and stakeholders participating in the stakeholder survey, there was limited awareness of the wide range of fishing apps available. However, notable apps like Redmap emerged as one of the most recognised, indicating that these participants may have had wider exposure to these types of platforms, resulting in their popularity beyond specific jurisdictions. The IGFA catch log app also gained recognition, highlighting its reputation and visibility in the Australian community despite being an American based app. Approximately 7–10% of respondents reported regular usage of region-specific apps such as Fishsmart NSW, GoFishVic, and RecFishWest, tailored to the fishing needs and regulations of their respective regions. Additionally, apps like GoFishVic, SA Fishing, RecFishWest, and NT fishing mate were used by 10-13% of respondents, at least once, which is expected considering the regional relevance. Redmap and Fishbrain were among the most popular choices for app downloads, due to their features, functionality, or reputation. These findings highlight the varying levels of awareness and usage of different fishing apps among the surveyed participants.

In assessing the functions deemed most valuable for informing future recreational fisheries management, stakeholder survey participants expressed a clear priority. Access to information on rules and regulations ranked highest, highlighting the participants' recognition of the significance of understanding and adhering to fishing guidelines. Species identification guides, the reporting of fishing trip information, and geo-locating capabilities closely followed as highly valued functions. These findings reinforce the participants' strong emphasis on the need for accessible information and tools that contribute to the promotion of effective and sustainable fisheries management in the future. Most participants (80%) indicated that their jurisdiction does not currently use participation, catch and/or effort data collected from smart phone apps for fisheries management, while several participants indicated that information was used to undertake rapid stock assessments or that methods to utilise this information were currently being developed.

4.3.3 Collection and utilisation of recreational fishing data

Most stakeholder survey participants (71%) reported that their jurisdiction has a fishing app, with features such as static maps (91%), species identification guides (82%), voluntary catch reporting (73%), and geo-locating capabilities (62%). However, compulsory catch reporting (15%) and management of licensing/registration/permitting (32%) were less commonly included. Information on rules and regulations was considered highly effective (100% combined), followed by species identification guides, static maps, and geo-locating capabilities (40–60% combined). Voluntary catch reporting, compulsory catch reporting, and management of licensing/registration/permitting were perceived as effective (25–75% combined). These findings highlight the perceived importance of providing information and certain app features for fisheries management, while also indicating areas for improvement in compulsory catch reporting and licensing/registration/permitting functions.

Most stakeholder survey participants reported that in the last 10 years, their jurisdiction has focused on collecting recreational fishing data using off-site, probabilistic survey methods (86%), on-site (creel) probabilistic survey methods (90%) (Figure 4.4). This indicates that these methods are widely employed and recognised for data collection in recreational fisheries management. While citizen science programs (86%) were also well utilised, a low percentage of participants (21%) reported that their jurisdiction has collected data using specific non-probability surveys, suggesting that these methods may be less commonly employed. The participants' confidence levels in the reliability and quality of the data varied across different survey methods (Figure 4.5). For probability-based surveys, including both off-site and on-site (creel) methods, a high percentage (86%) of respondents expressed being very confident or somewhat confident in the reliability and quality of the data. This aligns with the focus placed on these methods and reflects the trust placed in their ability to provide accurate and representative data for fisheries management purposes. In contrast, confidence levels were relatively low for non-probability surveys (45% very confident or somewhat confident) and citizen science programs (59% very confident or somewhat confident). These findings suggest that there may be reservations or uncertainties regarding the reliability and quality of the data collected through these methods, and how best to use these data effectively. It suggests that further efforts may be needed to address these concerns and enhance confidence in non-probability surveys and citizen science programs as valuable data collection approaches in recreational fisheries management.

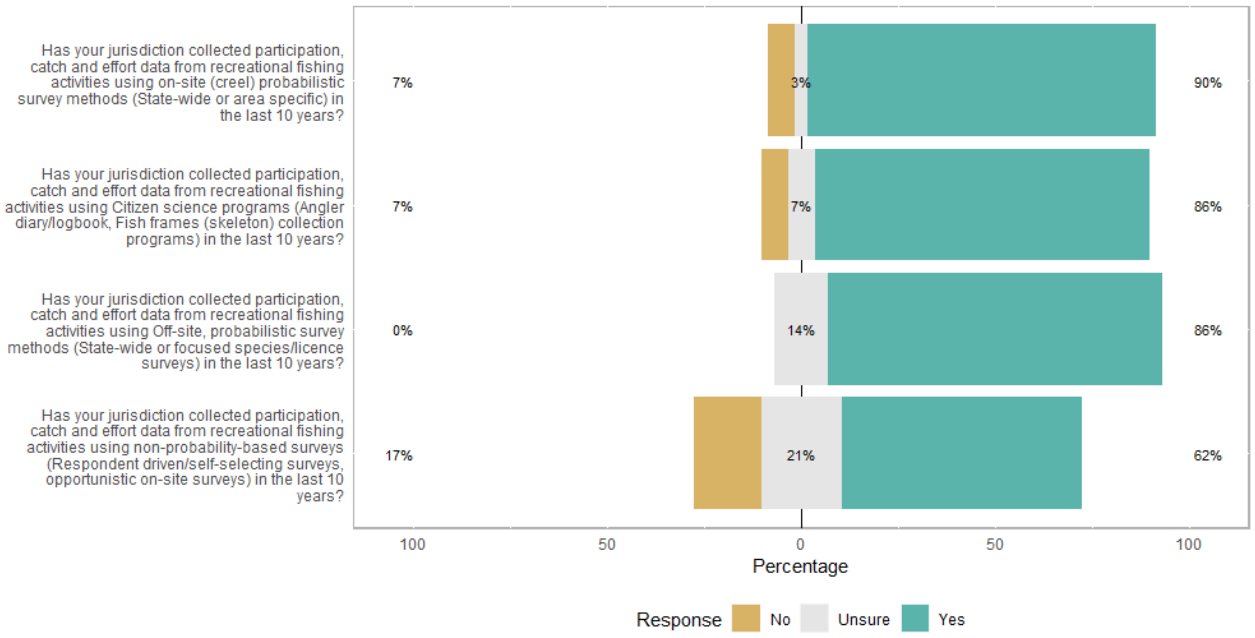

Figure 4.4 Summary of responses (% of total: no, yes or unsure) when stakeholder survey participants were asked about the information collected by participant's jurisdictions in the last 10 years.

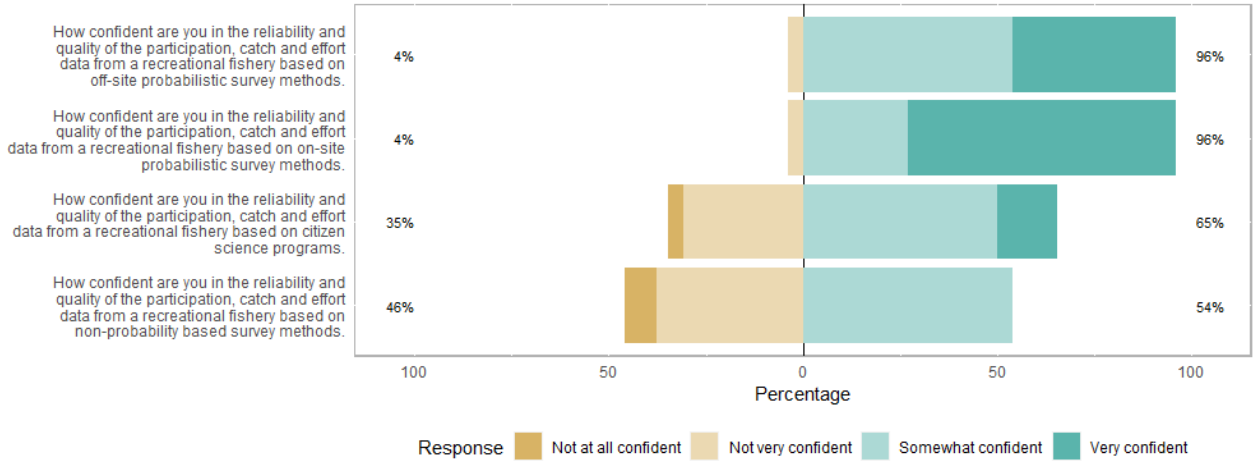

Figure 4.5 Summary of responses (% of total: not at all confident, not very confident, somewhat confident, very confident) when stakeholder survey participants were asked about how confident they are in the reliability and quality of the participation, catch and effort data from a recreational fishery provided by different methods, relative to all other methods they are familiar with.

When considering the information required to manage fish stocks effectively (sustainability), most stakeholder survey participants (62–100%) ranked catch data, effort data, catch rate data, participation rate and social dimensions somewhat important or very important (Figure 4.6). This indicates a strong emphasis on data related to catch and effort, which are crucial for assessing the health of fish stocks and making informed management decisions. Social dimensions, such as satisfaction, received a lower ranking, with only a small percentage of participants (21–41%) considering them somewhat important. When managing for stakeholder experience, a higher percentage of participants (79–83%) ranked participation rates, catch data, effort data, social dimensions, and economic dimensions as very important (Figure 4.7). This suggests that stakeholders place greater importance on a wider range of data types that encompass not only the biological aspects of fish stocks but also the social and economic aspects of the fishing experience. Relative importance of different data types was ranked similarly across all sectors, with only data on the economic dimension of recreational fishing being ranked as not very important by fishers (20%) and scientists (15%) than compared to managers (0%) (Figure 4.7). Overall, the different responses reflect the varying objectives and priorities of managing fisheries for ecological sustainability versus meeting the expectations and needs of recreational fishers. Considering these diverse objectives, it is important when designing an app for data collection to carefully assess whether it can effectively serve both ecological sustainability goals and recreational fishers' needs. This dual functionality may require thoughtful design and integration of features that address the multifaceted demands of fisheries management.

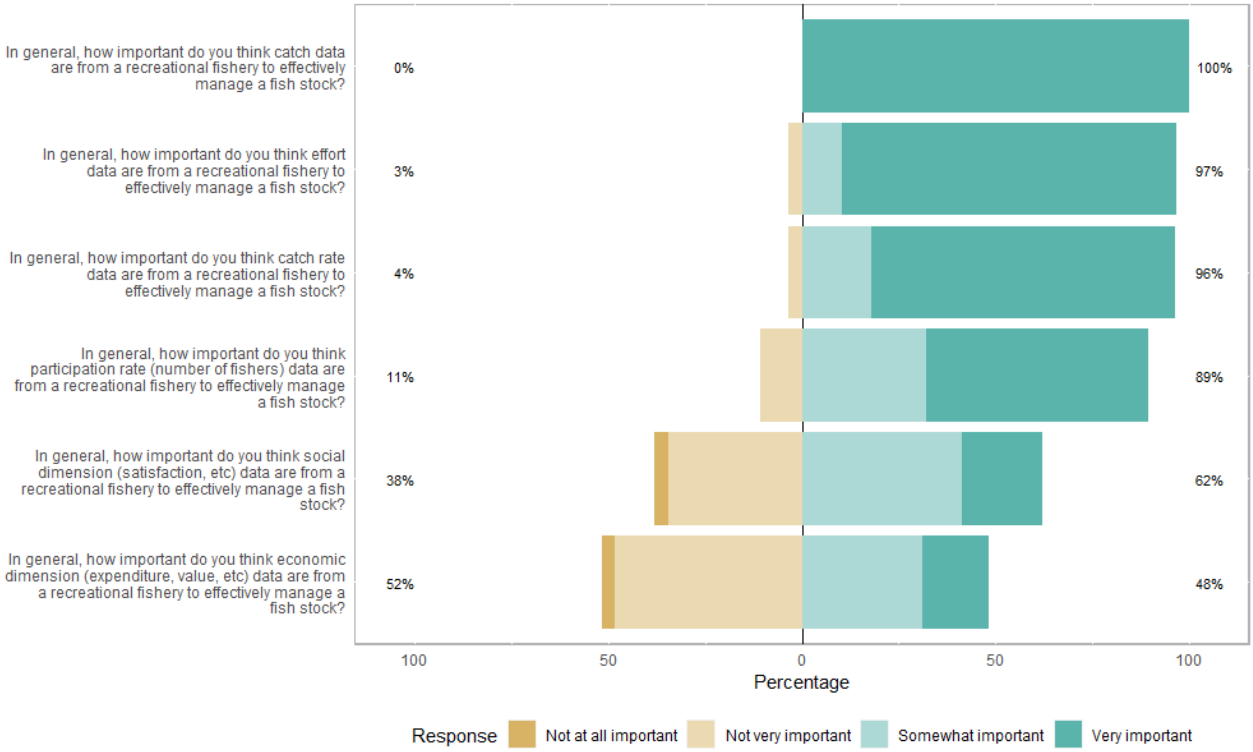

Figure 4.6 Summary of responses (% of total: not at all important, not very important, somewhat important, very important) when stakeholder survey participants were asked: “In general, how important do you think the following types of data are from a recreational fishery to effectively manage a fish stock?”

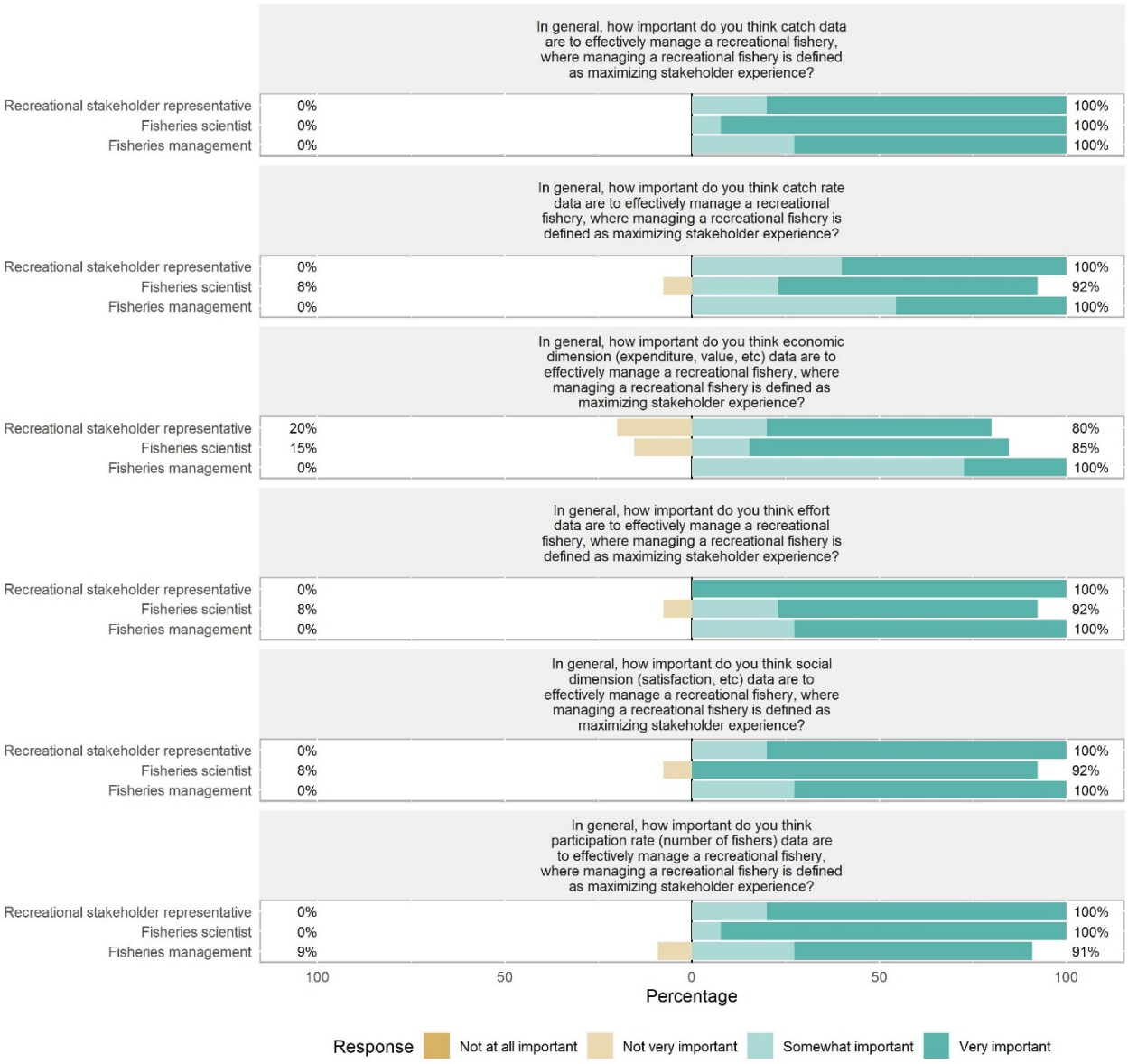

Figure 4.7 Summary of responses (% of total: not at all important, not very important, somewhat important, very important) per sector when stakeholder survey participants were asked : “In general, how important do you think the following types of data are to effectively manage a recreational fishery, where ‘managing a recreational fishery’ is defined as maximising stakeholder experience?”

Stakeholder survey respondents provided insights into the current use of recreational participation, catch, and effort data in their jurisdictions. The data are commonly employed for stock status reporting, stock assessment modelling, resource allocation/sharing, and managing a fishery to a quota, as reported by most respondents (76–90%, Figure 4.8). However, its utilisation for assessing recreational fishery performance and improving fisher experience was relatively lower (34–59%). These findings demonstrate the widespread application of recreational data available for management, while also indicating the potential for further leveraging this data to enhance fishery performance and the recreational fishing experience. Moreover, a significant percentage of participants anticipate an increased demand for this information in the next 10 years, particularly for stock status reporting, stock assessment modelling, resource allocation/sharing, recreational fishery performance, and managing a fishery to a quota (Figure 4.9). This underscores the perceived importance of high-quality recreational data in shaping effective management strategies and improving overall fisheries management and stakeholder experience in the future.

The frequency of collecting recreational participation, catch, and effort data varied depending on the purpose (Figure 4.10). For stock status reporting, stock assessment modelling, and managing fisheries to quotas, most stakeholder survey participants (45–62%) believed that periodic data collection with a frequency of two or more years is sufficient. However, for resource allocation/sharing and assessing recreational fishery performance and fisher experience, regular data collection (annual or biennial) was considered more important by most respondents (34–55%). This indicates that these purposes may benefit from more up-to-date information and closer monitoring of recreational fishing activities. Interestingly, there was little support for collecting near real-time data for any of the listed purposes, with only a small percentage of participants (3–21%) considering it necessary. This suggests that most respondents did not view real-time data as crucial for effective management in these contexts. Overall, the findings highlight the range of perspectives on the required frequency of data collection for different management purposes in recreational fisheries. Balancing the need for timely information with the practicality of data collection is crucial in effectively utilising recreational participation, catch, and effort data for informed decision-making. Future efforts should focus on addressing gaps in data collection and improving the availability and accessibility of data to support sustainable fisheries management and enhance the recreational fishing experience.

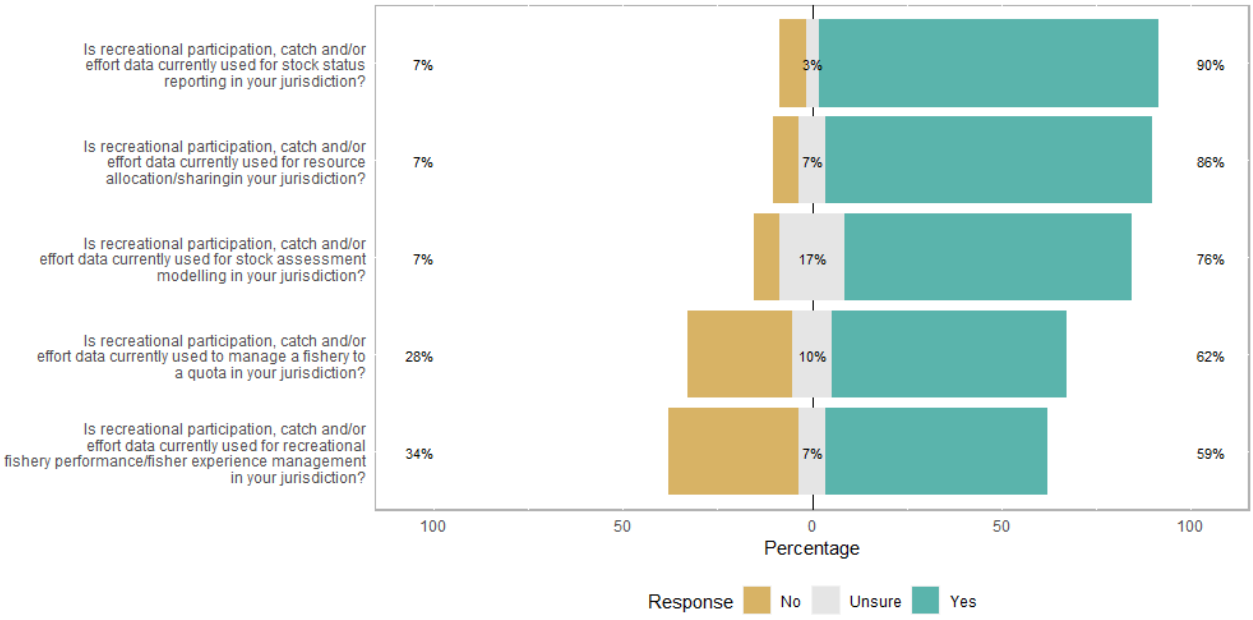

Figure 4.8 Summary of responses (% of total: no, unsure, yes) when stakeholder survey participants were asked: “Is recreational participation, catch and/or effort data currently used for any of the following purposes in your jurisdiction?”

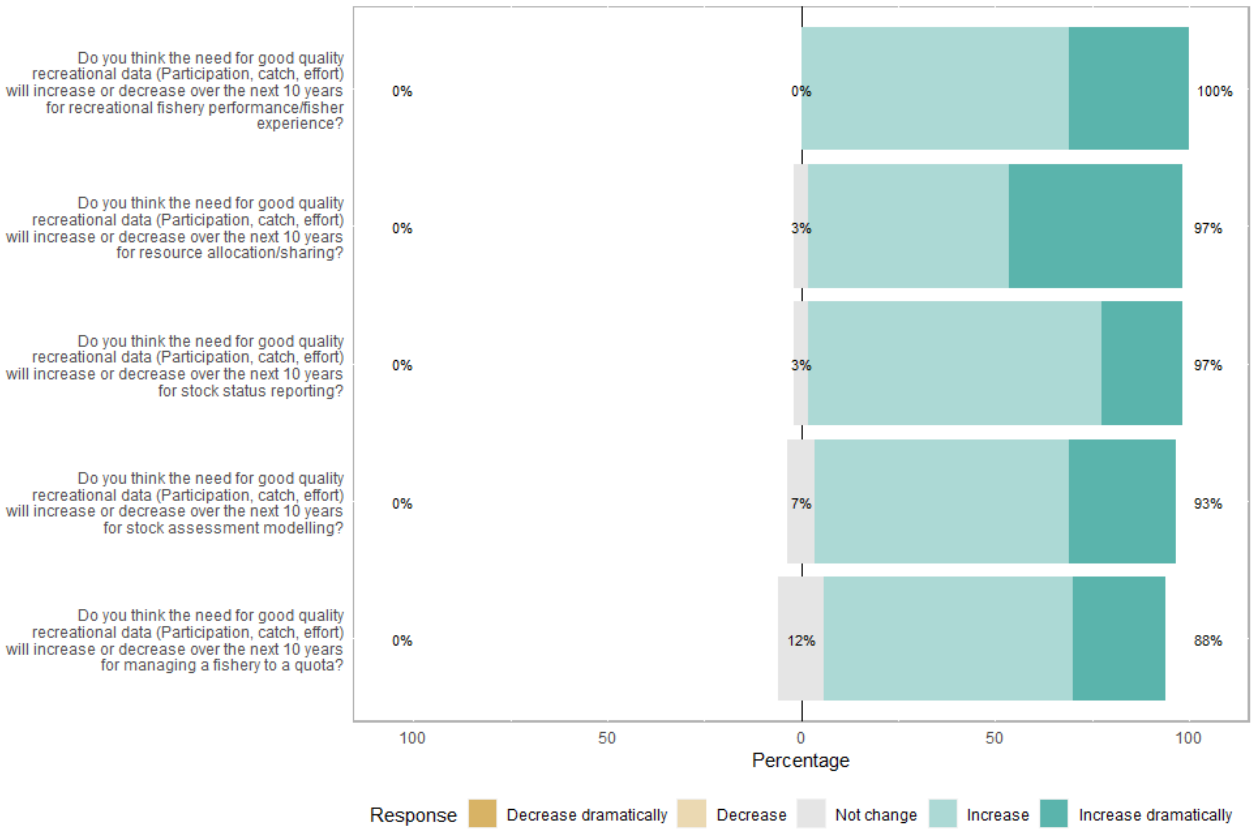

Figure 4.9 Summary of responses (% of total: decrease dramatically, decrease, not change, increase, increase dramatically) when stakeholder survey participants were asked: “Do you think the need for good quality recreational data (Participation, catch, effort) will increase or decrease over the next 10 years for the following purposes?”

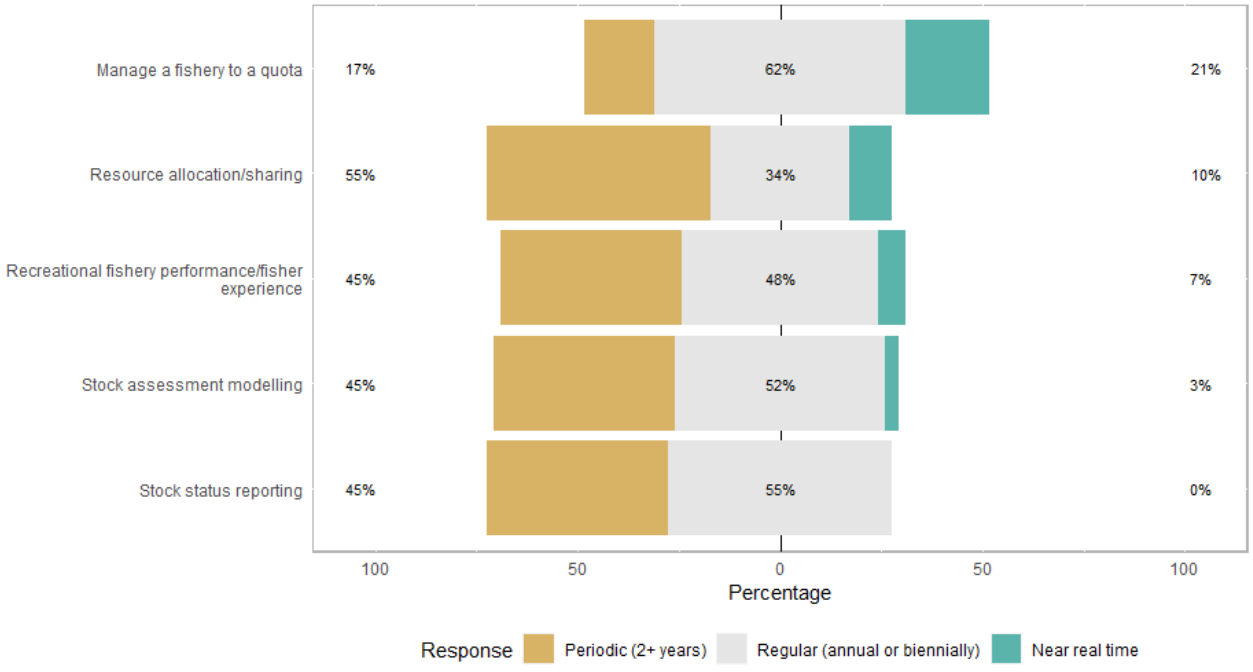

Figure 4.10 Summary of responses (% of total: periodic, regular, near real time) when stakeholder survey participants were asked: “In general, what do you think is the minimum frequency to collect recreational participation, catch and/or effort data for it to be used effectively for the following purposes?”

4.3.4 Future potential of recreational fishing apps

Fisheries managers, scientists and recreational stakeholders expressed mixed opinions regarding the potential use of phone app collected data compared to traditional probability-based survey methods in supporting recreational fisheries management (Figure 4.11). Responses varied across user groups for app-based catch, effort, catch rate, social and economic data. Most fisheries scientists (31–46% of participants), expressed low confidence in app-based data regardless of the parameter. Recreational stakeholder representatives indicated higher confidence in the use of app-based catch and social data but considered app-based effort and catch rate data on par with probability-based survey methods. However, recreational stakeholders' opinions were split on the use of economic data. Fisheries managers generally expressed uncertainty about the potential use of app-based data across all parameters considered. These findings highlight the diverse perspectives and uncertainty surrounding the suitability and effectiveness of phone app collected data for different purposes in recreational fisheries management. Similarly, participants expressed varied opinions regarding the use of fisher apps, with enthusiasm (cautiously or very enthusiastic) ranging from 52–97%, scepticism (sceptical or very sceptical) ranging from 0–31%, and uncertainty (no opinion or undecided) ranging from 3–28% (Figure 4.12). The percentages reflect the diverse range of perspectives on the potential benefits and limitations of fisher apps in supporting recreational fisheries research and management. Overall, the findings underscore the need for further research and evaluation to determine the feasibility and reliability of integrating phone app collected data and fisher apps into existing management practices.

Varied perspectives were observed among fisheries scientists, recreational stakeholder representatives, and resource managers regarding the use of data collection methods in recreational fisheries management (Figure 4.13). While fisheries scientists and managers emphasised the importance of government or affiliated research agencies collecting data (91%–100% agreed or strongly agreed), recreational stakeholder representatives and resource managers disagree or strongly disagree (100%). While most fisheries scientists and managers also agreed that mandatory reporting was important for effective management (45–54% strongly agreed), 80% of recreational stakeholders either disagreed or strongly disagreed. Respondent-driven catch reporting is considered useful by recreational stakeholder representatives (80% agreeing or strongly agreeing), while fisheries scientists and resource managers have mixed opinions. Understanding the needs and values of recreational fishers and the importance of catch and effort data for effective management is seen as essential by all groups. However, opinions differed on the usefulness of recreational catch trends where data is low, and the impact of angler diary programs. These findings highlight the need for further research and consensus-building to inform the integration of data collection methods in recreational fisheries management.

The stakeholder survey results indicate the perceived barriers to fully utilising app data in assessing and managing recreational fisheries in the respective views of fisheries managers, scientists and recreational stakeholders. Respondents ranked integration to existing data collection programs as the biggest barrier (64%), and a further 11% as a barrier (Figure 4.14). Retention for ongoing data reporting and uptake by a sufficient number of people, were also major barriers, identified by 48% and 38% of respondents, respectively. To address these challenges, it will be necessary to implement strategies that incentivise consistent app usage and seamlessly integrate app data into existing data collection programs. The perception that data would be used to regulate fishers was considered a barrier or major barrier by 66% of participants, and data privacy concerns were considered a barrier or major barrier by 55% for participants. Understanding and addressing these barriers will be vital in unlocking the full potential of app data for effective fisheries management.

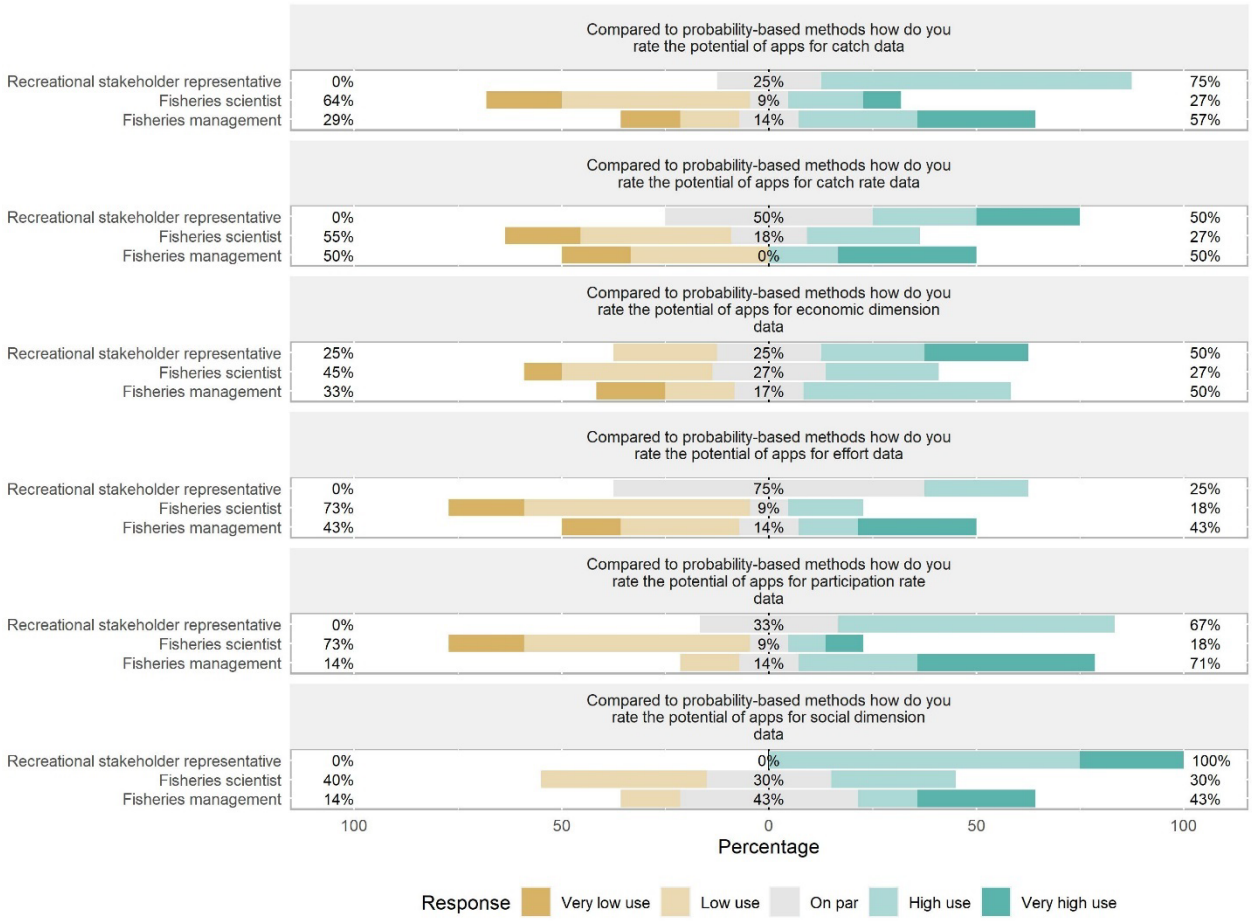

Figure 4.11 Summary of responses (% of total: very low use, low use, on par, high use, very high use) per sector when stakeholder survey participants were asked: “Compared with traditional probability-based survey methods (e.g., phone, diary, mail, access point, roving creel, etc) how would you rate the potential use of phone app collected data to support recreational fisheries management in your jurisdiction?”

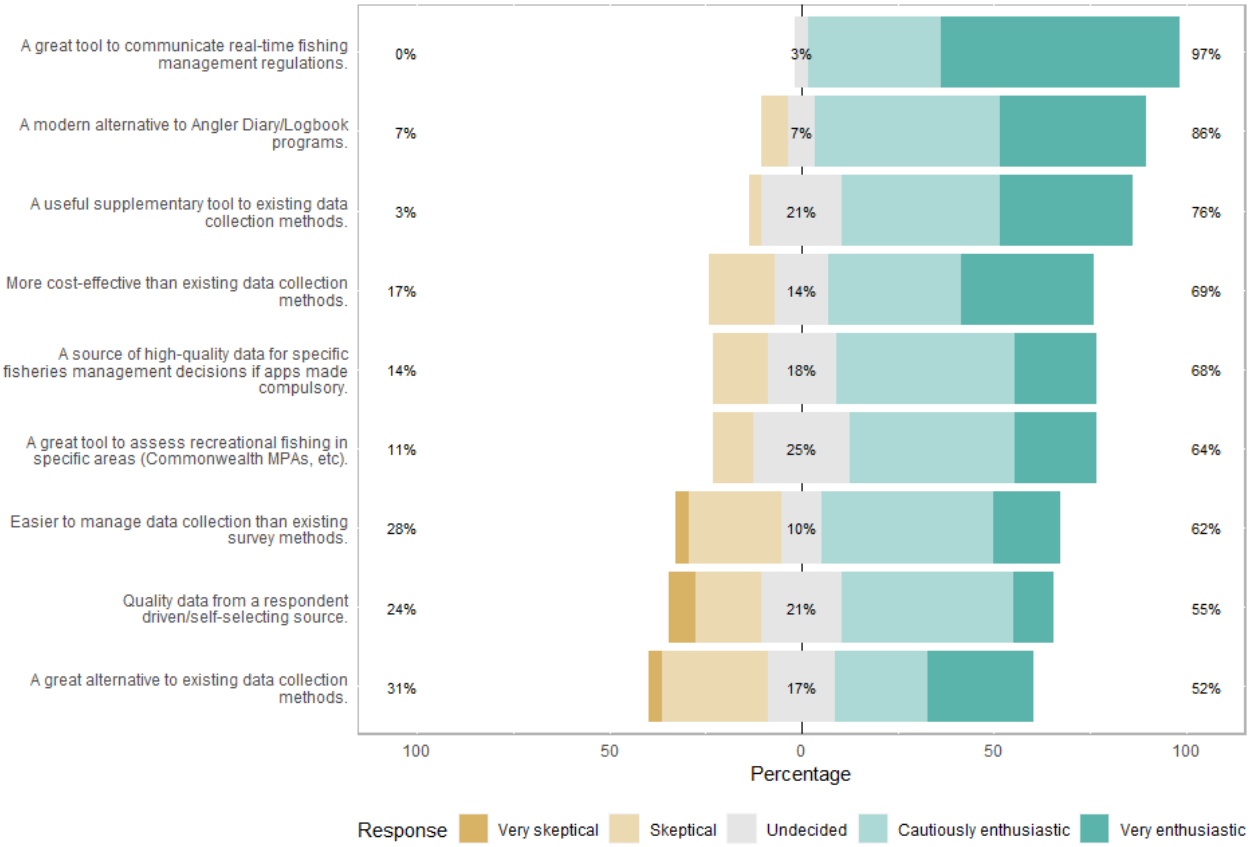

Figure 4.12 Summary of responses (% of total: very sceptical, sceptical, undecided, cautiously enthusiastic, very enthusiastic) when stakeholder survey participants were asked: “How do you feel about the following statements relating to the use of fisher apps to support recreational fisheries research and management in the near future?”

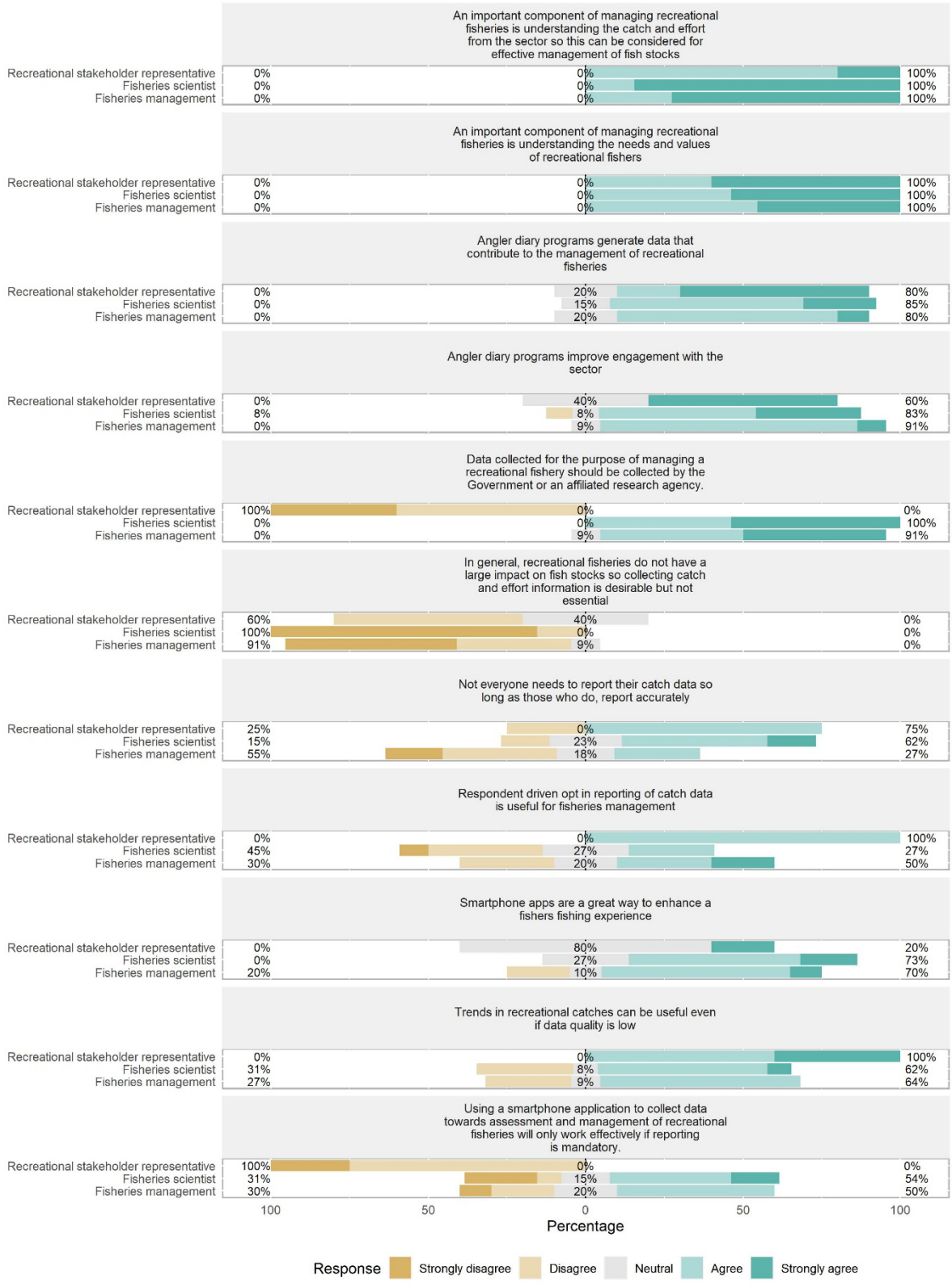

Figure 4.13 Summary of responses (% of total: strongly disagree, disagree, neutral, agree, strongly agree) per sector when stakeholder survey participants were asked: “Do you agree or disagree with the following statements?”

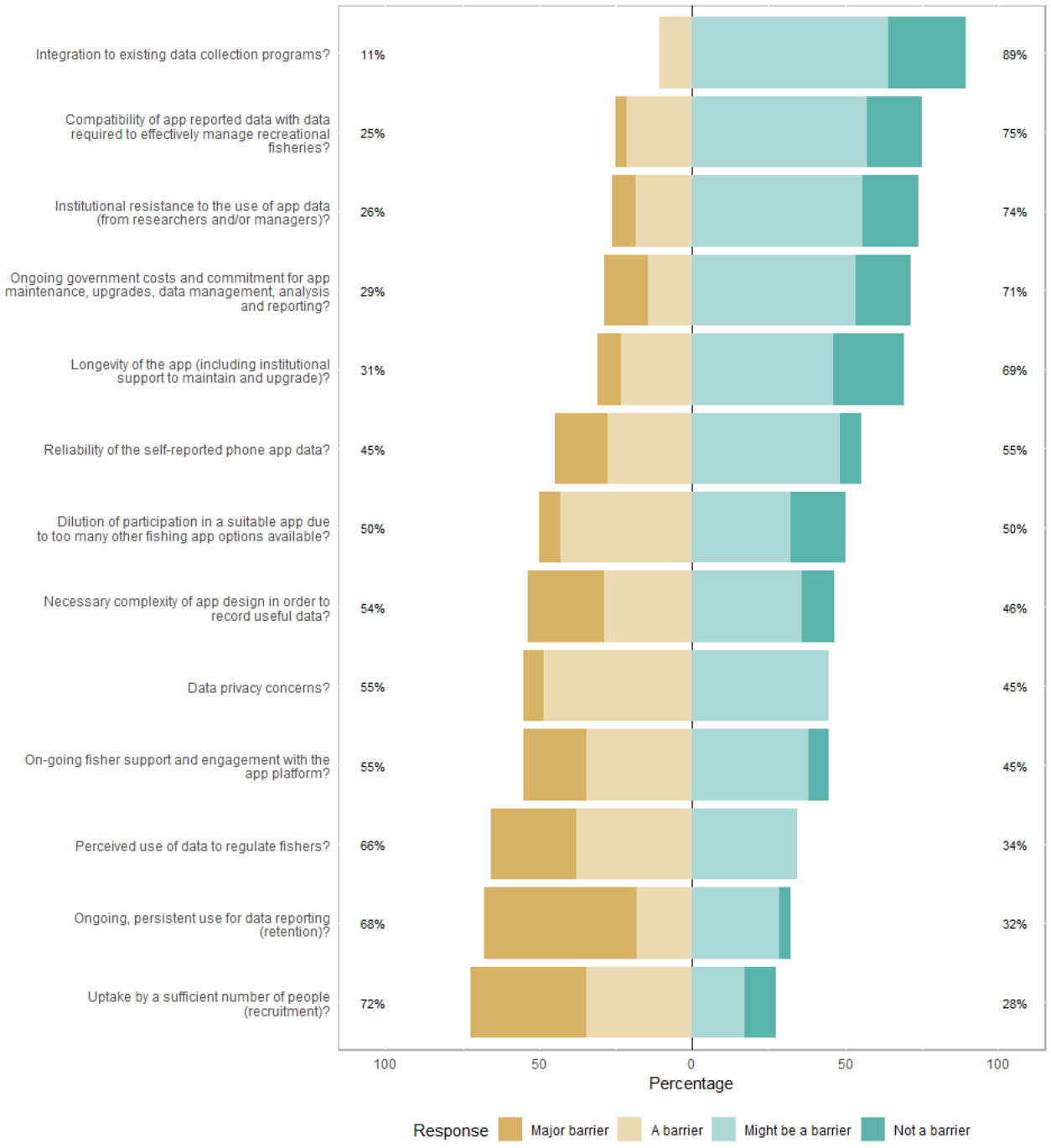

Figure 4.14 Summary of responses (% of total: major barrier, a barrier, might be a barrier, not a barrier) when stakeholder survey participants were asked: “How much of a barrier do you think the following aspects are to fully achieving the potential use of app data in support of assessing and managing recreational fisheries?”

There was unanimous agreement among fisheries managers, scientists and recreational stakeholders regarding the importance of certain app design considerations in optimising stakeholder engagement and ensuring high-quality reporting and data (Figure 4.15). A high quality and visually appealing design, simplifying the app to minimise respondent burden, and automation of as many aspects as possible were rated as either somewhat or very important by all of the respondents. This consensus emphasised the critical role of user-friendly and efficient designs in facilitating user engagement and reducing barriers to participation, underscoring the need to prioritise these aspects for effective app-based data collection in managing recreational fisheries. While most respondents expressed that the remaining features were somewhat or very important, there were notable differences in opinion. Incentivising app usage was considered somewhat or very important by most participants, however, ranked higher amongst fisheries scientists (92%) and managers (73%), when compared to recreational stakeholders (60%). Similarly, most scientists (77%) and managers (55%) considered the need to provide opportunity for social interaction as somewhat or very important, however, only 40% of recreational stakeholders considered this important. Enforcing compulsory reporting was somewhat or very important for most fisheries managers (73%) and scientists (54%), however, most recreational stakeholders felt this was not at all important (60%) or were unsure (40%). Providing an opportunity for individual challenges ranked highly for scientists and recreational stakeholders (60%), while opinions were divided for fisheries managers. There was general agreement that push notifications were important to remind people to use apps, with most scientists (92%), recreational stakeholders (60%) and managers (55%) either agreeing or somewhat agreeing. While most scientists (85%) and recreational stakeholders (60%) also generally agreed with the importance of sending notifications linked to geo-location information, the opinions of fisheries managers were divided. These findings demonstrated the varying perspectives among stakeholders, suggesting the need for further exploration and discussion to address concerns and identify the most effective design strategies to enhance stakeholder engagement and data quality in app-based approaches for managing recreational fisheries.

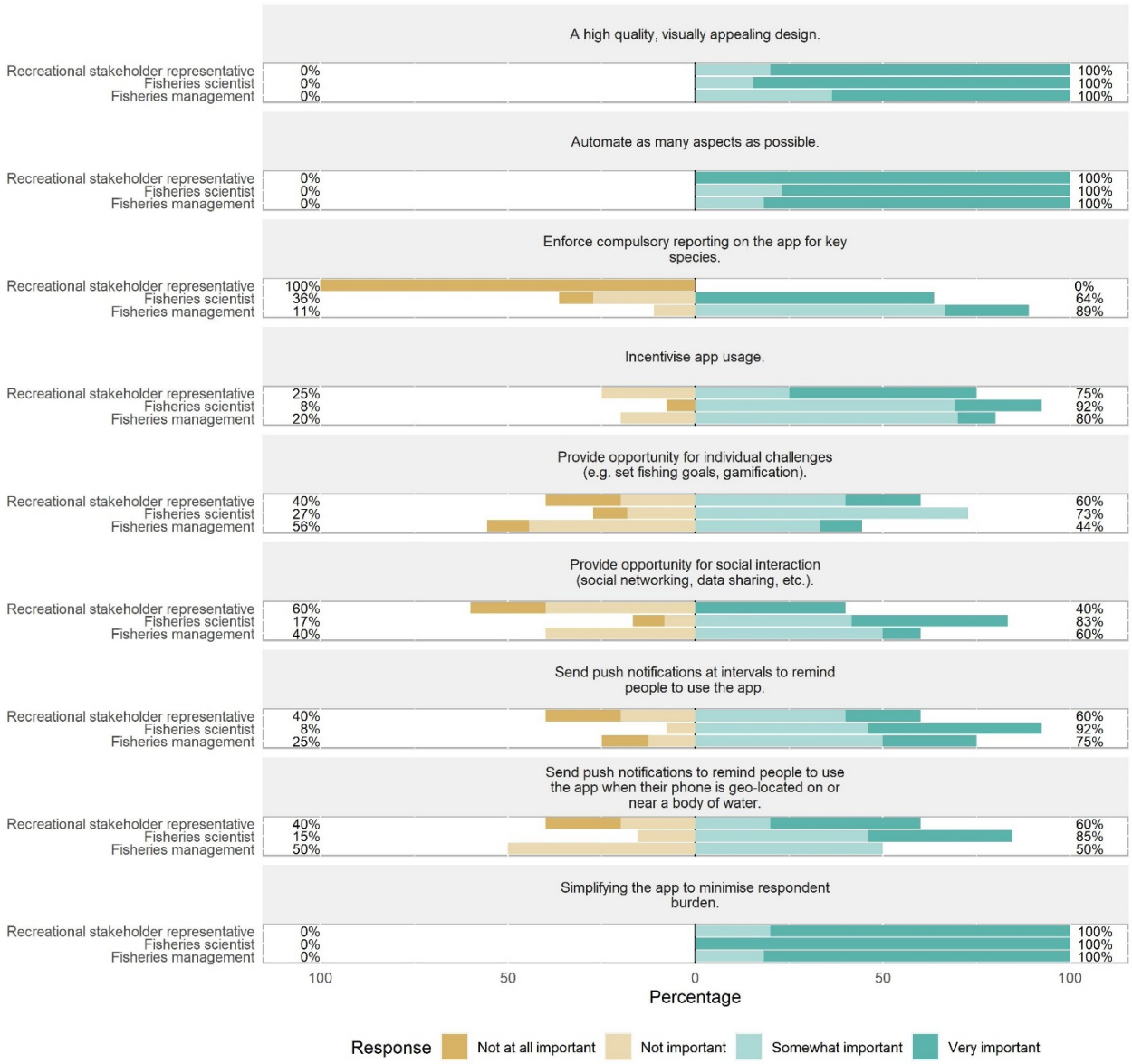

Figure 4.15 Summary of responses (% of total: not at all important, not very important, somewhat important, very important) per sector when stakeholder survey participants were asked: “How important do you think the following app design considerations are in optimising stakeholder engagement, report and data quality?”.

4.3.5 Summary

The stakeholder survey conducted on the use of fishing apps for data collection revealed valuable insights into the perspectives of fisheries managers, scientists, and recreational stakeholders. While there was overall enthusiasm about the potential of fishing apps, significant challenges were identified that hinder their effective implementation. Fisheries managers and scientists demonstrated a higher level of awareness and understanding of fishing apps, recognising their capacity to collect data and support recreational fisheries management. These groups emphasised the importance of app features for reporting fishing trip information, providing rules and regulations, and offering species identification guides. Recreational stakeholders, however, exhibited less familiarity with fishing apps and expressed concerns about data privacy, security, and the representativeness of app-based data. They

highlighted the need to ensure user privacy and build trust for widespread adoption of fishing apps among recreational anglers.

The stakeholder survey findings also highlighted a discrepancy between the perception of participants and the actual effectiveness of fishing apps in collecting the necessary data for stock assessment, resource allocation, and quota management. While participants believed that the data collected through apps were already used for these purposes, data suggested that only a few apps were effectively collecting the required data. This disconnect underscores the need to address the barriers and challenges regarding education of stakeholders that currently impede the efficient and reliable collection of fishing data through apps.

Regarding the collection and use of recreational fishing data, most participants reported their jurisdiction as having a fishing app with various features. Information on rules and regulations was considered highly effective, followed by species identification guides and geo-locating capabilities. However, areas for improvement in compulsory catch reporting and licensing/registration/permitting functions were identified. Participants ranked catch, effort and catch rate data, as well as economic dimensions, as important for effective fish stock management. The data collected through probability-based surveys has commonly been employed for stock status reporting, stock assessment modelling, and resource allocation, but has had limited use for assessing recreational fishery performance and improving the fishing experience.

Participants expressed mixed opinions about the potential use of app-based data compared to probability-based survey methods. Fisheries scientists expressed low confidence in app-based data, while recreational stakeholders showed higher confidence in certain parameters. Fisheries managers generally expressed uncertainty about the potential use of app-based data. These findings highlight the diverse perspectives and uncertainty surrounding the suitability and effectiveness of fishing apps for different purposes in recreational fisheries management.

In conclusion, the stakeholder survey provided valuable insights into the perspectives and experiences of fisheries managers, scientists, and recreational stakeholders regarding fishing apps for data collection. While there is enthusiasm about their potential, challenges related to data privacy, user engagement, and data accuracy need to be addressed to facilitate utilisation of fishing apps for improving data collection and informing management of recreational fisheries.

4.4 Online workshop

4.4.1 Overview

Prior to the workshop, participants were invited to participate in a stakeholder survey (see section 4.3) which aimed to build a better understanding of how effective apps can be to collect information on recreational fishing for the purpose of fisheries management. Following from the stakeholder survey, five key topics were selected to guide workshop discussions:

1. App functionality and availability.
2. Jurisdictional priorities relative to app use and development.
3. Effectiveness of apps for conveying and/or collecting information.
4. Recruitment and retention of participants; and
5. Using recreational data to inform science and management.

The workshop was divided into three groups: technical, science and management. The technical session focussed on what works and what does not when it comes to targeting recreational fishers based on participants experiences (points 1, 3 and 4). The science session

focussed on how to develop an app that is fit for purpose to collect information of catch, effort and participation (points 3, 4 and 5). The management session focused on the minimum requirements to manage a stock and how catch and/or effort data could be used (points 2, 3 and 5). A summary of the discussions is presented below.

4.4.2 Technical Session

App functionality and availability

- Providing data back to users may yield positive feedback and engagement, as seen in apps like Tacklebox for fishing tournament data.
- A need was identified to differentiate between voluntary apps (e.g., personal diary apps) and compulsory apps (e.g., mandated government apps) when considering comparisons.
- Artificial Intelligence (AI) could be used for species identification, with a project in QLD funded by the State government and 20 species currently identified through the app.
- Training AI for species identification is currently a manual and time-consuming process but may become more automated in the future.
- Ownership of data generated by AI projects is likely to be a significant barrier and source of conflict.
- Need to ensure that "Swiss army knife" apps with multiple functions should be simple and user-friendly, as complex apps with buried functions are unlikely to be used.
- Government apps that collect recreational fishing data can often be seen as ineffective (see Figure 4.13) due to the burden of usage, emphasising the need for a reduced number of questions.
- Motivating app participation could be achieved through gamification, photo submission, questions, feedback, marketing campaigns, and competitions.
- Legal and privacy issues need to be addressed, and appropriate disclaimers are important.
- Initiatives like Tacklebox's 'Gone Fishing Day' could have positive results in increasing app participation.

Effectiveness of apps for conveying and/or collecting information

- Apps are seen as effective for conveying information but currently not seen as effective for collecting information (see stakeholder survey results, Section 4.3).
- Effective apps could provide real-time information of what is going on around you as a reward for user submissions.
- App-based data requirements (downloads and/or storage space) are likely to be large and there would likely be a need for offline access in areas with poor data coverage.
- Linking to external websites was suggested as a solution to reduce download times and provide additional information.
- Participation in catch reporting in recreational fishing apps is generally considered to be poor, and it may be removed in apps with limited size or low uptake.
- There needs to be a focus on improving species identification to improve data quality.
- Challenges remain in calculating catch rates from a non-representative subset.
- Push notifications are widely used across various apps and sectors and these may deliver timely and valuable information, facilitate user engagement, and enable effective communication.

Recruitment and retention of participants

- Angler diary programs were seen to face challenges in recruiting and retaining participants, with apps suggested as a modern alternative.

- Barriers to participation were identified (e.g., concerns about data privacy and ownership), with discussions around peak recreational fishing bodies maintaining data ownership.
- Trust issues may arise regarding data sharing with the government, as the recreational sector may fear data being used against them.
- Peak bodies could serve as platforms for stakeholder engagement, utilising ambassadors and high-profile fishers to promote research and build trust.
- Marketing strategies for recruitment may include ministerial releases, social media posts, newspaper stories, competitions, and promotion at fishing sites.
- Apps were suggested as the preferred approach over websites due to the convenience of mobile usage, but challenges may exist for older participants without smartphone access or the required technical ability.

Summary of technical session

- Data ownership and privacy concerns may function as a significant barrier to using smartphone apps for data collection.
- Educating recreational fishers about the importance and use of data may be necessary to encourage open and honest data submissions.
- Compulsory data reporting could be an alternative for certain species, although it may face resistance from some individuals.
- Government apps are likely to adopt a "Swiss army knife" approach, incorporating surveys and using education to drive app downloads.
- Smartwatch devices and bluetooth-connected fishing equipment could potentially facilitate automated data collection in the future.
- Improvements in AI technology for fish identification and quantification may offer opportunities for automating data collection.
- Integrating technology into the fishing experience aims to allow anglers to enjoy fishing without constant reliance on their phones.
- The availability of more data could enable the creation of fishing activity heat maps and other features to enhance user engagement.

4.4.3 Science session

Recruitment and retention of participants

- Apps may be considered the modern-day equivalent of angler diaries, which traditionally focus on catch rates for the recreational sector.
- Validation of catch rates could be done by comparing with alternative data sources (e.g., on-site surveys, see (Vitale et al. 2021)) and by using structured survey designs to overcome potential biases.
- There is potential for angler diaries to be biased towards more avid fishers, however, using a structured probability-based design this may be overcome (Cornesse *et al.* 2020, Skov *et al.* 2021)
- Challenges may arise when measuring total catch, as it should be representative of all fishers and not biased towards specific groups.
- Apps can collect non-representative data for trend analysis, but structured surveys are likely to be crucial for obtaining quality data.
- Strategies for enhancing recruitment and retention could include providing feedback to users, using summarised information, and incorporating gamification.
- Mandatory reporting is being considered in various jurisdictions and could lead to more robust data if compliance is ensured.
- Political challenges may arise with mandatory reporting, but it is not unprecedented as it already exists for commercial fishing.

- Building trust within the recreational sector is likely to be essential to promote citizen science, but data privacy and ownership issues need to be addressed.
- Trust may be established by using data to support sustainability efforts or address declining stocks.

Effectiveness of apps for conveying and/or collecting information

- The need for high-quality recreational fishing data is expected to increase in the future, driving the investigation of non-probability methods for national surveys.
- Non-probability methods could provide a cost-effective alternative to large-scale surveys, but trade-offs in accuracy and precision would likely be necessary to increase survey frequency and capture trends.
- The national survey focused on social and economic data rather than catch and effort data, involving an omnibus design and an online survey with a wide range of participants. An online diary survey was conducted over 12-18 months, with dropouts suggested as an issue.
- Phone diary methods with interviewer interaction were seen as more effective in terms of building a rapport with participants to increase retention.
- Validity of data was discussed, highlighting the importance of sample size and acceptable error variance levels.
- Monitoring social media or targeting anglers through an app has potential to provide specific metrics over time but may not be suitable for species with frequent changes.

Using recreational data to inform science and management

- The discussion revolved around the essential data required for managing a fish stock, highlighting catch and effort data as the primary focus (Fig. 4.6).
- Catch data requires manual entry, while effort data has the potential for automated collection to reduce respondent burden.
- Both catch and effort data were considered as important for determining catch rates, and it can be challenging to separate the two.
- Various tools are available for data collection, each providing various levels of accuracy and precision.
- Remote cameras could enhance confidence in effort estimates from on-site surveys by providing extended temporal coverage (see Lai et al. 2021).
- Drones could be useful for studying large-scale or regional/remote fisheries (see Desfosses et al. 2019).
- Corroborating methods and considering important metrics, such as effort in hours or days, are likely to be crucial to ensure consistency when examining trends.
- State-wide surveys were considered unlikely to provide accurate catch estimates for all species due to the considerable number of fisheries with recreational components in most jurisdictions.
- Disaggregating catch and effort data at different scales, particularly for localised and small-scale fisheries, is challenging but necessary for effective fishery management.
- As localised and small-scale fisheries represent a small component of the overall sample, this limits the statistical power and precision of estimates.
- Exploring alternative methods for collecting supplementary data could alleviate the challenges faced in localised and small-scale fisheries and reduce the burden on app-users.
- Collecting effort data voluntarily is considered difficult, as people are less likely to report zero or low catch trips, emphasising the importance of encouraging app users to understand and provide catch rate data.
- Existing privately owned apps with a large following collect substantial data that could support science and management efforts.

- There is a clear interest in collecting information among app users, and it is important to address the lack of awareness regarding certain apps and the absence of data management systems in some jurisdictions (e.g., Tasmania).
- Photo recognition technology holds potential for conveying or collecting information, including the integration of brag boards to validate size estimates and provide length frequency data.
- Accessibility and skill limitations of users should be considered when developing technology, and extensive validation is necessary before implementing new technologies.

Summary of science session

- Participants recognised the increasing need for better quality data on recreational fishing in the future.
- The development of tools will need to be flexible to adapt to evolving technology.
- Challenges exist in interpreting trends, recruiting and retaining participants, and ensuring a representative sample when using respondent-driven data.
- Mandatory reporting could improve accuracy and precision, but it requires a significant compliance effort and may not guarantee 100% accuracy.
- Apps have the potential to complement existing methods for collecting recreational fishing data.
- Current apps were perceived to be in-effective in providing benefits to fishers and need improvement.
- Mistrust of the Government was identified as a potential barrier to participation, and education and awareness campaigns are likely to be necessary.
- Peak bodies should be involved in promoting education and awareness among fishers.
- Existing apps, such as Tacklebox, have received significant investment but serve specific purposes.
- It was acknowledged that the FRDC project (presented in this report) aims to evaluate the use of apps by comparing them with a probability-based design.

4.4.4 Management session

Jurisdictional priorities relative to app use and development

- Robust catch and effort data are considered important for fishery management, especially in jurisdictions where it informs resource allocation and management approaches.
- Virtual tags, where digital tags are made available within an app or online platform as a means of tracking and recording catch, were discussed as an option for tracking and recording catches, but challenges were identified in implementing this gamification concept.
- Integrating adaptive limits into a fishing app could allow for real-time updates on catch limits and protected species, promoting sustainable practices and resource conservation while enhancing user compliance and education.
- Probability-based surveys were generally supported, although comparing sample sizes and costs will likely be necessary to determine cost-effectiveness.
- Defensible data collection is crucial for managing heavily exploited niche or small-scale fisheries. Ensuring data accuracy is essential for decisions like reopening fisheries after closures.
- Understanding participation and fisher satisfaction through various surveys will continue to be important for effective engagement with the recreational sector.
- Key species, which are often prioritised for data collection, possess certain characteristics such as being niche in their habitat, economically significant, over-exploited or vulnerable to depletion, targeted specifically by fisheries, iconic in local

ecosystems, or popular among recreational or commercial fishers. These species are singled out for focused data collection efforts due to their ecological, economic, or cultural importance.

- Aggregating catches of key species could provide estimates for multispecies resources, but accuracy may be compromised.
- Mandatory reporting, such as for Yellowtail Kingfish (*Seriola lalandi*) in NSW, could be effective with proper education and precise estimation methods, particularly when targeting avid anglers in niche fisheries.
- Targeting avid anglers may ensure greater accuracy, representativeness, cost-effectiveness, and stakeholder engagement, but validation and follow-up efforts are likely to be necessary, and challenges may arise in small-scale and heavily exploited fisheries.

Effectiveness of apps for conveying and/or collecting information

- Apps could trace emerging species through engaging avid individuals and integrating AI species recognition for data validation and confidence.
- Long-term discussions have centred on implementing mandatory reporting to ensure robust catch estimates, using examples such as Southern Rock Lobster in Victoria and Snapper in South Australia. Education and promotion efforts are deemed crucial for enhancing compliance with these reporting requirements. Currently, there is limited integration of jurisdictional apps with evolving management arrangements, which could enhance data collection efficiency and management effectiveness.
- Mandatory reporting, similar to commercial logbooks, may not provide a complete catch estimate and requires accounting for uncertainty and compliance costs.
- Compliance for mandatory reporting is considered challenging and costly due to the significantly larger number of recreational participants compared to the commercial fishery, making coverage and checks more difficult and disparate.
- Cross-checking app data with compliance measures may allow assessment of reported data accuracy, and incentives could encourage accurate reporting rather than relying solely on punishments for non-compliance.
- Prior reporting could be utilised for enforceable rules, real-time monitoring, and potential linkage to boat or car registration.
- User-friendliness and support should be prioritised in app design, including group reporting options.
- Mandatory prior reporting before fishing trips could improve estimates for non-catch days, drawing inspiration from similar strategies used in NSW where hunters are required to book pre-departure (NSW Department of Primary Industries 2017).

Recruitment and retention of participants

- To better engage the recreational sector, we need to offer benefits that go beyond sustainability and resonate with what anglers find valuable. Educational initiatives can demonstrate why collecting recreational catch and effort data is crucial for effective management, encouraging more anglers to use app-based reporting.
- Apps could provide a platform that allows access to a resource while maintaining equity between recreational and commercial fishers and promoting sustainability (e.g. Snapper in South East SA)
- Apps are generally considered the most effective platform for collecting recreational catch and effort data compared to online, browser-based surveys.
- Requiring recreational fishers to report their catch would be a notable change and would likely face resistance. Mandatory reporting may be suitable for certain species, such as Southern Rock Lobster or overfished species requiring accurate mortality estimates for stock assessment.

- Avid fishers were considered more likely to use apps, while infrequent fishers may be less inclined to do so.
- The existing fishing license or access requirements in some states could be linked to catch reporting, leveraging the existing framework.

Summary of management session

- Ownership of data is considered a significant barrier to participation, with a perception that recreational fishers should have more control over how their data is used.
- Similar issues of ownership and co-management likely exist in the commercial sector, raising questions about who should own the data. Some argue that since fisheries are a community resource, the government should own the data.
- Challenges may arise when peak bodies change or there are multiple representative bodies, highlighting the need for continuity and data maintenance by the government.
- Granting ownership of data to recreational fishers could enhance their stakeholder experience and increase engagement from the recreational sector.
- The existence of numerous app options is likely to lead to user fatigue and confusion, with different apps serving different purposes.
- Government apps were considered to adopt a comprehensive approach, while privately owned apps primarily focus on individual data logging.

4.5 Key findings and implications

The key findings and implications from the review of existing technologies and knowledge assets, stakeholder survey and online workshop on smartphone apps for recreational fishing can be summarised as follows:

Key Findings

- Traditional probability-based surveys face challenges in recreational fishing surveys due to changes in communication methods and the lack of appropriate sampling frames.
- Smartphone apps and the internet have the potential to collect supplementary data on recreational catch, but limitations such as non-response and selection bias can impact the accuracy of estimates.
- Pilot studies in Western Australia, the Gulf of Mexico, Alberta, Florida, and Denmark have shown that app-based data can provide useful insights but may have biases and limitations.
- User patterns and behaviours, including demographics, specialisations, and avidity, can affect catch rates and data quality in app-based platforms.
- App design features include registration options, optional in-app purchases, mandatory reporting features, trip-based data reporting, personal logbooks, rules and regulations information, species information, mapping interfaces, social media sharing features, and integration of third-party information.

Implications

- Recruiting participants for app-based data collection from the general population, where a license frame is unavailable, poses significant challenges that require significant investment in communications activities.
- App developers, particularly private companies, have the opportunity to advance app technology and make them more attractive to a broad range of users.
- App-based data collection could complement probability-based surveys by providing additional data, especially in terms of near real-time information, but biases and limitations need to be addressed through comparative studies and data validation.

- Ensuring user-friendly app design, user feedback mechanisms, transparency in data use, and developing standards and guidelines for app development are likely to be crucial for participant recruitment and retention.
- Apps have the potential to provide data to inform stock assessment, resource allocation, and quota management, but concerns about data privacy, security, and representativeness need to be addressed to encourage widespread adoption among recreational anglers.
- Apps could enhance the timeliness of fisheries management and decision-making processes by providing near real-time data and developing catch proxies between large-scale surveys.
- Ongoing challenges include participant recruitment and retention, data privacy, user engagement, and data accuracy, which need to be addressed for effective utilisation of fishing apps in improving data collection and enhancing management practices in recreational fisheries.

In summary, this chapter highlights the significance of user engagement, data ownership, privacy considerations, recruitment and retention approaches, and the potential of smartphone apps in improving data collection and information dissemination in the recreational fishing sector.

5. South Australian app-based trial

5.1 Introduction

Challenges in the availability and coverage of sampling frames, declining response rates and growing user base of app-based data collection platforms meant that this South Australian case study provided an ideal opportunity to investigate alternative methods for undertaking recreational fishing surveys. This led to additional objectives to assess the use of a smart-phone app as a method for collecting recreational catch and effort information and to explore whether smart-phone apps can be integrated into future recreational fishing surveys.

Data collection from an app-based platform was conducted using the Qualtrics survey platform and integrated into the existing South Australian Government "SA Fishing" app, which has been available for free download since 2013 (previously known as the "SA Fishing Guide"). In addition to hosting the survey, the app includes the latest fishing rules and regulations and provides a platform to report illegal activity, shark sightings, and Snapper catches for the South-East Fishery. The survey was open for all to participate from 1 March 2021 to 14 December 2022. The app-based survey was open for the duration of the longitudinal component of the State-wide survey (1 March 2021 to 28 February 2022), enabling comparisons between the two data-sets.

This chapter examines the results of app-based data collection and is divided into five main sections, exploring:

- **Recruitment, retention and data quality:** how were participants recruited and retained, what were the barriers to participation, how accurate was the data reported?
- **Participation:** how many people participated in the self-selected survey during the diary observation period, and what were the patterns in fishing and reporting?
- **Fisher profiles:** how representative are participants in the app-based data of the general recreational fishing population, and what are the potential biases?
- **Fishing activity:** how representative is fishing activity data (catch and effort), and what are the potential biases?
- **Fishing motivations, skill and experience:** how important was fishing to participants, and what was their perceived level of fishing experience/skill?

In this section, survey submission refers participants reporting their fishing activity (reported as a single trip per submission) on the app-based data collection platform.

5.2 Recruitment and retention to the app-based data collection platform

5.2.1 Feedback on participation

The wash-up survey of app participants was used to investigate how participants were recruited to the app-based data collection platform and which strategies were most successful for retaining participants or reminding them to participate. Overall, 839 randomly selected app users participated in the wash-up survey, equivalent to 31% of the total app participants.

The wash-up survey of app participants revealed that just over half (51%) of participants had downloaded the SA Fishing app prior to the launch of the survey, indicating that they were already using the app for various reasons unrelated to the survey. Additionally, during the survey period, a further 48% of participants downloaded the app, suggesting that survey participation was a possible motivation (Figure 5.1A). However, this was not supported by the results of wash-up survey of app participants which found that the most common reason for

downloading the app was to find out about regulations (72% of participants), rather than specifically for survey participation (7% of participants) (Figure 5.1B). This finding aligns with the fact most participants indicated that they downloaded the app prior to the survey being launched.

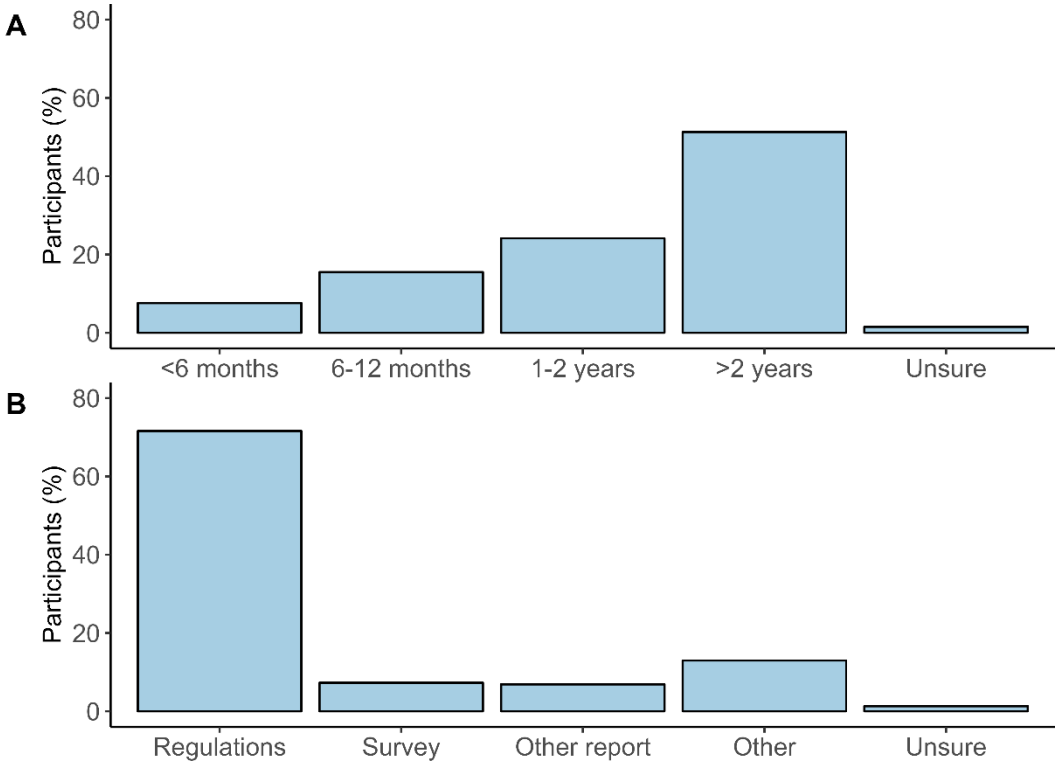

Figure 5.1 The percentage of wash-up survey participants by (A) how long the SA Fishing App was installed and, (B) why they initially downloaded the app.

Most participants in the wash-up survey of app users (19%) indicated that they heard about the recreational fishing survey through app-based reminders or push-notifications, followed by social media (17%) or via a website (14%) (Figure 5.2). The findings suggest that the app-users and the subsequent wash-up survey of app users may have a bias towards the type of fishers who downloaded the app to learn about regulations. This may limit the generalisability of the findings to the broader population of recreational fishers who may not have downloaded the app or have different motivations for doing so.

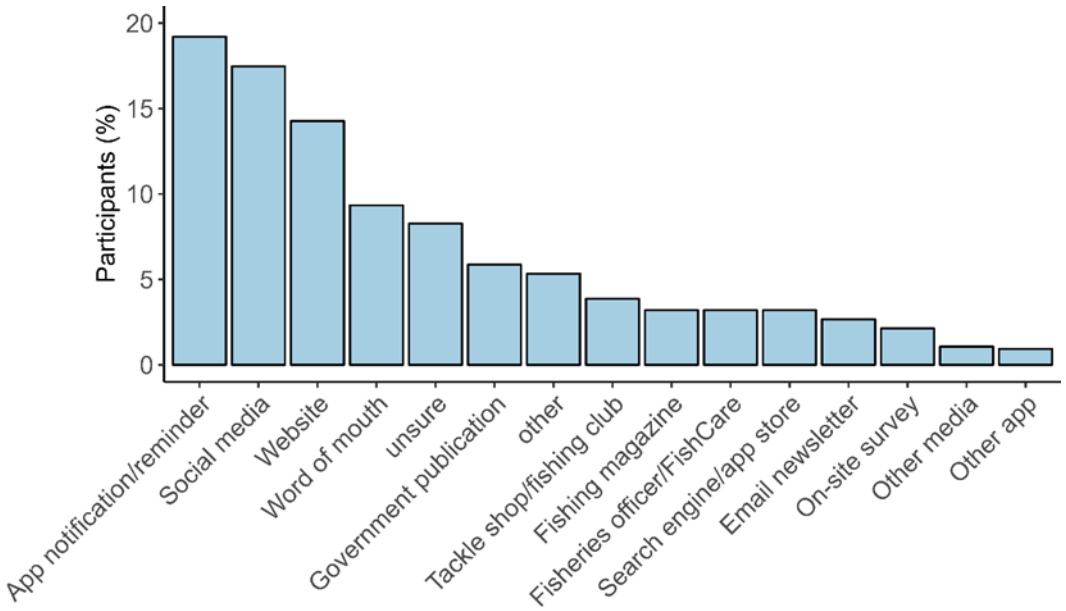

Figure 5.2 The percentage of wash-up survey participants by where they heard about data collection via the SA Fishing app.

It is worth noting that the app-based survey was actively marketed, likely influencing individuals to download the app. While participation in the survey was not cited as a common motivation for downloading the app, a relatively substantial proportion of participants downloaded the app during the time that the survey was underway. This indicates the potential effectiveness of using an app to recruit survey participants and highlights the impact of marketing efforts on app downloads. The high percentage of participants who heard about the survey through app-based reminders or push-notifications and social media further supports the use of these communication methods for recruitment to app-based surveys. However, it is important to note, that relying solely on these methods may result in a biased sample, as those who are less technologically inclined or lack access to modern devices and internet connectivity are less likely to participate. Therefore, a combination of recruitment methods should be used to ensure a representative sample.

When reflecting on the communications strategies used to promote participation in the app-based survey, just over half (55%) of participants in the wash-up survey reported not receiving any communications reminding them to participate (Figure 5.3A). This was despite a wide range of communications strategies being used (see section 3.4.2). A further 27% of wash-up survey participants recalled some form of communication reminding them to participate, with the remainder (18%) being unsure. When reflecting on the frequency of personal communications received (i.e., notifications sent to phone/email, as opposed to broader communications such as social media posts), just over half (54%) reported never receiving any communications encouraging participation. This was consistent with the results of the wash-up survey of app participants, which revealed a preference for limited or no personal communications (49%, Figure 5.3B). A further 17% of participants received monthly reminders, which was the next most preferred frequency (42%). Some participants (27%) were unsure about what they had received, suggesting a potential recall bias. App-based reminders (37%), emails (30%), and push notifications (28%) were the most recalled communication methods (Figure 5.4A). Push notifications received a relatively high percentage of Rank 1 responses (38%) and was among the top three communication methods ranked by respondents as most likely to result in survey submission. This suggests that push notifications may be a valuable tool for encouraging survey participation and increasing response rates. However, it is important to note that not all participants may have enabled push notifications on their devices, and that other communication methods such as app-based reminders and

emails may still be important for reaching those users. While social media was not ranked as highly as a means for hearing about the survey, it is likely to have indirectly increased participation through increased awareness or exposure. Social media platforms can have a wider reach and can potentially reach individuals who may not have otherwise heard about the survey through other channels. Additionally, social media can facilitate word-of-mouth promotion, where users share information about the survey with their social networks. Therefore, while the immediate impact of mechanisms like social media on survey participation may not be as obvious, it is possible that it may have had a more subtle, long-term effect on raising awareness and increasing participation in the survey.

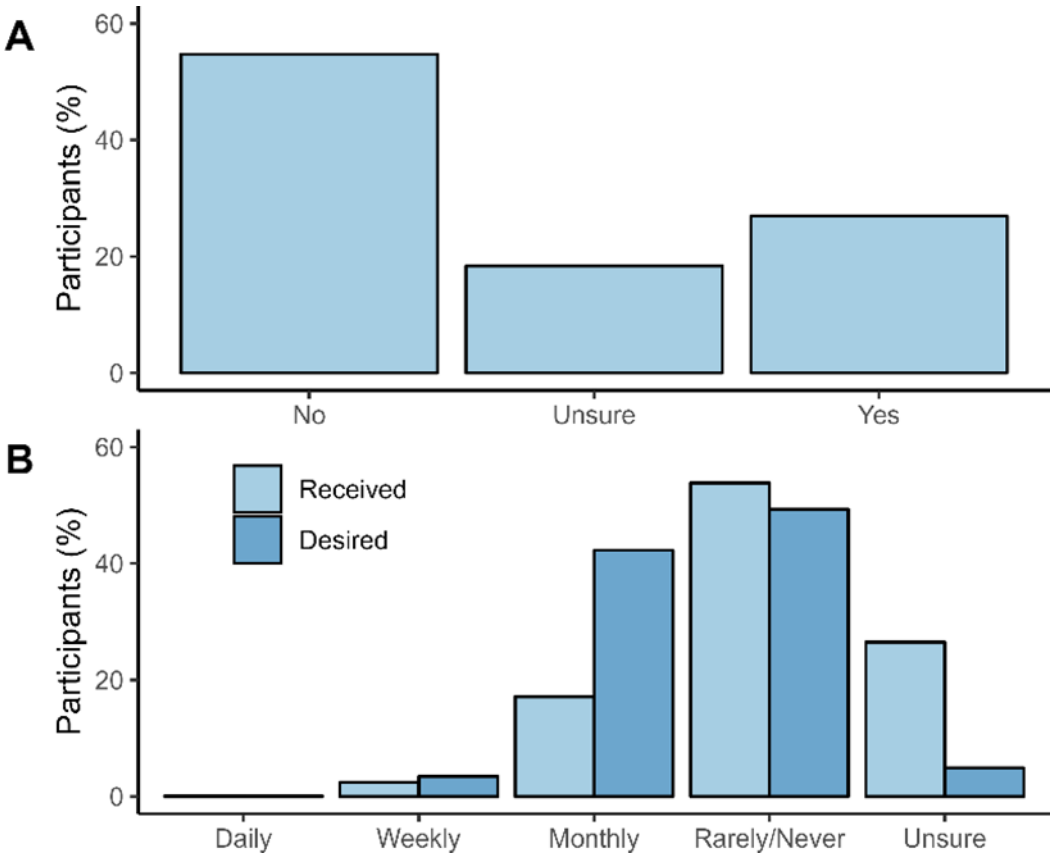

Figure 5.3 The percentage of wash-up survey participants who (A) received communications reminding them to participate in the survey, and (B) how frequently personal communications encouraging participation (i.e., notifications sent to phone/email etc., as opposed to broader communications such as social media posts) were received compared to how frequently participants would have liked to received communications.

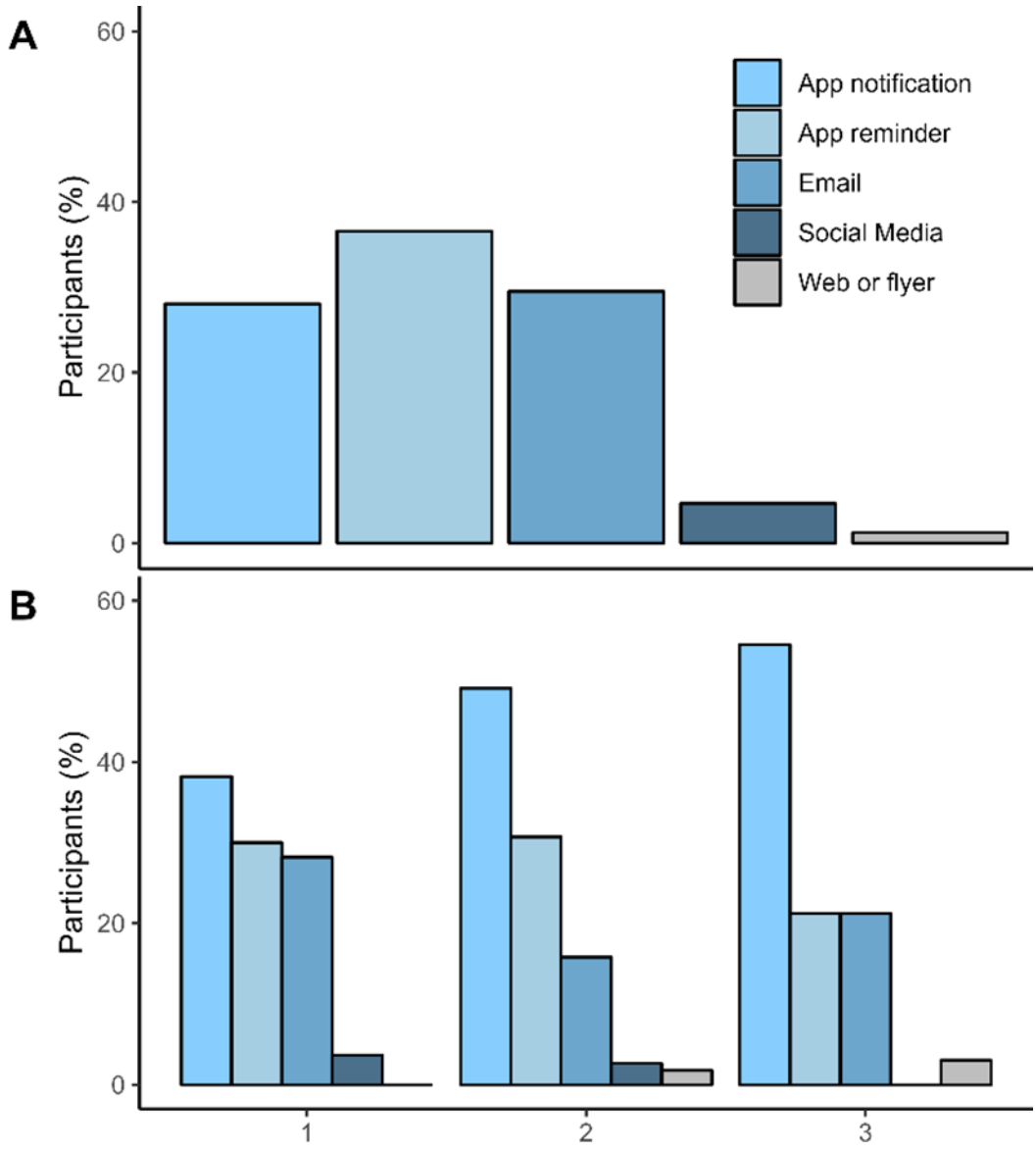

Figure 5.4 The percentage of wash-up survey participants who (A) received or viewed communications by category, and (B) which communications were most likely to result in submission of a survey response ranked from most (1) to least likely (3).

While 87% of respondents reported at least one catch event during the survey period, a majority (52%) of participants in the subsequent app-based wash-up survey did not recall using the app to report their catches (Figure 5.5A). This stark contrast between the high percentage of reported catch events and the low recall of reporting them through the app suggests a significant level of recall bias among participants. However, given that 87% of respondents reported at least one catch event, this suggests an elevated level of recall bias. The most common reason cited for not reporting fishing activity was forgetfulness, followed by losing interest, having limited data to report (such as not catching enough fish or not catching anything worth reporting), or lacking time (Figure 5.5B). These reasons suggest that improving the ease and convenience of reporting could increase participation, retention and data accuracy.

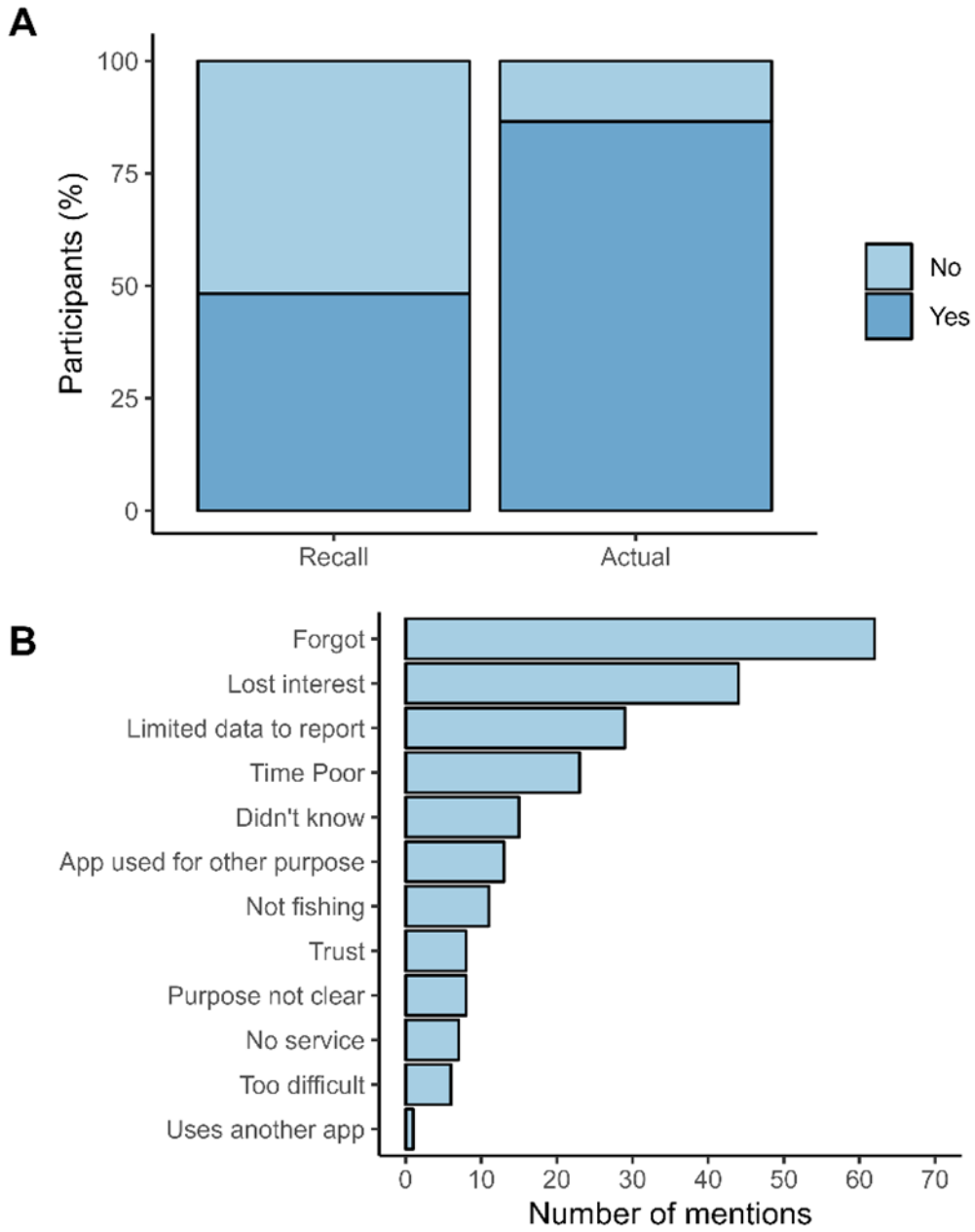

Figure 5.5 The percentage of wash-up participants who (A) recalled submitting fishing activity to the app versus the recorded (actual) submitted fishing activity, and (B) reasons that fishing activity was not reported (number of mentions).

According to participants in the app-based wash-up survey, most were comfortable providing information (92%) and found it easy to enter profiling data (92%), as well as fishing trip data (85%) and use the map to enter fishing data (71%, Figure 5.6). Additionally, most participants were comfortable reporting their catch (86%) and confident in their ability to identify species (89%). However, some participants had concerns with the usability of the dropdown menu for locating and adding multiple species, with 16–25% expressing neutrality and 4–15% expressing disagreement on these issues. Furthermore, a moderate number of participants would have liked to provide more information (38%), upload photos (40%), and to see other people's data (42%). While most would have liked access to their data after submission (64%). There was relatively low interest in sharing participant data on social media (16%). Overall, these findings suggest that app-based data collection was well-received by participants and provided an effective means for collecting data on recreational fishing. However, there is room for improvement in terms of the app's usability and features to better meet participants' preferences and needs.

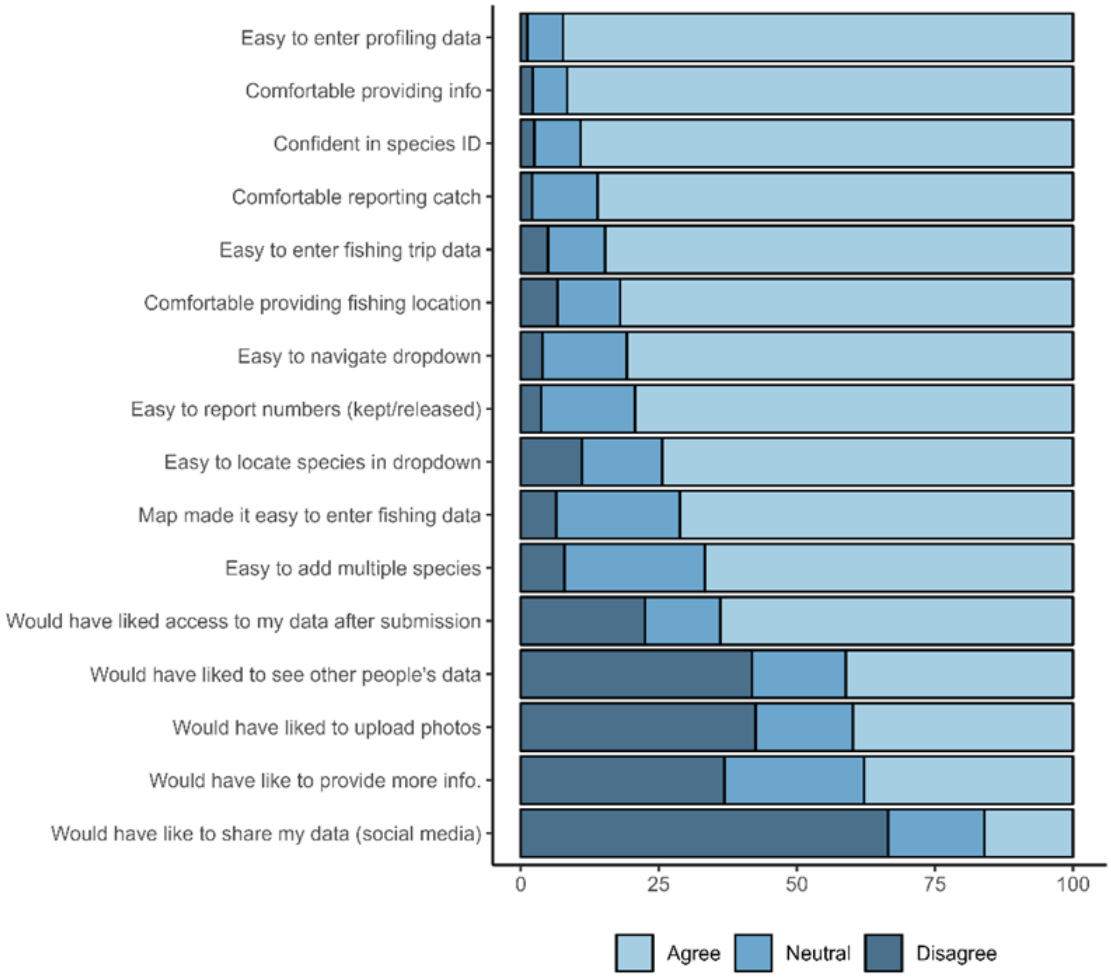

Figure 5.6 The percentage of wash-up participants who either agreed, disagreed or were neutral about statements in regard to their experience using the survey.

The wash-up survey of app-users yielded important insights into the potential motivators of future participation and engagement. The findings emphasised the significance of effective communication strategies, such as regular reminders via various channels (email, text, phone calls, in-app notifications), to maintain engagement and boost response rates (Figure 5.7). Additionally, transparency about the research purpose, collaboration with stakeholders, education on data importance, and providing recognition and ongoing engagement opportunities were identified as essential factors for enhancing future participation.

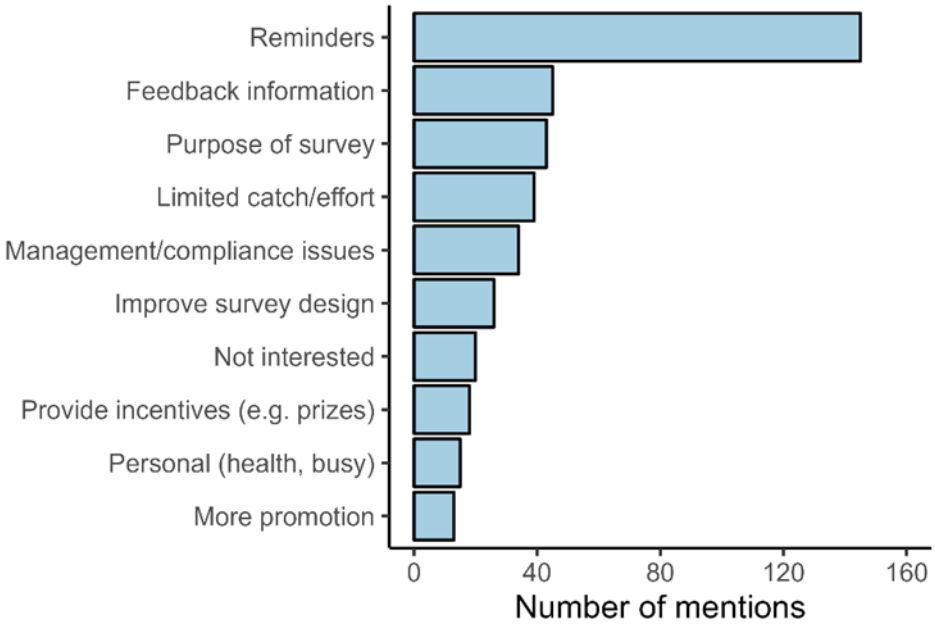

Figure 5.7 The top ten reasons that may increase the chance of participants continuing to contribute to app-based data collection in the future (number of mentions).

Among the wash-up survey participants, time constraints emerged as the primary barrier to sustained participation in the app, followed by difficulties in data submission and functional issues (Figure 5.8). These findings indicated that while participants initially engaged in the survey, they struggled to maintain regular participation due to time limitations and competing priorities. To address these barriers, streamlining data submission processes, ensuring user-friendly survey design, and resolving technical difficulties are crucial. While the functionality of the app is important, effective communication strategies were found to have a greater impact on participation. Participants prioritised factors that could be improved through better communication, rather than focusing on functionality-related issues (see Figure 5.6).

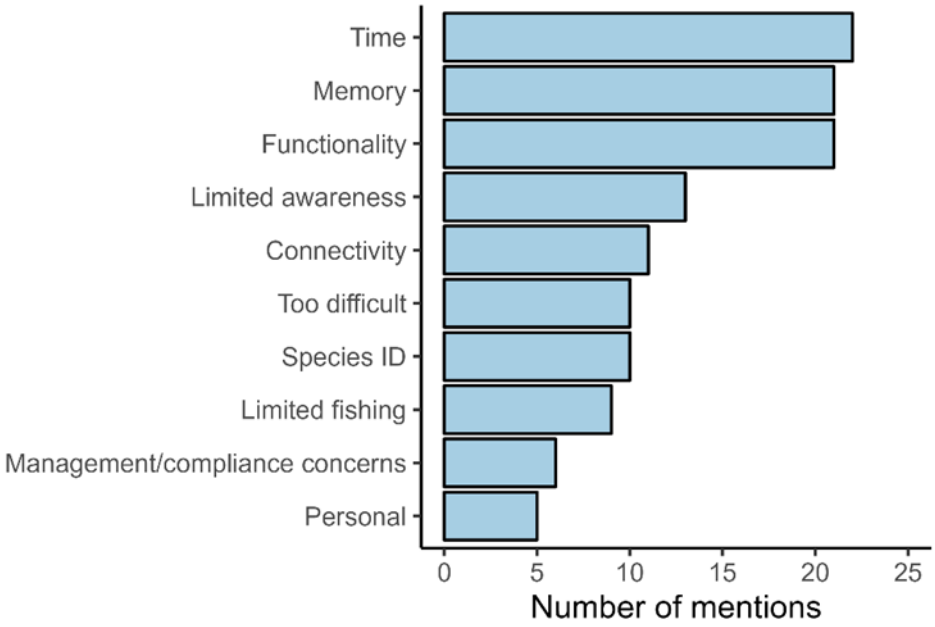

Figure 5.8 The top ten reasons for why the survey was difficult to participate in (number of mentions).

The primary motivation for participants to provide data to the app was accessing information on rules, regulations, species identification, or closures (Figure 5.9). However, this was not the intended objective of the app-based data collection platform, likely explaining participants' difficulty in recalling their participation (see Figure 5.5A). To improve future app-based data collection, it is recommended to make information about the research easily accessible within the app itself. This would complement external communication strategies (e.g., social media), promoting the research with existing app users who may have downloaded the app for alternative reasons. The second most prevalent motivation for participation in the app-based data collection platform was the willingness to contribute to fishery management and research efforts, indicating the high value recreational fishers place on providing data for scientific knowledge and decision-making. Additionally, participants demonstrated a keen sense of conservation and sustainability, driven by personal responsibility and a desire to contribute to these causes. These findings highlight the potential of promoting stewardship among the fishing community to leverage their enthusiasm and knowledge for research.

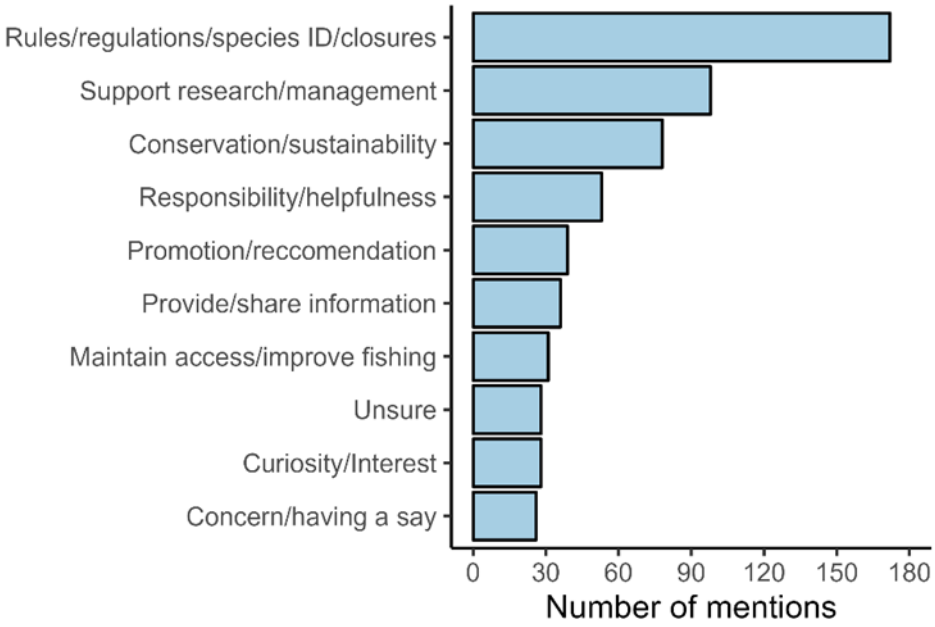

Figure 5.9 The top ten reasons for why participants chose to take part in the survey (number of mentions).

5.2.2 SA Fishing app activity levels

A key method of recruitment to the app-based data collection platform was through contacting existing users of the SA Fishing app. The survey was positioned prominently in multiple places within the app and reminders to participate were issued as in-app pop notifications (requiring the app to be open) and push notifications which were sent to a user's device by a mobile app that appear even when the app is not open.

The data available for app analytics was gathered from Google Firebase analytics, which uses authenticated user data generated during the login process on the SA Fishing App. However, it is important to note that several app updates were released during the data collection period, and a version control issue may have resulted in an under-representation of app-based activity for approximately 88 days (from 3/9/21 to 29/11/21).

Between 1 March 2021 and 14 December 2022, the SA Fishing app had a considerable user base, with 35,000 unique users participating in 112,000 active sessions, demonstrating an elevated level of user engagement (Figure 5.10). The 22,926 initial app openings by 22,104 unique users during this period reflect strong user engagement with the app, but a relatively

low participation rate (7%) relative to the 297,243 recreational fishers participating during the State-wide survey period. However, the low open rate (39%) of the 13,962 push notifications sent during the same period suggests that some users may have either disabled push notifications or were not interested in the content of the notifications. It is important to note that these usage statistics may not reflect the experiences of all app users, as the results of the wash-up survey showed that most participants had downloaded the app for the purpose of learning about fishing regulations, and not specifically for the survey or to receive push notifications. Therefore, while the app appears to have a strong user base, the level of engagement with push notifications may vary among different user groups.

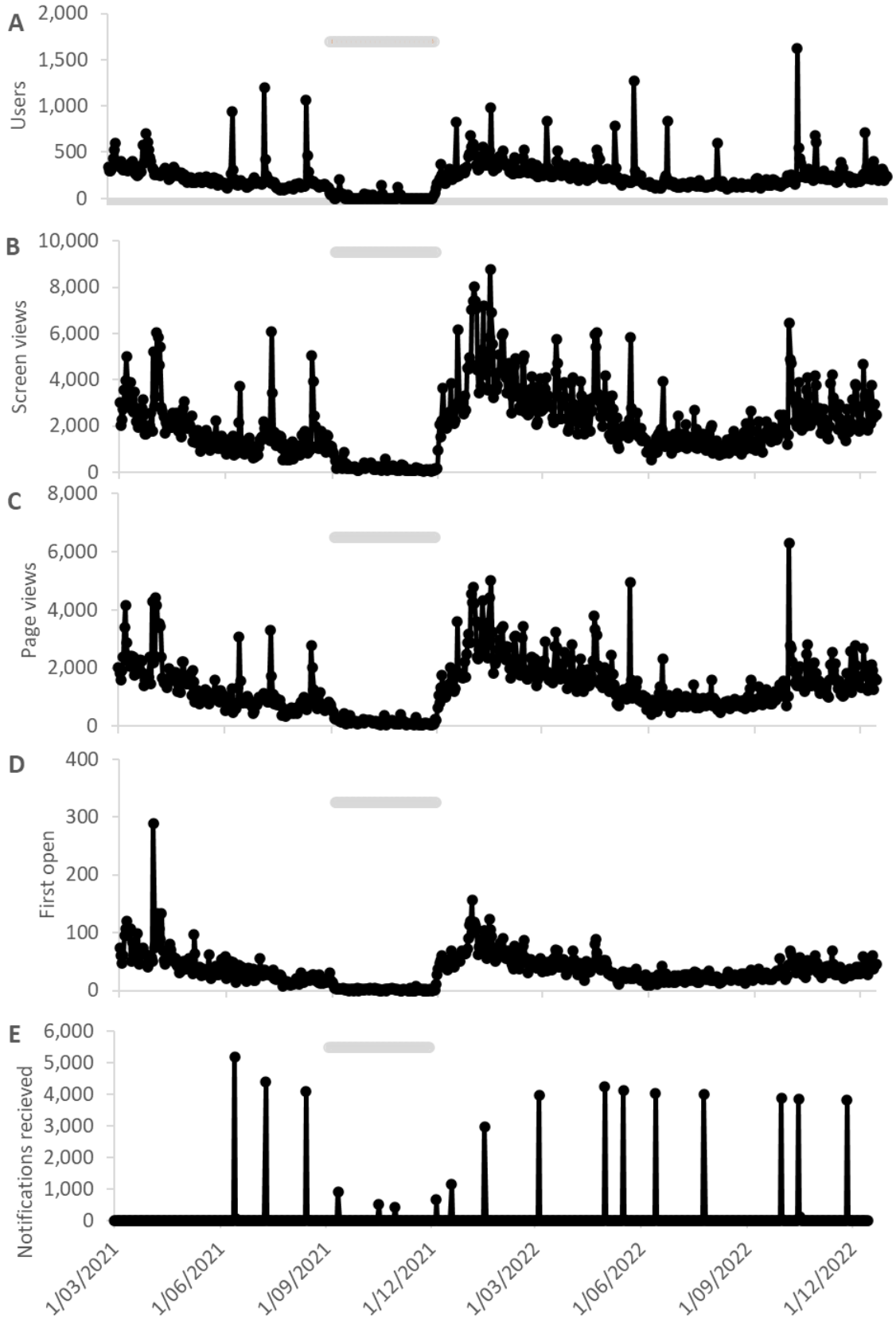

Figure 5.10 Google Firebase analytics showing the daily number of (1) users, (B) screen views, (C) page views, (D) first opens, (E) notifications received and, (F) notifications opened. Grey line denotes period where a version control issue may have resulted in an under-representation of app-based activity (3/9/21 to 29/11/21).

During the survey period, push notifications were sent out to app-users on 18 occasions (Table 5.1). Notifications were categorised as either general information (e.g., fishery closures, invasive species, representation on advisory councils), or relating specifically to participating in app-based data collection. On dates where notifications were sent, there was a clear pattern of increased activity on the app and in terms of survey submissions. The highest number of app-based submissions were generally observed on dates where push notifications were sent, with a maximum of 77 submissions received following the push notification on the 16 January 2022. Notably, push notifications relating to general information, also resulted in a substantial number of submissions, for example on 11 September 2021 a push notification was issued calling for nominations in a recreational fishing advisory committee. On the same day, 44 submissions to the app were received, the fourth highest day during the data collection period. This illustrates that while participants were not drawn to the app specifically to undertake the survey, general messaging was still a useful strategy to engage users in the survey.

Table 5.1 Summary of push notifications by theme (i.e., general information or survey promotion), date sent, number sent and opened, and resulting number of survey submissions on the corresponding date (ranked from highest to lowest by number during the survey period)

Notification Theme	**Date Sent**	**Sent**	**Opened (%)**	**Submissions (rank)**
General information	16/10/2021	11,337	83 (1%)	31 (10th)
General information	30/10/2021	10,588	94 (1%)	10 (26th)
Survey promotion	13/6/2021	14,244	625 (4%)	31 (9th)
Survey promotion	10/7/2021	14,299	483 (3%)	46 (3rd)
Survey promotion	14/8/2021	14,945	566 (4%)	55 (2nd)
General information	11/9/2021	15,304	117 (1%)	44 (4th)
Survey promotion	5/12/2021	10,927	160 (1%)	23 (18th)
General information	18/12/2021	11,952	521 (4%)	20 (22nd)
Survey promotion	16/1/2022	15,707	415 (3%)	77 (1st)
Survey promotion	4/3/2022	19,190	566 (3%)	42 (5th)
Survey promotion	30/4/2022	22,028	532 (3%)	29 (13th)
General information	16/5/2022	22,429	1,142 (5%)	12 (25th)
Survey promotion	13/6/2022	23,078	594 (2%)	31 (9th)
Survey promotion	25/7/2022	24,034	412 (2%)	37 (6th)
General information	30/9/2022	25,098	1,445 (6%)	24 (16th)
Survey promotion	15/10/2022	24,381	567 (2%)	31 (12th)
Survey promotion	26/11/2022	25,978	426 (2%)	5 (28th)

5.2.3 User retention within the app-based data collection platform

The median retention time on the app-based data collection platform stood at 250 days, signifying that half of the participants stayed engaged with the survey for approximately 8 months or more. However, the average retention time was notably lower, recorded at 47 days (± 2 days, SE). The observed maximum retention time reached 649 days, illustrating prolonged user engagement for over a year and a half. This distribution skew (refer to Appendix 5.7 for histogram) indicates that while a portion of participants disengaged relatively quickly, a smaller subset exhibited sustained engagement. Notably, the maximum retention time significantly exceeded the average, indicating the presence of highly engaged or motivated participants contributing to the longer tail of the distribution. The right-censoring of data, where participants not experiencing the dropout event by the observation period's end were treated as censored observations, likely contributed to this skew towards longer retention times. However, it is essential to note that the true maximum retention time for these censored participants remains unknown, potentially extending even further beyond the observed maximum of 649 days.

Survival analysis also revealed that the probability of retention, representing the likelihood of users remaining engaged at any given point, declined over time (Figure 5.11). At 30 days, the probability of retention was 73%, indicating that approximately three-quarters of users remained engaged after one month. However, this probability decreased to 50% at 250 days, indicating that about half of the users remained engaged after eight months. At 365 days, the probability of retention was 34% (95% CI: 30%, 39%), meaning that approximately one-third of users remained engaged after a year. By 500 days, the probability of retention was only 11%, suggesting few users remained engaged beyond this point.

To identify the factors influencing retention, we employed a Cox proportional hazards model (Cox 1972), incorporating variables such as stratum, age, sex, avidity, education, and country of birth. This model satisfied the proportional hazards assumptions tests, suggesting that hazard ratios remained consistent over time (see Appendix 5.7). Country of birth was a significant factor in the model (Table 5.2), with a hazard ratio of 0.823 ($p = 0.047$), indicating that participants born overseas exhibited a higher likelihood of sustained engagement in the survey compared to their Australian-born counterparts. This suggests that overseas-born individuals may possess unique characteristics, experiences, or cultural factors that contribute to their continued participation and retention in the app-based data collection platform. Our investigation into interaction effects related to country of birth revealed that the relationship between retention rates and variables such as sex is dependent on the country of birth. The interaction term for sex was significant ($p = 0.05$), indicating that the effect of sex on retention varies by country of birth. However, it is important to note that the inclusion of these interaction terms collectively introduced concerns regarding the proportional hazards assumption (see Appendix 5.7). This potential violation suggests that the hazard ratios may not remain constant over time for specific combinations of variables. Therefore, caution should be exercised when interpreting the results of the model with interaction terms.

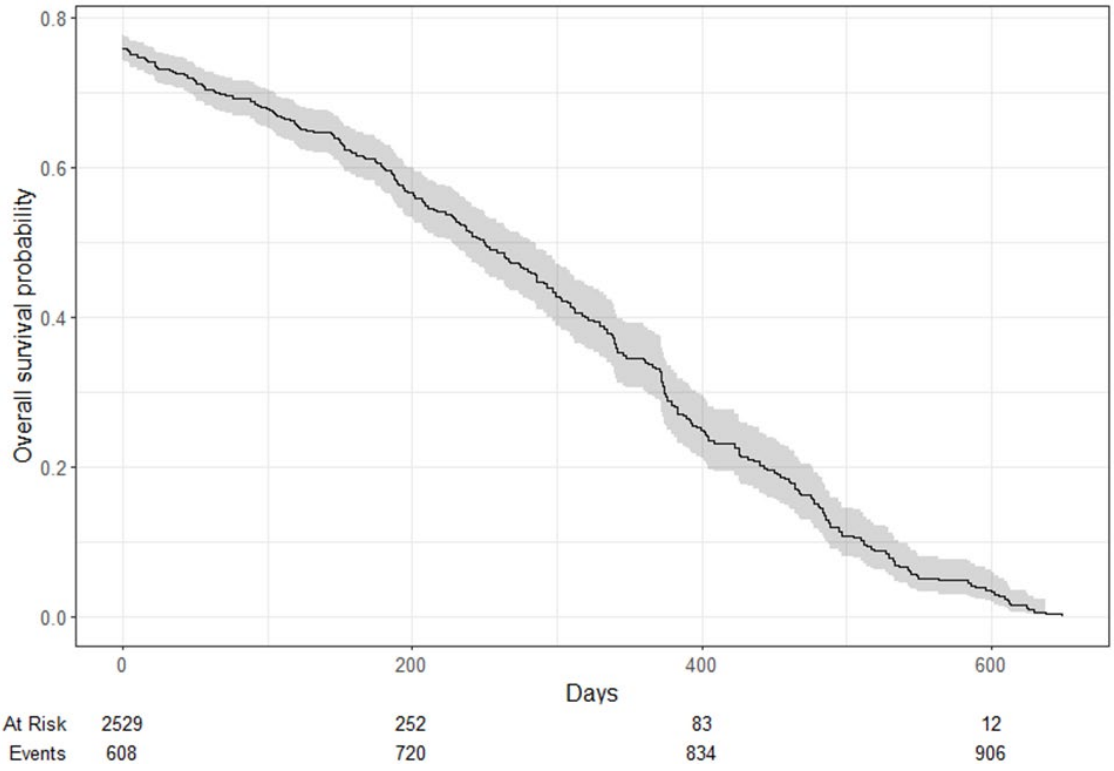

Figure 5.11 The probability of user retention in the app-based data collection platform as a function of time. The accompanying risk table indicates the number of individuals at risk and the number of events (i.e., disengagement from the survey) at each time point.

Table 5.2 Cox proportional hazards regression coefficients for potential predictors of retention in the app-based data collection platform. Hazard ratios (HR) and 85% confidence intervals (CIs) are shown for age, sex, avidity, stratum, country and education along with the corresponding p-values and coefficients. * p< 0.05

Variable	**HR (CI 95%)**	**P-value**	**Co-efficient**
Age	0.999 (0.962-1.04)	0.948	-0.001
Sex	1.219 (0.945-1.564)	0.121	0.198
Avidity	1.003 (0.970-1.038)	0.845	0.003
Stratum	0.993 (0.963-1.023)	0.634	-0.007
Country	0.823 (0.680-0.997)	0.047*	-0.195
Education	0.999 (0.931-1.07)	0.983	-0.001

The complexity of factors influencing user retention is underscored by these findings, highlighting the need for further exploration. Subgroup analyses and qualitative research methods can offer deeper insights into these interactions. Understanding the intricate relationships between these variables and retention rates has the potential to guide the development of targeted interventions and strategies to enhance user engagement and retention in the app-based data collection platform. Tailoring approaches to specific demographic segments or cultural contexts may optimise user experiences and increase the likelihood of sustained participation. Future research could focus on exploring specific cultural

or social factors associated with being born overseas, which contribute to increased engagement and retention in the survey.

While the other predictors (age, sex, avidity, stratum, and education) did not reach statistical significance, comparing their hazard ratios provides valuable insights. Males had a slightly lower hazard of dropping out compared to females, as indicated by the hazard ratio of 1.219 for sex. Avidity, stratum, country, and education exhibited hazard ratios close to 1, implying minimal deviations from the average hazard rate for these variables. It is important to note that the lack of statistical significance does not necessarily negate the potential influence of these predictors on user retention.

This study has provided valuable insights into user retention in the app-based data collection platform. However, it is important to acknowledge the limitations related to the sample size. The dataset had a moderate sample size, which may have constrained the ability to detect smaller yet meaningful effects of certain variables. To address this limitation, future research should prioritise increasing the sample size to improve the accuracy and precision of estimates. With a larger sample, a more comprehensive exploration of variable interactions can be conducted, potentially revealing relationships that may have been missed in the current analysis. Additionally, expanding the study to include a more diverse population, and thus more representative sample, would contribute to a better understanding of user retention across demographic groups. By including participants from various backgrounds, subgroup analyses could be performed to examine the effects of predictor variables on retention within different demographic segments. This approach would provide insights into factors influencing user engagement and retention among population subgroups. Furthermore, considering the temporal aspect of the data is crucial. While this analysis focused on the initial period of the survey, it is important to investigate the long-term retention patterns as well. Examining retention rates over an extended period would provide a more comprehensive understanding of the factors that contribute to sustained engagement within the app-based data collection platform. Addressing these considerations in future research would strengthen our understanding of user retention and enable the development of more targeted strategies to enhance engagement and improve the overall success of app-based data collection.

5.2.4 Feedback on data quality submitted via the app-based data collection platform

When reflecting on how they used the app-based data collection platform to report their fishing activity, most wash-up participants (87%) indicated that they did not report their fishing activity every time they went fishing, with just 11% indicating they reported every time and 2% were unsure (Figure 5.12A). This suggests inconsistent reporting behaviour among app-based participants, with the most common reasons for not reporting including forgetting to do so, finding the data process too difficult, not having enough time, and losing interest (Figure 5.12B). This was further emphasised when comparing the number of fishing events reported by app-based participants compared to fishers reported avidity level (based on the previous 12-months activity, Figure 5.13). During the State-wide survey period (i.e. 1 March 2021 to 28 February 2022), the average number of events reported by app users ranged from 1.1 (± 0.1 SE) for those who fished zero days per year in the previous 12-months, up to only 1.6 (± 0.1 SE) for those who fished 20 or more days in the previous 12-months. This contrasts with the State-wide survey, where fishers were assumed to report all fishing activity undertaken, which demonstrated a higher number of fishing events across all avidity categories, with a proportional increase observed relative to increased avidity. The average number of events reported by State-wide survey participants ranged from 3.7 (± 0.3 SE) for those who fished zero days in the previous 12-months, up to 22.1 (± 2.4 SE) for those who fished 20 or more days in the previous 12-months. This is an important consideration when attempting to expand

app-based data as avidity can be directly related to the number of events each fisher is expected to report.

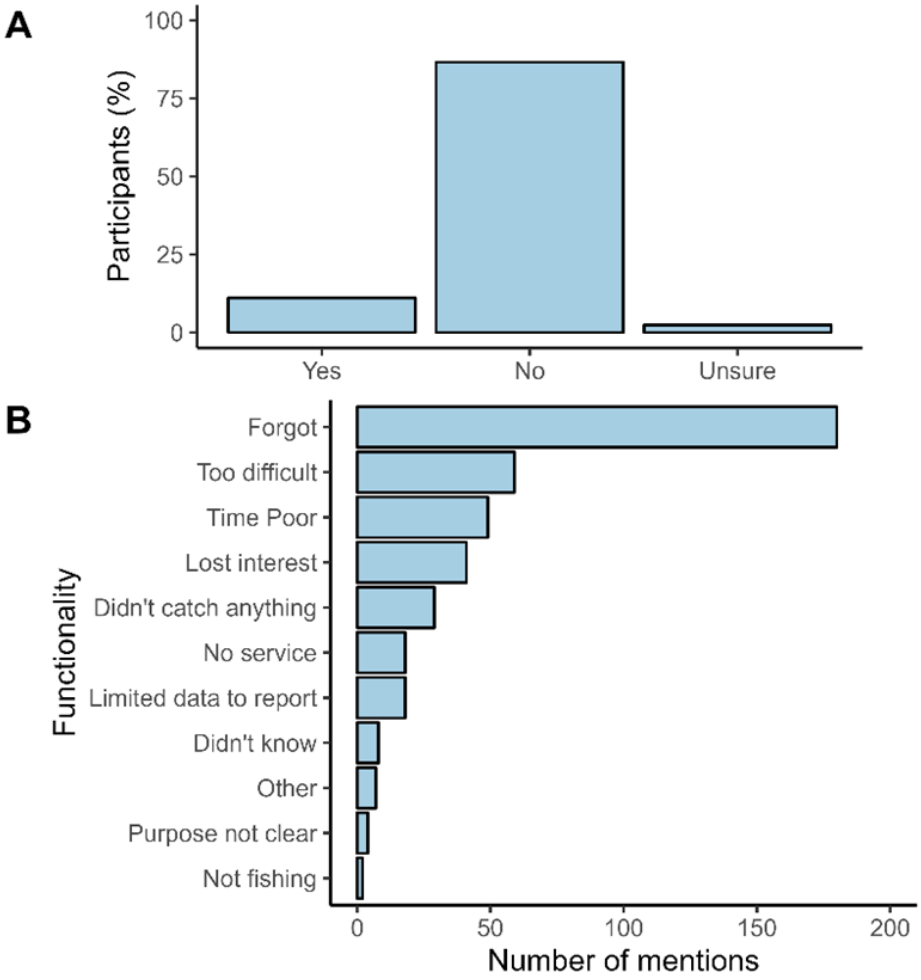

Figure 5.12 The percentage of wash-up participants who (A) reported their fishing activity each time they went fishing, and (B) reasons that fishing activity was not always reported (number of mentions).

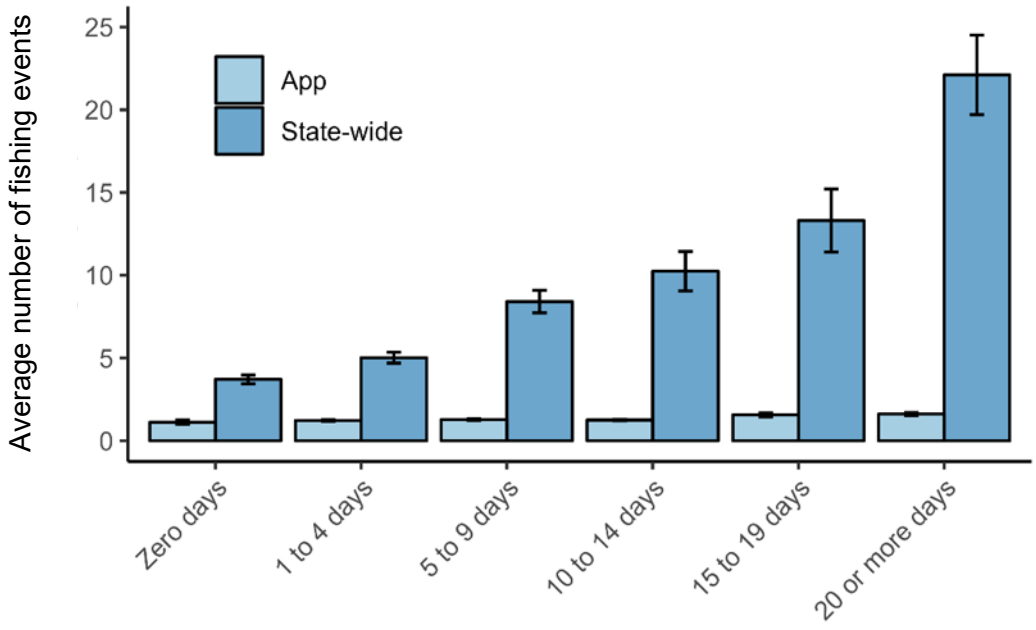

Figure 5.13 The average number of fishing events (± standard error, SE) submitted by app-users (and participants in the State-wide survey from 1 March 2021 to 28 February 2022.

Most participants (78%) in the wash-up survey also indicated that they never logged any fishing events where they did not catch any fish (Figure 5.14A). A further 11% sometimes logged non-catch events, while 9% always logged non-catch events and 2% were unsure. There were a further 37 participants who indicated that they always catch fish, therefore, did not need to input any non-catch events. The main reasons listed for not entering non-catch events were that they did not know this was a requirement, forgot to enter data, lost interest or were time poor (Figure 5.14B). Most participants (59%) indicated that they reported all species kept, with 41% only reporting certain categories of species such as only kept (22%) or only what was targeted (7%) (Figure 5.15).

The findings relating to data quality, highlight the need to improve app design by optimising the survey interface. To address reasons for losing interest or forgetting to submit data, there may be a need to increase the frequency of reminders, incentivise participation or incorporate interactive features to enhance experience. As participants indicated they were time poor, catering reminders to fit their schedule (e.g., weekly or monthly) could make data entry more flexible. Data quality would also be increased by clarifying the purpose of the survey and the benefits to participants to motivate more regular reporting. In particular, many participants indicated that they did not report catch unless it was for Snapper, indicating that there was confusion about the purpose of the app-based data collection platform, versus the app's functionality to complete mandatory reporting of Snapper catch. Addressing these barriers to participation would enhance data accuracy and provide a more complete understanding of participants' fishing patterns. Moreover, as data expansion efforts are considered, it is important to account for data quality in this non-probabilistic sampling. Adjustments will likely be required to account for missing data to ensure that the expanded data can be more representative and dependable for making inferences about the larger population.

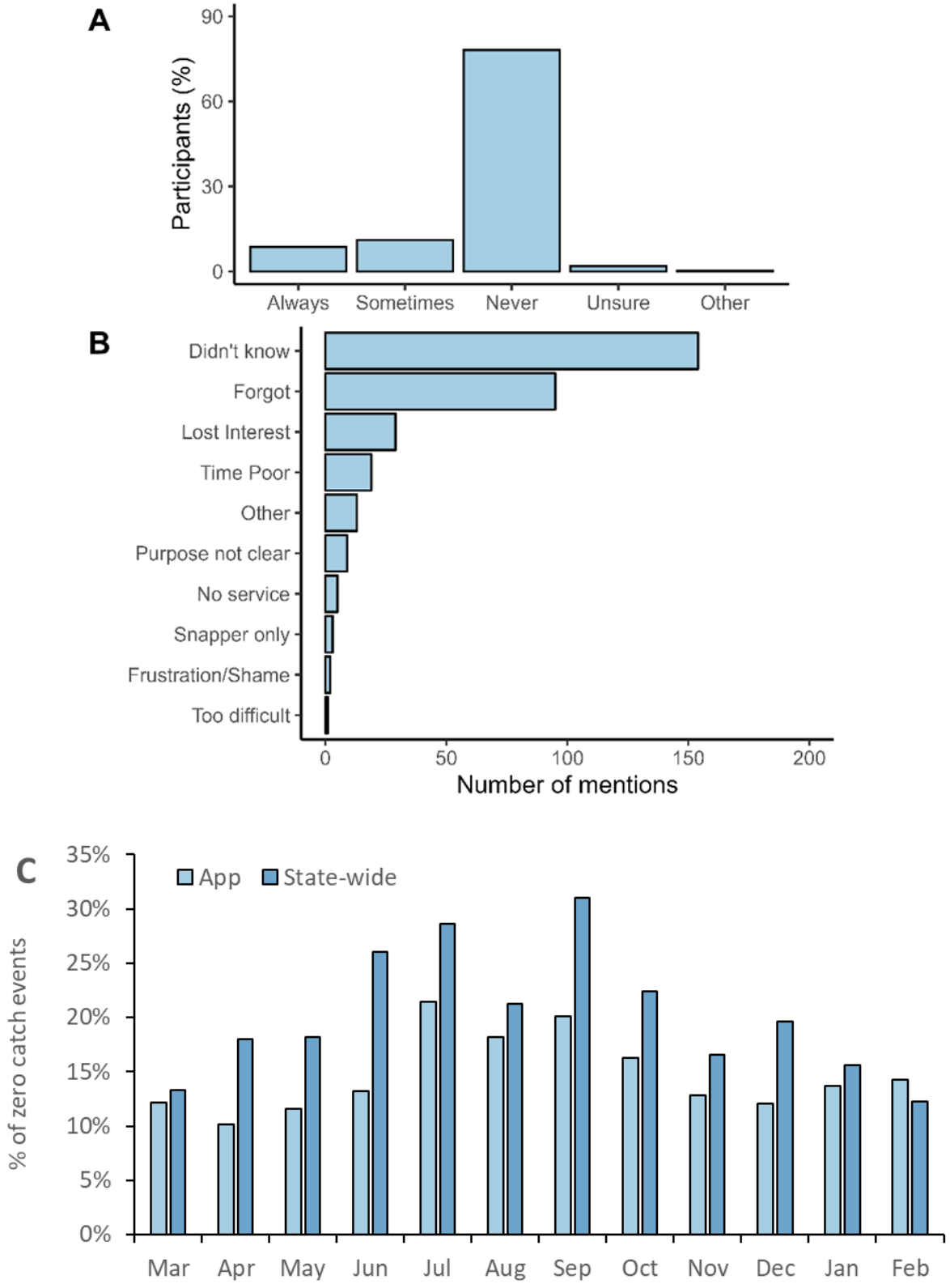

Figure 5.14 The percentage of wash-up participants who (A) logged fishing events on the app if they did not catch any fish, and (B) reasons that participants did not log days in the app when fish were not caught (number of mentions) (C) monthly comparison of zero catch events from the app and State-wide survey.

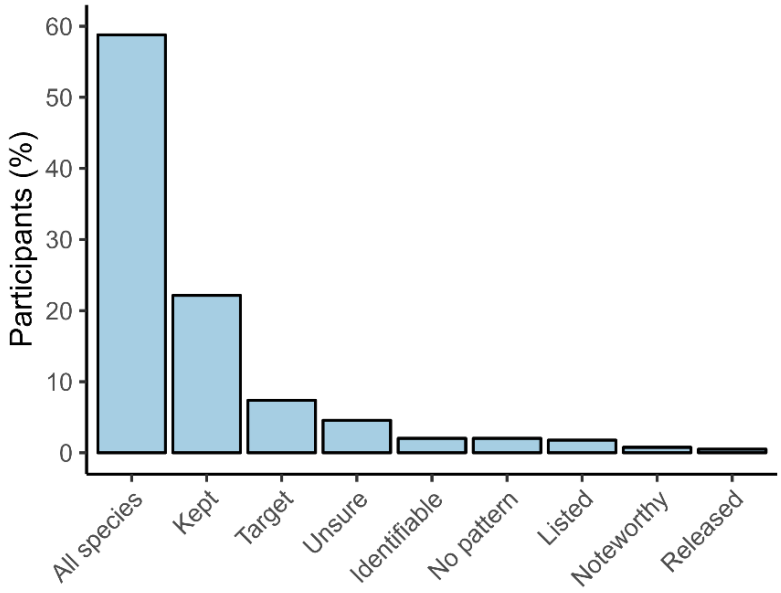

Figure 5.15 The percentage of wash-up participants who reported across the different categories of species. Noting that 'kept' would also relate to fish that are not prohibited to be released (e.g., Carp).

5.3 App-based participation

5.3.1 Data validation

During the data collection period (i.e., 1 March 2021 to 14 December 2022), 2,774 unique devices consented to participate in the survey, with a total of 4,356 fishing events submitted (Table 5.3). A further 528 devices chose not to participate in the survey (582 submissions, noting that users could decline to participate on more than one occasion). A total of 1,559 participants reported 2,249 in scope fishing events. Data were considered to be 'in scope' if complete user profiling data was available (i.e., avidity, gender, age, residential location, country of birth, education), residential location was reported as South Australia, data was within the State-wide survey period (i.e., 1 March 2021 to 28 February 2022), the reported fishing date occurred prior to the date of data submission fishing activity was reported to have occurred in South Australia, and information was reported on group size (to inform total catch and effort estimates) (Figure 5.16). Of the devices consenting to participate, 1,782 (64%) provided either a phone number, email address or both. Based on this information, a low number of users (4% overall, 1% in scope) were identified as participating in the survey multiple times using different devices. No instances of multiple users participating using the same device were identified.

Despite the large amount of missing data for individual app-based participants (see Figure 5.13), the number of participants and fishing events in the app- and State-wide surveys was relatively similar (Table 5.3). This highlights that while the app-based survey was able to attract a similar number of participants, it was hampered by low levels of reporting which were emphasised by the large number of avid fishers who reported a low number of days fished.

Table 5.3 Summary of participation in the app-based and State-wide surveys. App-based data were considered to be in scope if residential location was reported as South Australia, data was within the State-wide survey period (i.e., 1 March 2021 to 28 February 2022), the reported fishing event occurred prior to the date the survey was submitted, fishing activity was reported to have occurred in South Australia, and information was reported on group size. Note: app-based participants were sampled by device ID, rather than household, therefore, devices or individuals may have belonged to multiple households. NA = not available.

Sample	Parameter	Devices	Households	Individuals	Fishing events
App	Overall	2,774	NA	2,713	4,356
	In scope	1,580	NA	1,559	2,249
State-wide (diary)	All	NA	1,019	2,751	5,551

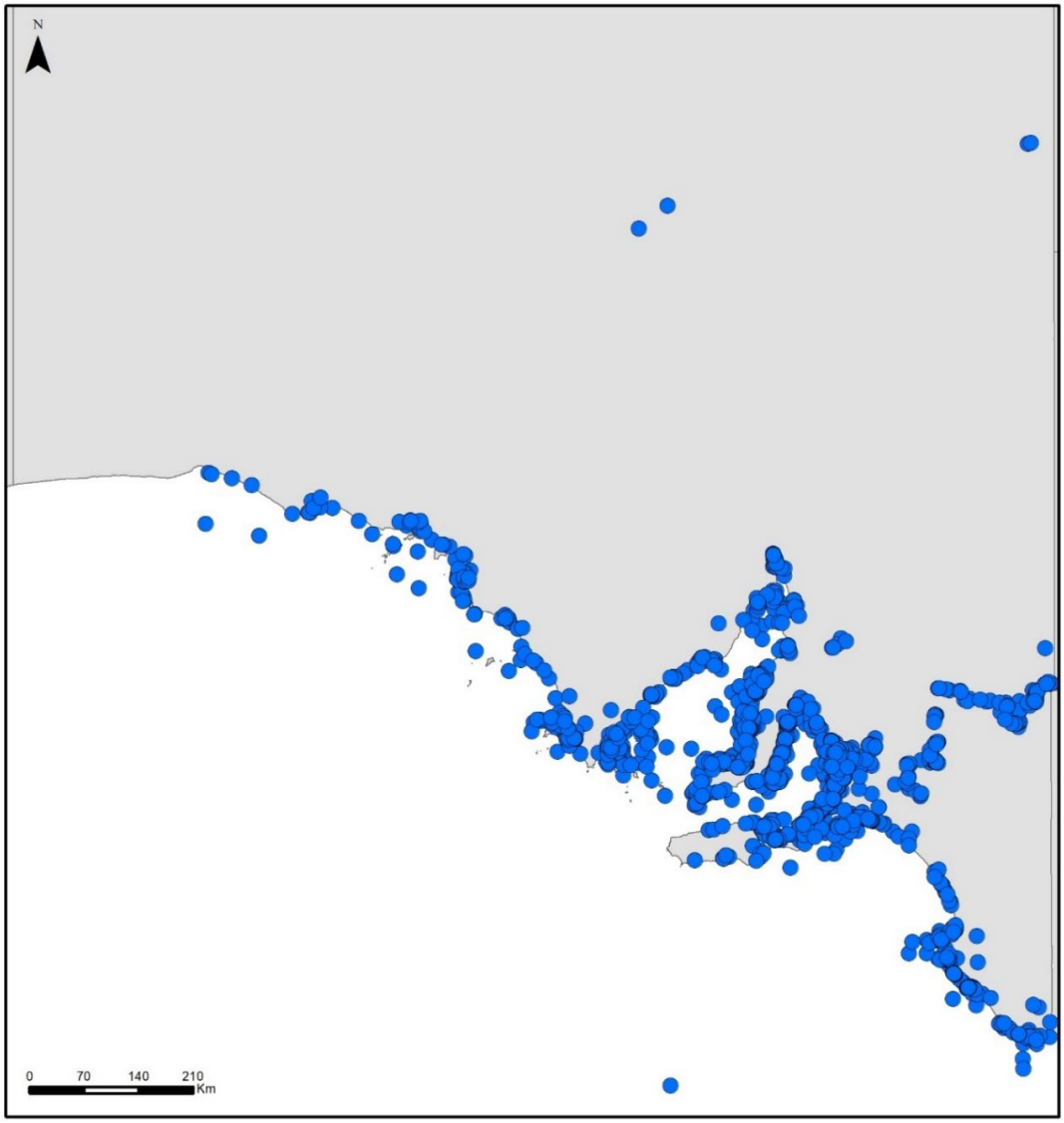

Figure 5.16 In-scope fishing events from the app-based data collection platform (n = 2,249). Data were considered to be in scope if residential location was reported as South Australia, data were within the State-wide survey period (i.e., 1 March 2021 to 28 February 2022), the reported fishing date occurred prior of data submission, fishing activity was reported to have occurred in South Australia, and information was reported on group size.

5.3.2 Reporting

During the State-wide survey period, app-users submitted data on an average of 1.45 (± 0.04 SE) fishing events. Most participants (80%) submitted only a single fishing event, with 12% submitting two events and 8% submitting three or more fishing events. While new users submitted the most data, the number of fishing events by repeat participants increased from 9% in March 2021 up to 47% in September 2021, before stabilising at about 39–46% per month (Figure 5.17). The highest number of fishing events and submissions took place in January 2022, with the lowest number of fishing events and submissions in June and July 2021 (Figure 5.18). A similar trend was observed in the State-wide survey, with the most days fished in December 2021 (13%) and January 2022 (12%).

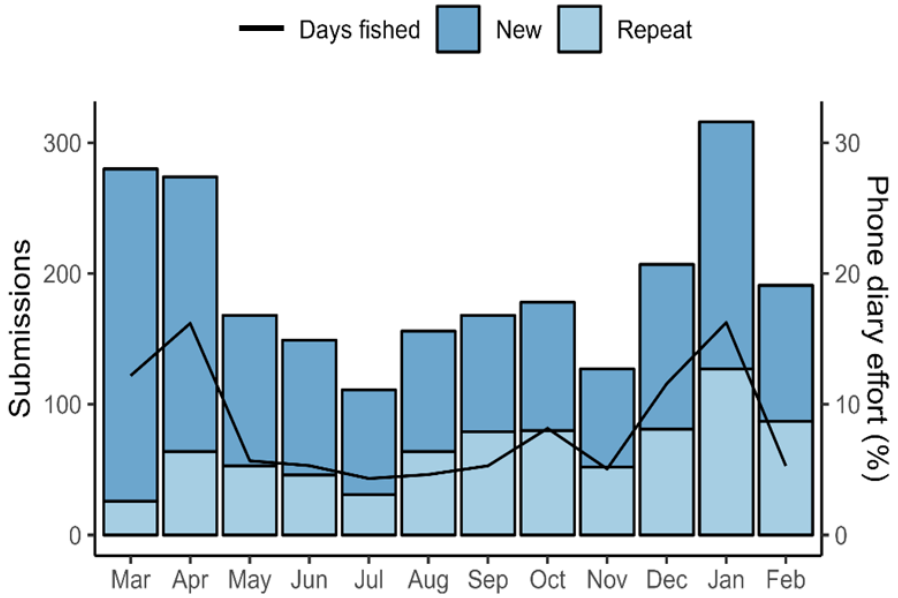

Figure 5.17 The total number of submissions (x axis) as part of the app-based data collection platform per month by new and repeat participants and the fishing effort (y axis) by days fished as a percentage of the total expanded effort estimate from the State-wide survey. Submissions refer to the completion (submission) of the survey, irrespective of the date of fishing.

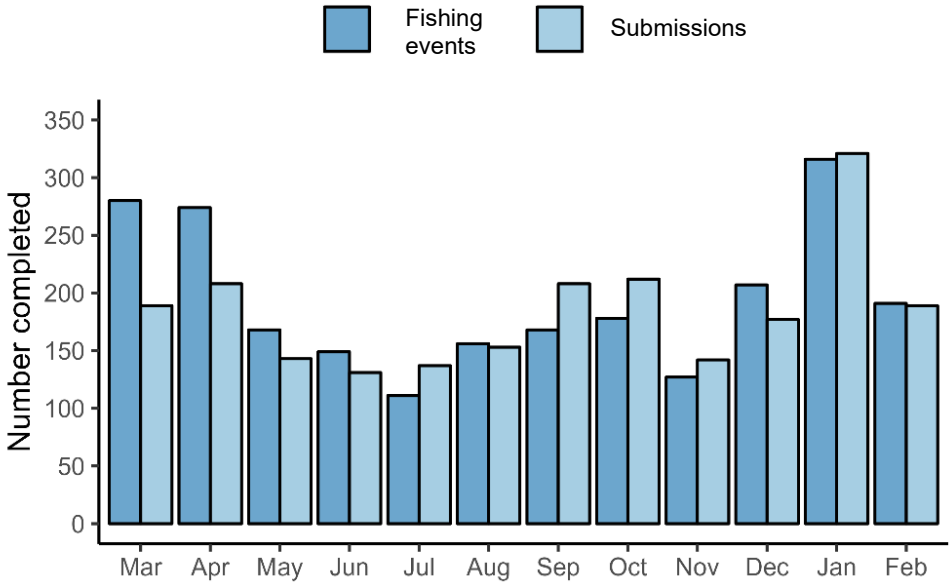

Figure 5.18 The total number of fishing events and submissions per month. Submissions refer to the completion (submission) of the survey, irrespective of the date of fishing.

Overall, app users averaged 32 days (± 3 days) between fishing events and 30 days (± 2 days) between submissions. Most users (61%) made submissions on their fishing activity within nine days of their trip, with 29% of submissions occurring either the day of, or the day after the fishing trip (Figure 5.19). A moderate proportion of submissions were made 10–19 (14%) or 20–99 (18%) days after fishing, while a relatively small number of submissions occurred after 100 or more days (7%). The number of days between subsequent submissions and events generally declined for users with an increasing number of total submissions (Figure 5.20). With each submission, the duration between submissions and events also declined (Figure 5.21). On average, about 90 days passed between the first and second submission or trip, declining to ~40 days between the third and fourth submission or trip. From the fifth submission or trip, the number of days that passed was relatively similar (≤ 25 days). Overall, the proportion of zero catch events was higher for State-wide survey participants (19%) compared to app-users (14%). The largest differences were observed during June and September (Figure 5.22).

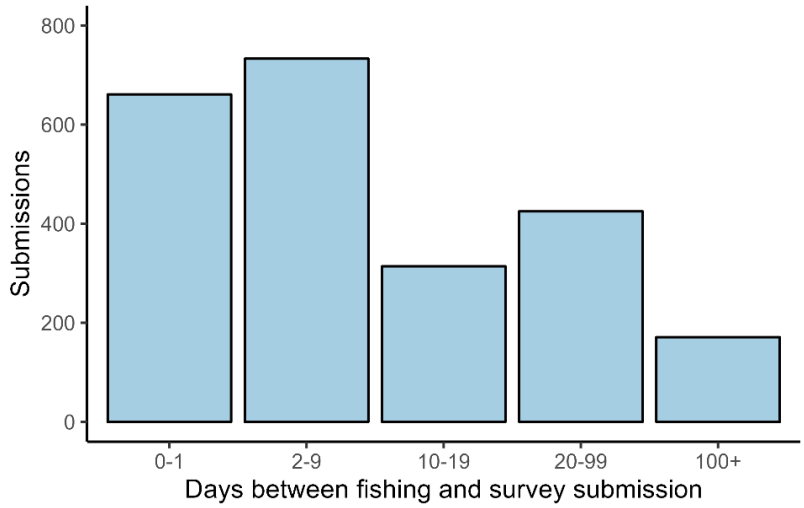

Figure 5.19 The number of days between fishing event and survey submission.

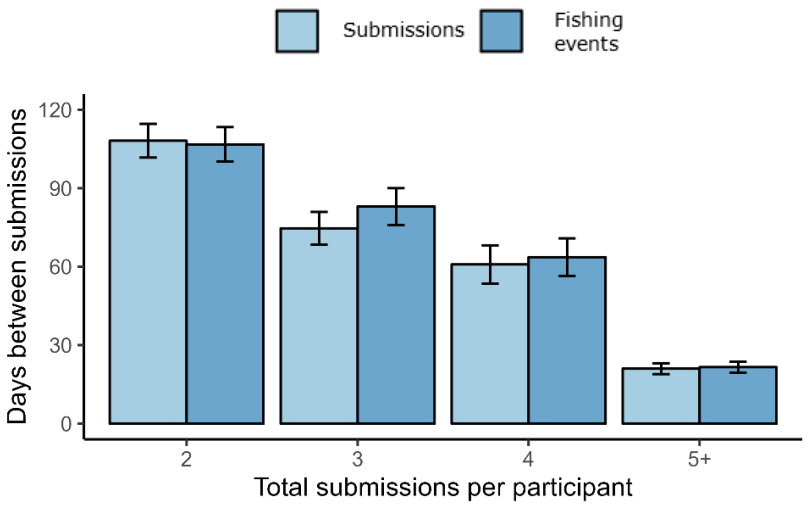

Figure 5.20 The average number of days between survey date (i.e. date of submission) and date of fishing event (i.e. fishing date) for users by total number of submissions. Error bars are standard error.

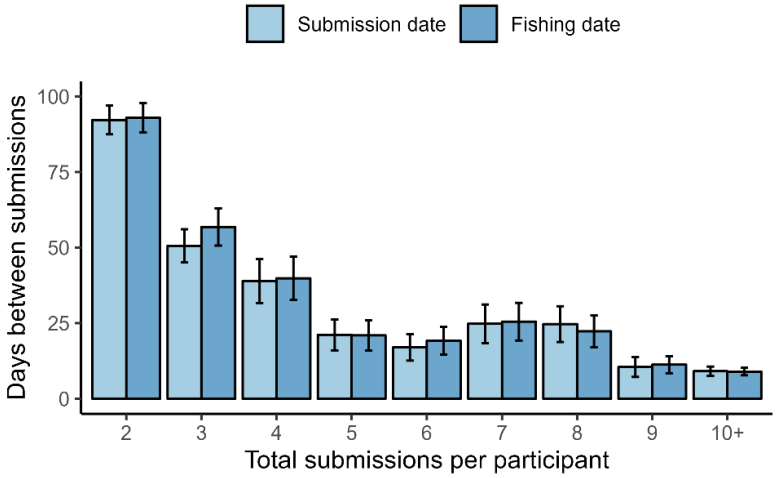

Figure 5.21 The average number of days between submissions for users for each subsequent submission or fishing event. Error bars are standard error.

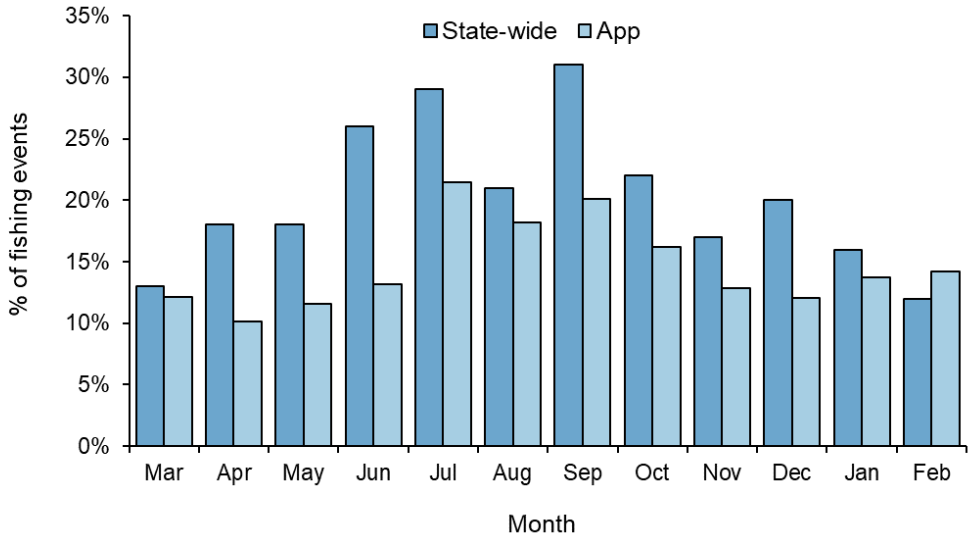

Figure 5.22 The proportion of fishing events by month reported as zero catch for State-wide survey participants and app-users.

5.4 Fisher profiles

5.4.1 Residential stratum

During the State-wide survey period, most South Australian app-based users were from the Greater Adelaide Region (59%), particularly Adelaide-South (19%) and Adelaide-North (17%) (Figure 5.23). Participants from regional South Australia constituted 41% of the total, with the largest proportion from the South-East (19%) and Barossa-Yorke-Mid North (13%). Most regions were relatively well represented by app-based users in comparison to participants in the phone diary phase of the State-wide survey (i.e., participants in the 12-month longitudinal survey). The largest discrepancy was observed in Adelaide-Central and Hills, where the app-based samples showed a 6% lower representation of residents compared to the phone diary

and screening samples. Similarly, Adelaide-North residents were under-represented by 3% in the app compared to the phone diary and screening sample. All other residential locations had similar relative proportions or were over-represented in the app-based samples, relative to the phone diary and the larger screening sample.

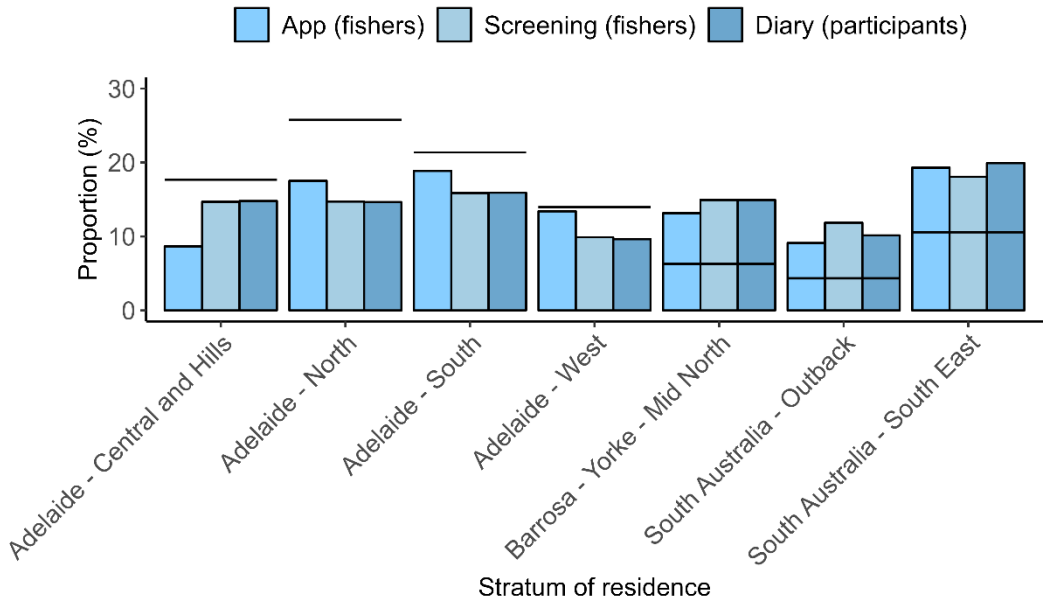

Figure 5.23 The percentage of total survey participants for the app-based (fishers only), screening (fishers only) and diary (intention to fish in next 12 months) surveys by residential location. Black lines represent the proportion of South Australian residents recorded in the 2023 Australian Bureau of Statistics Census.

5.4.2 Age and gender

During the State-wide survey period, 93% of app-based users were male compared to 54% of fishers during the diary period and 65% at screening. The proportion of males and females across the relative age groups was similar in the app- and State-wide surveys. Overall fishers aged under 15 which were not well represented in the app-based samples. This was due to ethical requirements for participants which were outlined in the consent form. Despite this, there were a small number of males who indicated that they were under 15 years of age (1%). Female fishers in the app-based data were mostly aged 30–44 years of age (35%), while males were mostly aged 45–59 years (34%) (Figure 5.24).

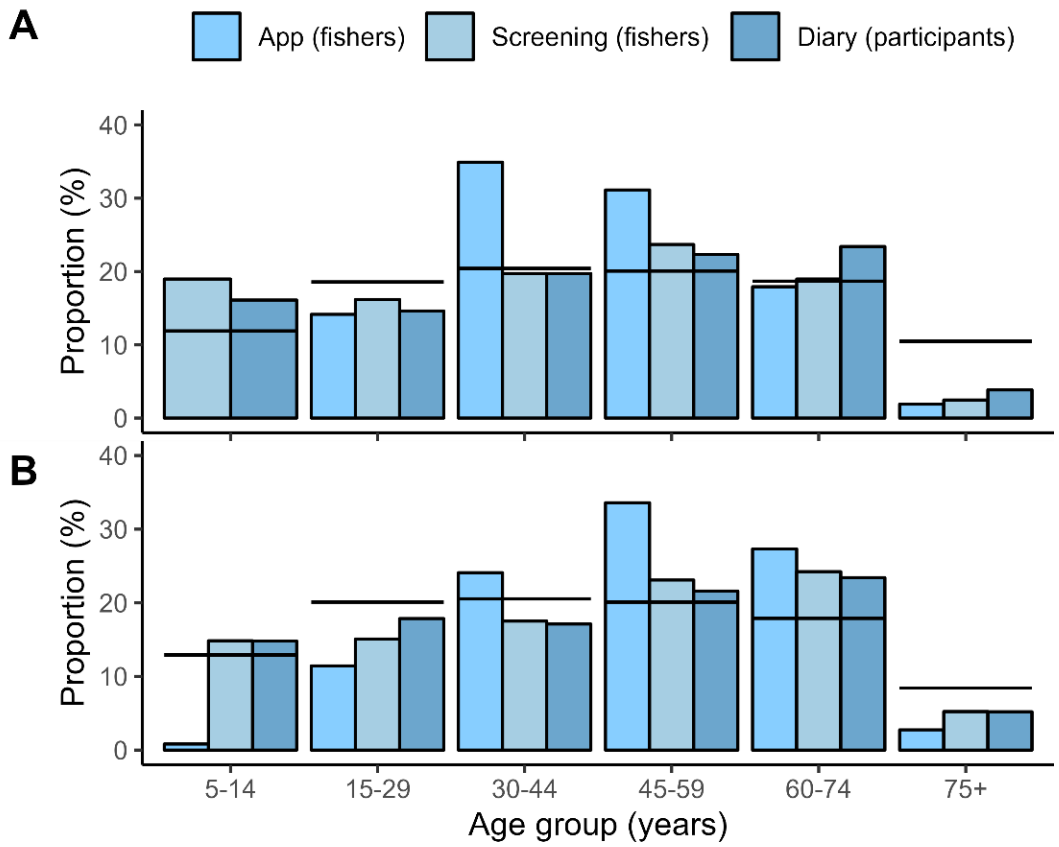

Figure 5.24 The percentage of (A) female and (B) male survey participants for the app-based (fishers only), screening (fishers only) and diary (intention to fish in next 12 months) surveys by age for (A) females and (B) males. Black lines represent the proportion of South Australian residents recorded in the 2023 Australian Bureau of Statistics Census.

5.4.3 Education

Most app-users who participated in the survey had completed school years 10–12, accounting for 64% of the app user base (Figure 5.25). This proportion aligns closely with the screening survey, where an equal percentage of individuals who completed years 10–12 was identified. This suggests that the app-based data collection platform effectively gathered a representative sample of recreational fishers concerning their educational background, particularly at the secondary schooling level. However, disparities emerged when examining higher education levels. While 32% of app users reported post-graduate studies, only 23% were identified in the screening survey. This indicates that the app may have attracted a more educated segment of recreational fishers, possibly reflecting greater interest and engagement among individuals with advanced degrees.

Conversely, the app-based platform recorded a lower proportion of participants who had completed schooling up to year 9 or below, with only 4% falling into this category. In contrast, the screening survey identified a significantly higher proportion of individuals with this level of education, accounting for 22% of the fishers who participated in the screening survey. This discrepancy suggests that the app-based platform may have attracted a relatively smaller number of participants from lower education levels. The proportion of participants among education groups were similar between the screening and diary surveys (Figure 5.25).

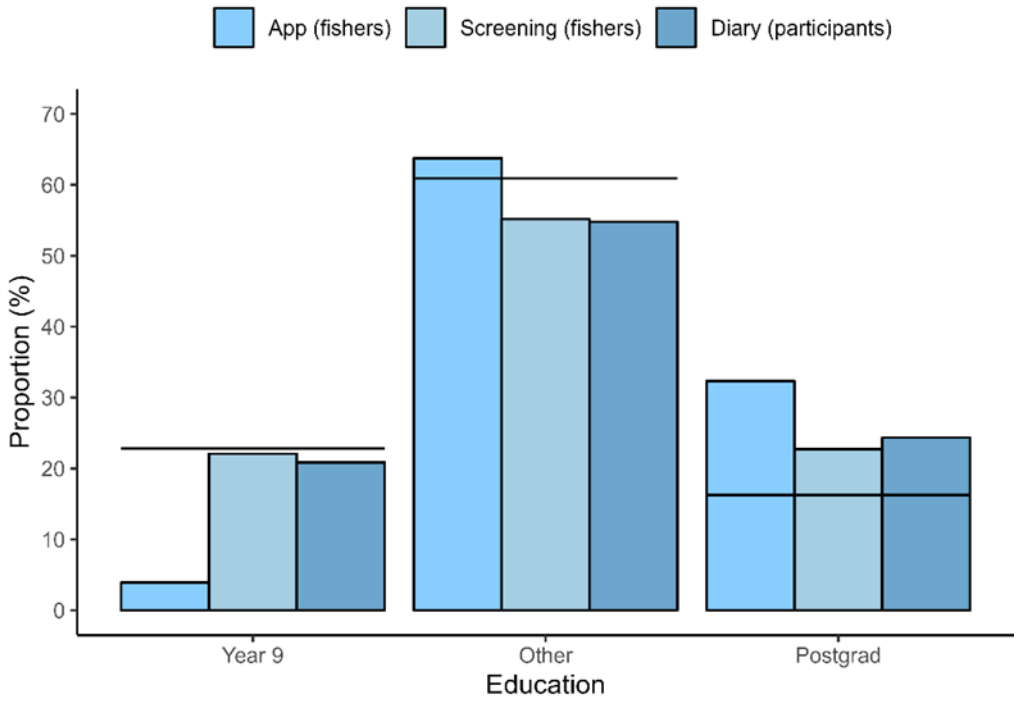

Figure 5.25 The percentage of total survey participants for the app-based (fishers only), screening (fishers only) and diary (intention to fish in next 12 months) surveys by education. Black lines represent the proportion of South Australian residents recorded in the 2023 Australian Bureau of Statistics Census.

5.4.4 Country of birth

For app-based data, most participants were born in Australia, comprising 85% of the total (Figure 5.26A). This closely mirrors the findings from the phone-based screening survey, where 88% of fishers were born in from Australia. Participants who were born in Australia also occur at similar proportions in the diary survey (87%). These results indicate that both survey methods effectively captured a representative sample of participants born in Australia.

When analysing participants born in different continents (outside of Australia), similar patterns emerged between the app-based, screening and diary surveys (Figure 5.26B). Most participants were born in Europe in all three surveys (60–62%), followed by Asia (17–20%) and Africa and Middle East (8–11%), corroborating the effective capture of participants from overseas. However, when compared to data from the Australian Bureau of Statistics (ABS) Census 2023, a higher proportion of participants from Asia was expected, suggesting a bias towards participants from European backgrounds.

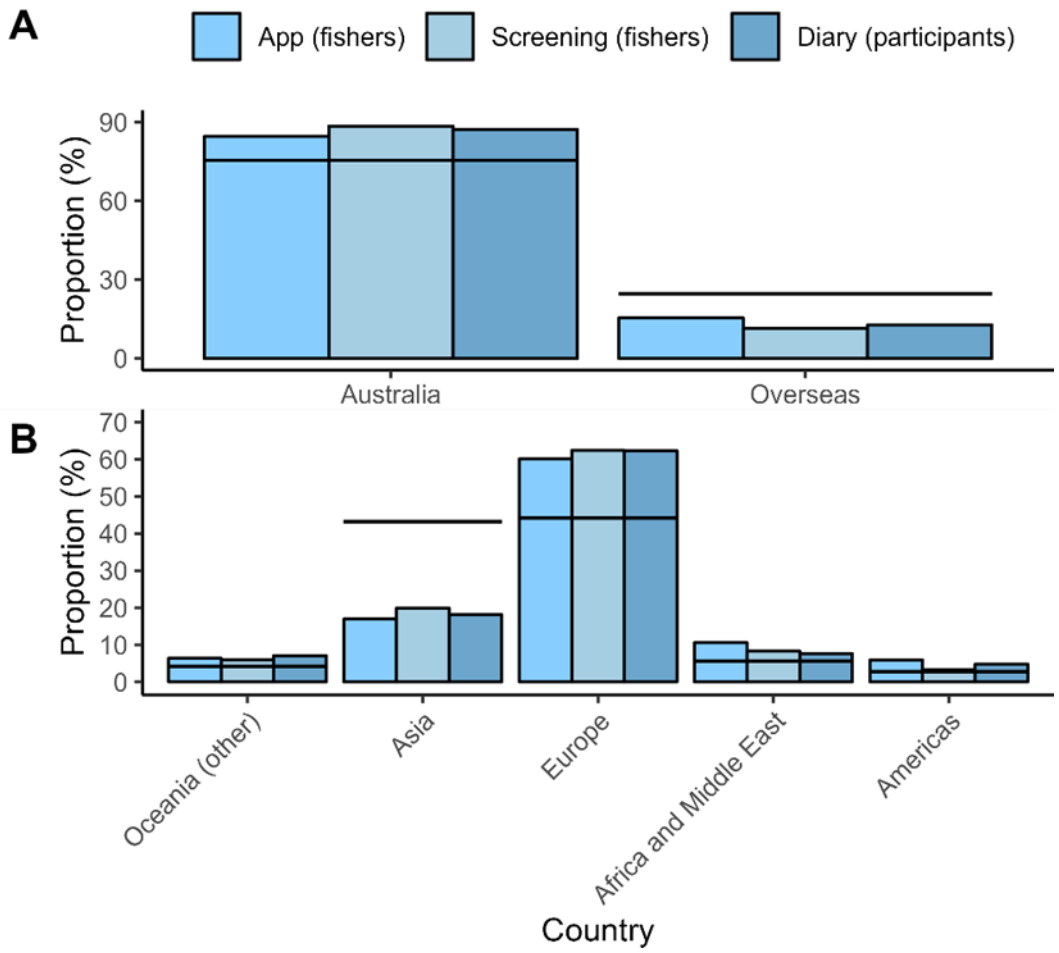

Figure 5.26 The percentage of total survey participants for the app-based (fishers only), screening (fishers only) and diary (intention to fish in next 12 months) surveys by (A) country of birth, grouped as Australian or overseas, and (B) overseas participants by region. Black lines represent the proportion of South Australian residents recorded in the 2023 Australian Bureau of Statistics Census.

5.4.5 Avidity

Most South Australians who participated in the app-based survey reported fishing 20 or more days in the previous 12 months (42%), however, this group was highly over-represented compared to the phone-based screening (13%) and diary surveys (8%) (Figure 5.27). Conversely, those who fished 1 to 4 days were under-represented in the app (12%), compared to the screening (44%) and diary (24%) surveys. There was a similar proportion of participants who fished 5–9 days between the app and diary surveys, while those fishing between 10 and 19 days were generally over-represented in the app. As only fishers were included in the plots of the screening survey (data used in the non-probability estimates), the avidity group of zero days fished is absent in this dataset. On the other hand, participants in the diary survey were selected from their intention to fish during the 12-month longitudinal survey, even when their avidity was zero (Figure 5.27).

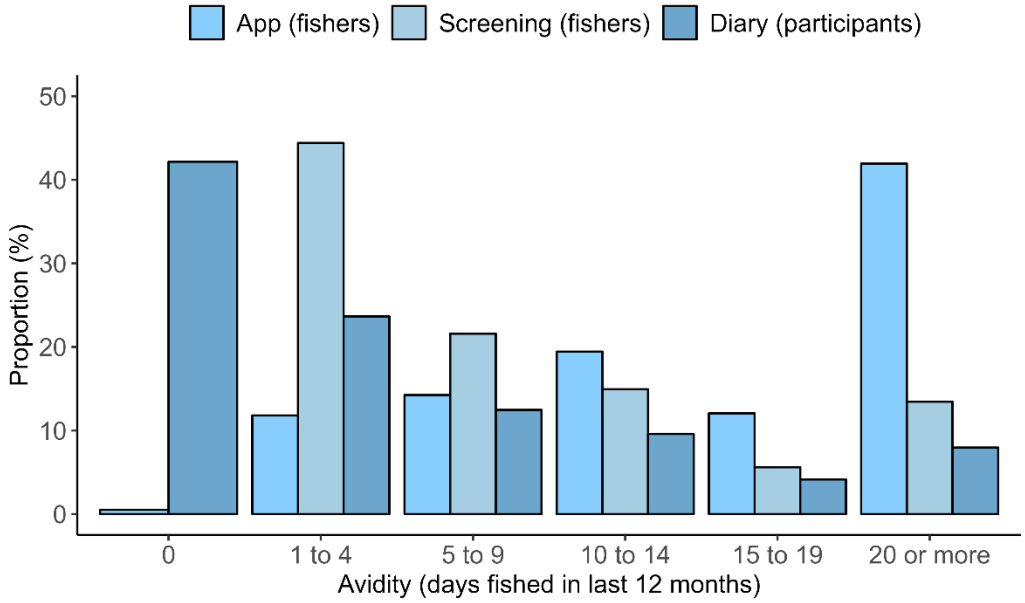

Figure 5.27 The percentage of participant fishers in the app-based, screening and phone diary phases of the State-wide survey by reported avidity (i.e., days fished in the previous 12 months).

5.5 Fishing activity

During the State-wide survey period (1 March 2021 to 28 Feb 2022), phone-diary survey participants reported a diverse range of finfish, crustaceans, molluscs, and other animals, with a total of 96 taxa reported. Overall, 53,137 individual animals were reported as caught, of which 58% (30,902) were kept, and 42% (22,235) were released.

Overall, 26 species from the State-wide phone-based survey had data reported from >30 households (HHS) compared to 27 species from the app-based trial. The app-based data had high levels of reporting relative to the State-wide survey for highly targeted marine species such as Southern Bluefin Tuna (*Thunnus maccoyii*), King George Whiting (*Sillaginodes punctatus*) and Western Australian Salmon (*Arripis truttaceus*), while Blue Mackerel (*Scomber australasicus*), which is predominantly a non-target marine species was also reported more frequently by app-based users compared to the State-wide survey. The State-wide survey had high levels of reporting relative to the app-based data for freshwater species such as Carp (*Cyprinus carpio*), and Golden Perch (*Macquaria ambigua*), as well as common Western Striped Grunter (*Pelates octolineatus*) which is commonly reported as a non-target species.

There were some differences observed in the number of households and users across different fish species across the two sampling platforms (Table 5.4). Some species, such as Blue Mackerel and Southern Bluefin Tuna had nearly twice the number of app-based participants, when compared to the number of households in the phone survey. Conversely, species like Yabby (*Cherax destructor*), Freshwater Shrimp (*Parataya australiensis*) and Cod (marine) (*Gadiformes*), and Carp had less than half the number of app-based users compared to the State-wide survey. Comparing participation between the two surveys, provides insights into the level of interest in reporting data for different fish species, and is likely to be highly linked to how the app-based data collection platform was promoted. For example, the app-based data collection platform was promoted on special interest fishing pages relating to Southern Bluefin Tuna, which may have increased reporting for this species. Furthermore, as app-based participants indicated that they often did not report all species that were caught (see section 5.2.4), the reported catch in the app-based data is likely to be lower across most species when compared to the catch reported in the State-wide survey (which may have more closely matched actual realised catch) .

Table 5.4 Reported number of households (HHS) in the State-wide survey, and app users by species or species group, reported catch (total, harvested and released numbers) and release rates for species with >30 HHS or users. Estimates derived from records involving fewer than 30 HHS (or users) have been highlighted (red) since they may not be representative.

Common name	Species/Group	State-wide	App				
		HHS	Users	Kept	Released	Total	Release rate (%)
Australian Herring	*Arripis georgianus*	238	315	2,178	1,610	3,788	43%
Bight Redfish, Swallowtail	*Centroberyx* spp.	22	37	266	133	333	33%
Black Bream	*Acanthopagrus butcheri*	33	52	41	396	437	91%
Blue Mackerel	*Scomber australasicus*	20	46	200	35	235	15%
Blue Swimmer Crab	*Portunus armatus*	220	241	3,021	3,043	6,064	50%
Blue Weed-Whiting	*Haletta semifasciata*	30	49	54	147	201	73%
Cod	*Gadiformes*	62	17	22	99	123	80%
European Carp	*Cyprinus carpio*	104	46	699	1	700	0%
Flathead	*Platycephalidae*	110	122	153	316	469	67%
Freshwater Shrimp	*Parataya australiensis*	30	7	204	154	358	43%
Freshwater Yabby	*Cherax destructor*	41	7	954	394	1348	29%
Golden Perch	*Macquaria ambigua*	45	35	38	125	163	77%
Gummy Shark	*Mustelus antarcticus*	23	35	47	18	65	28%
King George Whiting	*Sillaginodes punctatus*	303	523	6,950	3,093	10,043	31%
Leatherjacket	*Monacanthidae*	102	161	2,542	541	3083	18%
Port Jackson Shark	*Heterodontus portusjacksoni*	28	37	23	112	135	83%
Red Mullet	*Upeneichthys vlamingii*	73	106	256	278	534	52%
School Whiting	*Sillago sp.*	41	37	223	112	335	33%
Snapper	*Chrysophrys auratus*	58	90	106	576	682	84%
Snook	*Sphyraena novaehollandiae*	54	76	291	107	398	27%
Southern Bluefin Tuna	*Thunnus maccoyii*	12	30	98	65	163	40%
Southern Calamari	*Sepioteuthis australis*	270	422	3,278	298	3,576	8%
Southern Garfish	*Hyporhamphus melanochir*	105	112	1,484	399	1,883	21%
Sweep	*Scorpis* sp.	38	52	156	202	358	56%
Toadfish	*Tetradontidae*	72	65	139	623	762	82%
Trevally	*Pseudocaranx sp*	35	57	218	198	416	48%
Western Australian Salmon	*Arripis truttaceus*	154	263	1,099	1,499	2,598	58%
Western Striped Grunter	*Pelates octolineatus*	71	33	121	358	479	75%
Yelloweye Mullet	*Aldrichetta forsteri*	44	45	199	189	388	49%
Yellowfin Whiting	*Sillago schomburgkii*	51	48	362	191	553	35%

Note- app-based participants were sampled by device ID, rather than household, therefore, users may have belonged to multiple households.

5.6 Fishing motivations, skill and experience

Overall, 87% of participants in the app-based wash-up ranked fishing as eight or more in importance (out of 10) when compared to other hobbies, in comparison to just 40% of participants in the State-wide survey wash-up (Figure 5.28A). In terms of fishing experience, most fishers across both datasets had fished 20 or more years and most spent less than five hours viewing fishing related content each week (Figure 5.28A and C). App participants mostly identified as advanced (50%) and there were a higher proportion of experts (13%) than in the State-wide survey (3%). A higher proportion of State-wide survey participants identified as having intermediate skill or were beginners (Figure 5.28D).

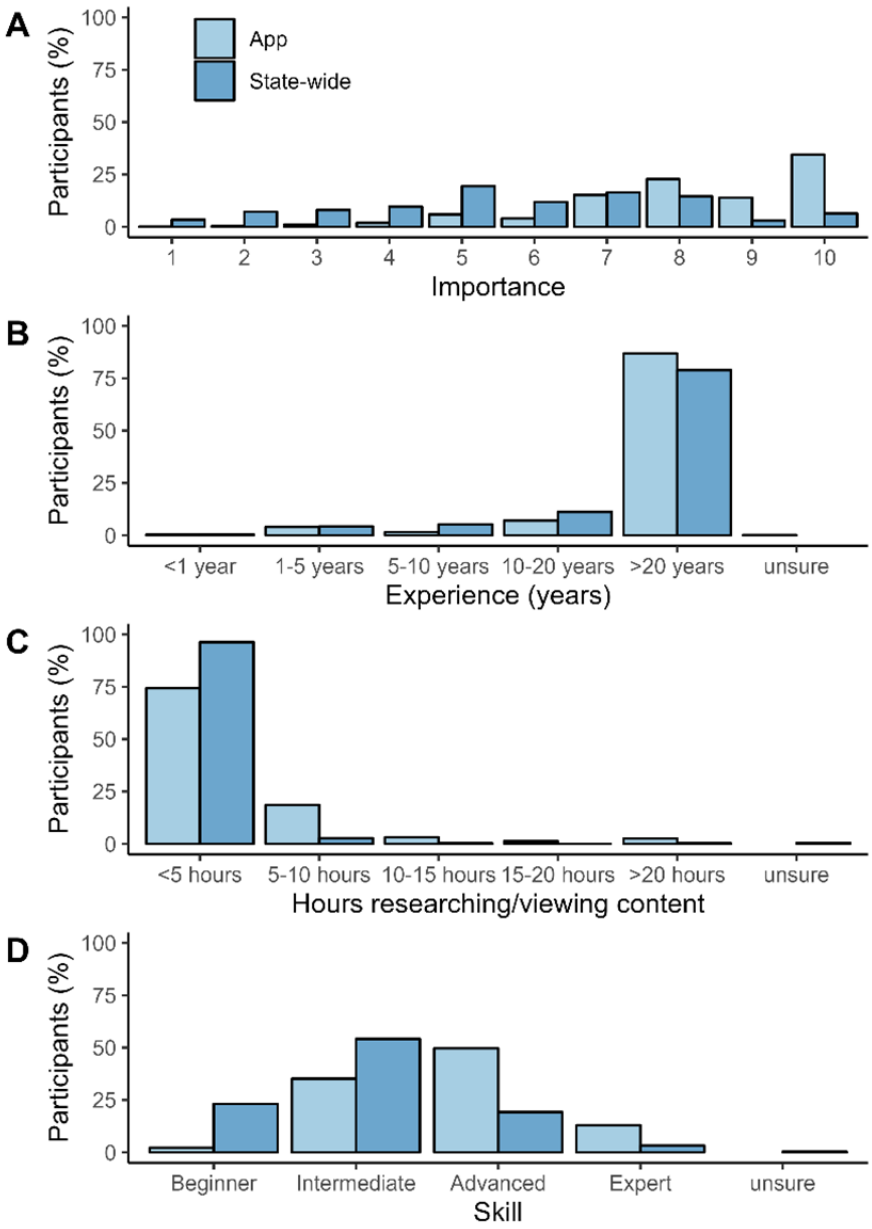

Figure 5.28 The percentage of survey participants for the app-based and State-wide wash-up indicating (A) important participants rank fishing compared to other hobbies (one being least important and ten being most important), (B) how many years participants have been fishing, (C) how many hours per week participants spent viewing fishing related content, and (D) how participants rate their fishing skill.

5.7 Key findings and implications

The key findings and implications from the app-based trial can be summarised as follows:

Key Findings:

- Half of the participants who participated in app-based survey were existing users of the SA Fishing app, indicating pre-existing app usage.
- The app had a significant user base with high engagement.
- Participants primarily downloaded the app to access information on fishing regulations, rather than fishing data.
- Participants could not recall most of the communications strategies used and indicated a preference for limited communication.
- Push notification open rates were low, despite corresponding increases in survey participation and app activity.
- Participants in the app-based data collection platform had an average retention time of 47 days, with declining retention rates over time, with approximately one-third of users remaining engaged after a year, emphasising the importance of sustained engagement strategies.
- A small percentage (4.4%) of users remained engaged for over a year. An average retention time of 47 days and median retention of 250 days indicated skewed participation.
- Participants born overseas showed higher sustained engagement.
- Factors like age, sex, avidity, stratum, and education did not significantly influence retention rates.
- Participants reported lower fishing event numbers compared to the phone diary phase of the State-wide survey, citing reasons like forgetfulness, limited data, and lack of time.
- The app-based platform captured a representative sample from various residential strata but avid fishers were over-represented.
- Targeted promotion strategies are needed to encourage participation and data reporting for specific species but can bias responses to particular species reporting or demographic groups.
- The app-based data collection platform was easy to use but could benefit from improved functionality and information provision to enhance data accuracy.

Implications:

- Use a combination of recruitment methods to ensure a representative sample, considering user preferences and platforms.
- Enhance ease and convenience of reporting to increase participation and improve data accuracy.
- Optimise app design, survey interface, and reminder frequency to address barriers, clarify the survey's purpose, and incentivise regular reporting.
- Use app-based reminders, emails, and push notifications to reach all users effectively.
- Refine push notification content and frequency to increase open rates and consider user preferences and interests.
- Tailoring interventions and strategies based on demographic segments, user preferences or cultural contexts may optimise user experiences and increase sustained participation.
- Conduct further research to investigate factors associated with increased engagement and retention, especially among participants born overseas.
- Increase the sample size and include a more diverse population for more comprehensive insights and reliable results.

- Engaging participants in the app-based data collection platform requires a substantial allocation of resources, including implementing diverse communication strategies and maintaining regular contact with participants.
- Address biases and limitations in participant representation by applying post-stratification and weighting techniques.

6. Exploration of methods to expand catch and effort from app-based data

6.1 Introduction

Probability-based surveys typically use a stratified random design with known sampling fractions enabling the development of expansion factors to convert estimates of catch and effort to the known resident population. This may be achieved under an integrated approach where adjustments are also made for non-response and estimates are calibrated against population benchmarks (e.g., Lyle et al. 2010). The key difference when considering non-probability surveys, such as the app-based trial, is that sampling is not randomised or stratified. Therefore, no known selection probabilities are associated with those who opt into the study. Furthermore, census data on the number of fishers in the resident population is generally unavailable, making probability-based surveys the primary source for population estimates of recreational fishers (Beckmann *et al.* 2023).

Probability-based surveys have limitations, such as declining response rates and availability of appropriate sampling frames. Despite these challenges they represent the best model currently available to estimate recreational fishing participation, catch and effort. They provide confidence intervals that indicate the relative levels of uncertainty in the estimates. While absolute estimates are not available, probability-based surveys allow for comparison against a statistical representation, enabling the assessment of under- or over-reporting. When assuming that probability-based estimates are unbiased representations of the resident population of recreational fishers, these estimates are treated as "population benchmarks." This allows for the expansion of app-based estimates to the population, making non-probability surveys reliant on probability-based surveys.

Non-probability surveys are typically cheaper to implement and could be conducted more frequently, supplemented by periodic, albeit less frequent, probability-based surveys to recalibrate the expansion of the non-probability data. Identification of potential biases associated with the under- or over-represented groups because of the non-probability sampling design was examined by comparing the probability and non-probability estimates for different groups. In addition to adjusting for basic demographic variables collected from screening (e.g., stratum, age, gender, education, country of birth), more detailed information is available on fisher behaviour from those who were recruited into the longitudinal phase of the probability-based survey (e.g., fishing avidity).

A major challenge with app-based data is the difficulty of assessing the accuracy of the reported data. While both survey methods rely on accurate information reported by participants, the probability-based survey is more structured, with interviewers regularly contacting participants to record information promptly and ensure accurate reporting. This approach is designed to reduce respondent burden and maximise response and data quality. Alternatively, app-based data collection is largely respondent driven. Therefore, the potential for mis- and under-reporting is much higher (see Chapter 5) (Jiorle *et al.* 2016). These biases were investigated using the coefficient q (see Section 3.4.4 for details on statistical analysis) between app-based and the State-wide surveys, and adjustments were applied to the app-based data before expansion.

Once important biases are identified and adjusted, post-stratification methods can be employed to enhance representativeness by balancing under- and over-sampled groups. The fundamental approach involves iteratively developing weightings, known as raking, to balance population totals across all demographic groups. Additionally, app-based data can be matched with a probability sample of the population, generating weights either for the app-based data

through propensity score adjustments or for the probability records through statistical matching. These approaches prove particularly valuable in situations where population totals are unavailable. Furthermore, modelling techniques, including generalised linear models and multilevel regression, can be used to model the relationship between variables of interest and demographics. These techniques enable the prediction of population totals for the variables of interest (see Table 3.2) without the need for expansion weights.

Seven species were selected for the expansion analysis based on their importance to recreational fishers in SA (Beckmann *et al.* 2023), and the availability of sufficient sample sizes (Table 5.4). Ordered by their contribution to the total catch during the 2021–22 State-wide survey these were:

Blue Swimmer Crab (*Portunus armatus*): The most caught recreational species in South Australia, representing 18% of the total recreational catch. Blue Swimmer Crabs are mainly caught with crab nets from shore and boats, with only 53% of catches being released.

King George Whiting (*Sillaginodes punctatus*): The second most caught recreational species and the most popular marine finfish species, representing 40% of the total marine finfish recreational catch. King George Whiting is primarily caught by rod and line from boats with 38% of catch being released.

Australian Herring (***Arripis georgianus)*** : The second most caught marine finfish species by recreational fishers, amounting to 14% of the total marine recreational finfish catch. Mainly caught by rod and line from both shore and boats with release rates of 30%.

Southern Calamari (*Sepioteuthis australis*): The third most caught marine invertebrate species by recreational fishers, representing 5% of the total recreational catch. Mainly caught by rod and line from boats with only 4% of catch released.

Southern Garfish (*Hyporhamphus melanochir*): The third most caught marine finfish species by recreational fishers, making up 7% of the total marine finfish recreational catch. Southern Garfish is mainly caught by rod and line from boats, with 19% of the catch being released.

Western Australian Salmon (*Arripis truttaceus*): Popular recreational finfish species, accounting for 6% of the total recreational finfish catch. Caught by rod and line mostly from shore, with a release rate of 45%.

Yellowfin Whiting (*Sillago schomburgkii*): Popular recreational finfish species, contributing 4% to the total catch, mostly caught by rod and line from shore and boats and with a release rate of 30%.

Several other species (e.g., Goolwa Pipi, Yabbies, Freshwater Shrimp and Western Striped Grunter) also ranked highly in terms of their contribution to the total catch during the State-wide survey but were not included in the analysis due to data limitations (i.e., low sample size due to localised capture), or their predominant role as a by-catch species (e.g., Western Striped Grunter).

This chapter is divided into three main sections exploring:

- **Differences in catch rates and events reported:** comparison of species-specific catch rates and number of fishing events reported between the phone and app surveys to evaluate the accuracy of app-based reporting and estimation of coefficient q for adjustments.
- **Different methods of estimation (using coefficient q adjusted app data):**

    - Raking: expansion of estimates using census data to expand to population totals, considering within group or overall participation rates.
    - Propensity scores: expansion weights generated based on a probabilistic sample of the population
    - Statistical matching: expansion weights generated using the expanded dataset available from the screening survey
    - Model-based approach: predictions of catch and effort values for each fisher in the population using a model trained with app-based data, the advantages and disadvantages of more advanced model-based approaches such as multilevel regression and post stratification (MRP) are also discussed
- **Comparison of species-specific catch and effort estimates**: comparisons are investigated for each method above relative to the probability-based survey benchmarks, including the temporal variability of catch rates and fishing events which is important information used to inform the expansion of catch and effort estimates.

6.2 Differences in catch rates and events reported

To aid in interpreting the results, we employed the coefficient q to assess the accuracy of each survey method in capturing true catch rates and the number of events reported by fishers (see Section 3.4.4 for statistical analysis details). The coefficient q represents the proportion of the actual catch rate or number of events that each survey method captures from the target population. Higher coefficient q values indicate greater accuracy in estimating these metrics, while lower values suggest potential underestimation. Differences in coefficients were assessed under the assumption that the State-wide survey method provides a more accurate estimate of the true catch rate or number of events. The decision to apply separate adjustments for catch-per-unit-effort and events in the app-based data was based on the observed discrepancies and differences in reporting patterns between these two aspects of fishing activity. By using reported avidity as a basis for adjustments, the aim was to account for the expected number of events each fisher should report if there was no underreporting . Adjustments are applied by species, due to the varying fishing behaviours (e.g., methods, platforms, level of targeting or specialisation), which can result in differences in catch rates and reporting patterns, particularly among different avidity groups.

Bootstrap estimates of coefficient q show significant differences in catch rates and number of events reported between the State-wide and the app-based data for most species examined. Specifically, app-based catch rates were found to be significantly higher for Western Australian Salmon (average of q =1.63 ± 0.01 SE), Southern Calamari (q =1.61 ± 0.03), King George Whiting (q =1.25 ± 0.002), and Australian Herring (q =1.42 ± 0.01) (Figure 6.1A). Average days reported by each fisher were small (q =1.13 to 1.62) and similar for all avidity groups (see Figure 5.13), resulting in significantly smaller number of events reported for all species examined by approximately a factor of two (Figure 6.1B). Average coefficient q values for events reported per fisher varied from 0.37 ± 0.001 for King George Whiting to 0.69 ± 0.004 for Yellowfin Whiting. Expanding the app-based data without adjustment for this bias would lead to significant over-estimation of catch per event, as well as under-estimation of the total catch from each fisher over the survey period, owing to the reduced number of reported events.

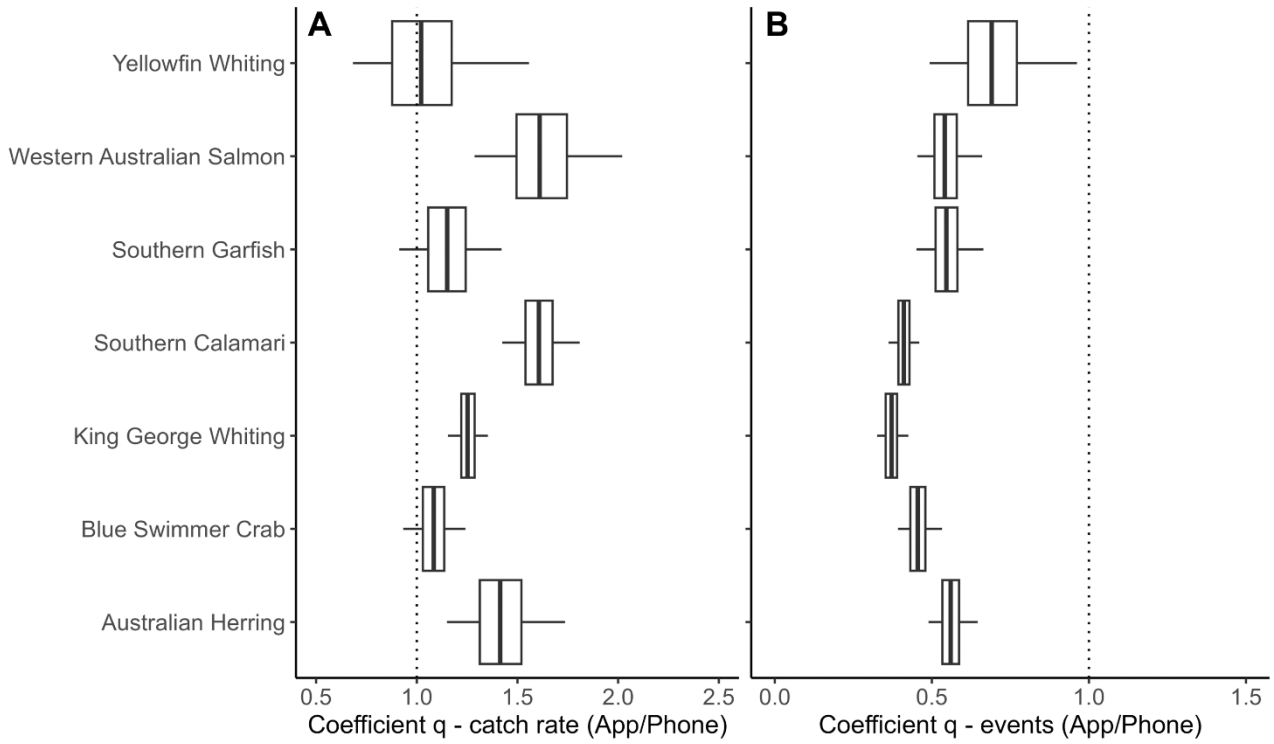

Figure 6.1 Coefficient q distribution for various species between the app-based (App) and State-wide (Phone) surveys, representing the (A) catch rate of harvested catch per event and (B) the number of events reported per fisher. The boxplot line indicates the median values, while the box illustrates the interquartile range with 50% of the data. The whiskers indicate the distribution of 95% of the results, and the dashed line represents the value one, which corresponds to no difference between datasets.

Estimates of coefficient q were also calculated by demographics and fisher avidity group within each species. Results for King George Whiting (Figure 6.2) suggest considerable yet predictable variability between app-based and State-wide survey data in both reported catch rates and effort. Although catch rates remained largely consistent among different avidity groups (Figure 6.2), highly avid fishers (i.e., those who fished for 20 or more days in the previous 12 months) reported significantly fewer events in the app-based data compared to the State-wide survey (see Section 5.2.4 For catch rates of harvested King George Whiting among avidity groups, the average coefficient q varied, with values ranging from 1.13 ± 0.002 for avidity of 20 or more days to 1.37 ± 0.005 for avidity of 15 to 19 days fished. The number of events reported per fisher displayed a larger range of average coefficient q among avidity groups, ranging from 0.23 ± 0.001 for avidity of 20 or more days to 0.54 ± 0.002 for avidity of 1 to 4 days fished (Figure 6.2). This reflects the low number of events reported by app-based participants, regardless of their reported avidity (see Section 5.2.4) and this trend was reflected across most species analysed (Figure 6.3 and Appendix 7.1). Yellowfin Whiting, Western Australian Salmon and Southern Garfish displayed the largest variabilities in the coefficient q and their average among avidity groups, potentially due to their lower sample sizes in the app-based data. The average of coefficient q adjustments used prior to expansions are displayed in Appendix 7.1. Although some distributions of coefficient q are not considered significantly different than 1, due to the high variability and small sample sizes in some groups, all coefficient's averages calculated for each species and avidity groups were applied to the app-based raw data as adjustments. Adjustments were undertaken for each avidity group because avidity can be directly related to the number of events each fisher is expected to report. While other fisher characteristics are also likely to be important, more research is required to understand their complex relationship with catch rates. In general, coefficient q

adjustments decreased catch rates and increased the number of events reported for each fisher in the app-based data (see Section 3.4.4). Applying the coefficient q adjustment by avidity group increases the effort (fishing events) more for avid fishers compared to those who were less avid.

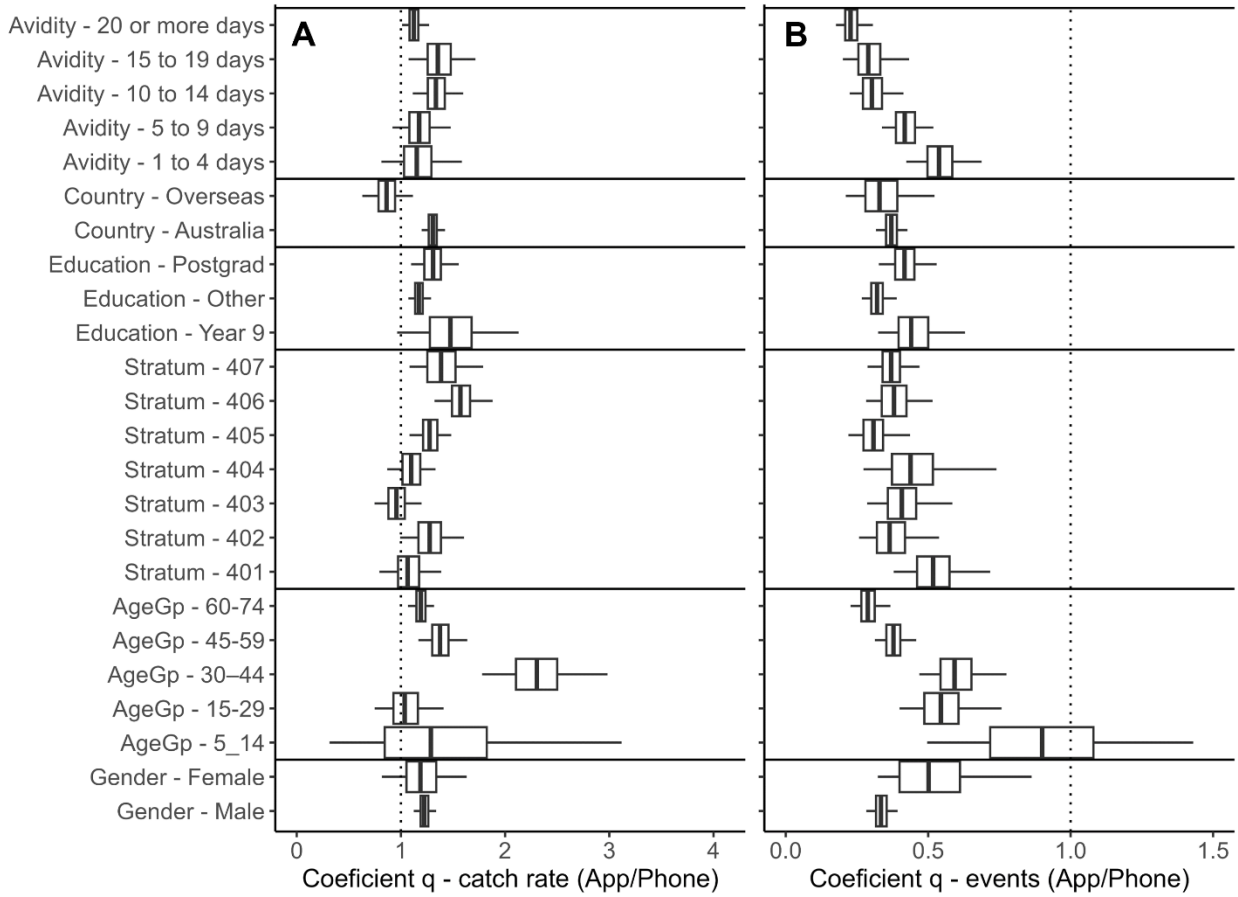

Figure 6.2 Coefficient q distribution for various covariates between the app-based (App) and State-wide (Phone) surveys, representing the King George Whiting (A) catch rate of harvested catch per event and (B) the number of events reported per fisher. The boxplot line indicates the median values, while the box illustrates the interquartile range with 50% of the data. The whiskers indicate the distribution of 95% of the results, and the dashed line represents the value one, which corresponds to no difference between datasets.

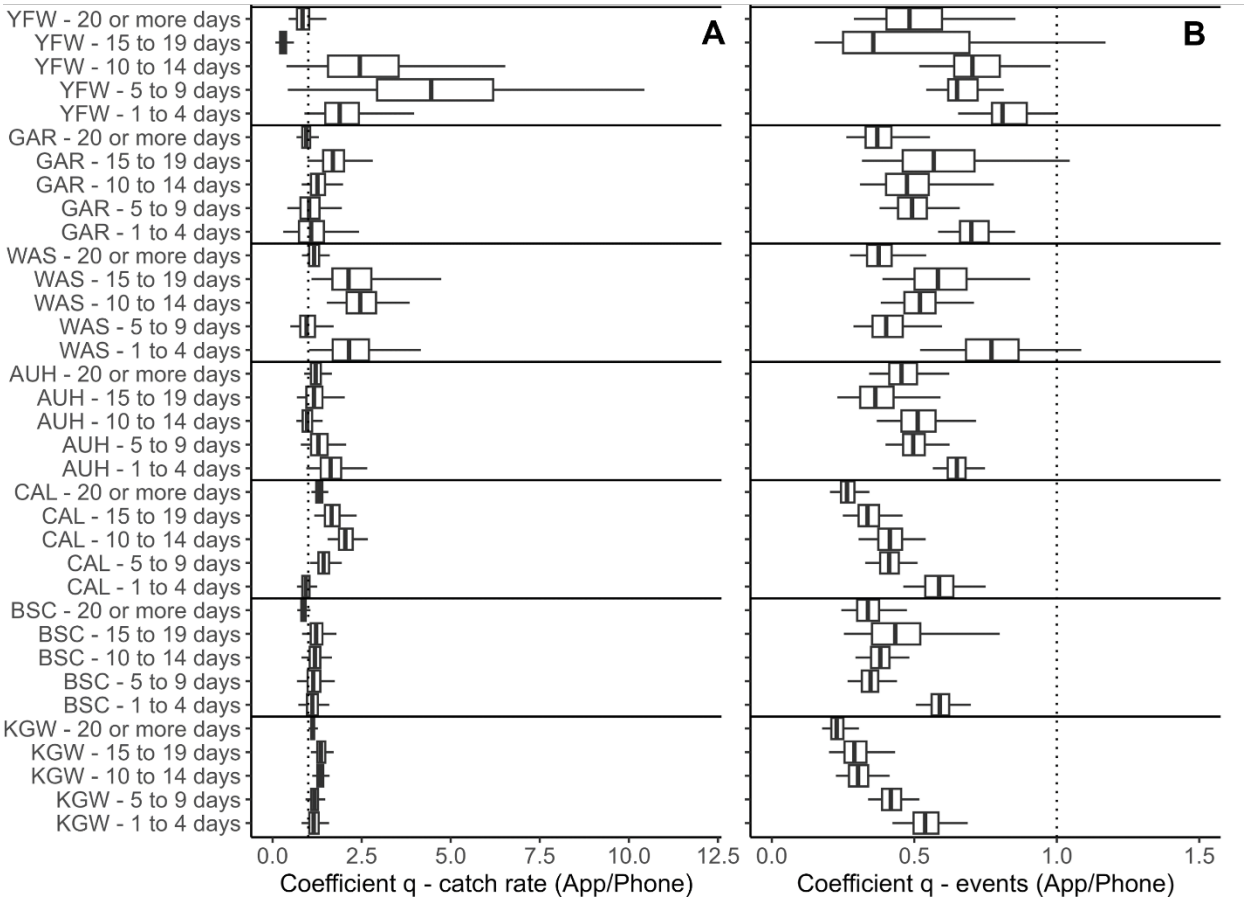

Figure 6.3 Coefficient q distribution for various species at all avidity levels between the app-based (App) and State-wide (Phone) surveys, representing (A) catch rate of harvested catch per event and (B) the number of events reported per fisher. The boxplot line indicates the median values, while the box illustrates the interquartile range with 50% of the data. The whiskers indicate the distribution of 95% of the results, and the dashed line represents the value one, which corresponds to no difference between datasets. Abbreviated species include Australian Herring (AUH), Blue Swimmer Crab (BSC), Southern Calamari (CAL), Southern Garfish (GAR), King George Whiting (KGW), Western Australian Salmon (WAS) and Yellowfin Whiting (YFW). Details in Appendix 7.1.

6.3 Raking

The raking expansion method can be considered the simplest expansion method examined in this report. This method allows researchers to weight the sample data to marginal fisher population totals. It is important to note that the expansion results are influenced by the coefficient q adjustments made in the analysis. The coefficient q adjustment accounts for potential underreporting and is applied to adjust the catch rates and number of events reported in the app-based data. This adjustment helps align the app-based data with the estimated population catch rates from the State-wide survey. In the analysis, expansions were undertaken with three different datasets and adjustments scenarios: (1) using only census data assuming an overall 23% participation rate (Beckmann *et al.* 2023); (2) applying participation rates from screening data collected in the State-wide survey, and (3) participation rates from screening survey and app-based data adjusted using coefficient q. By employing the raking expansion method in conjunction with the q coefficient adjustments, we aim to generate comprehensive estimates of the total harvest and days fished, while accounting for potential biases in the app-based data. This combined approach helps ensure that the

expansion results reflect both the adjustments made for underreporting (q coefficients) and the overall population totals (raking).

Harvested (kept) catch after screening and coefficient q adjustments were estimated as 1,112,178 ± 195,844 (SE) fishes for King George Whiting, 939,795 ± 397,570 for Blue Swimmer Crab and 498,531 ± 97,002 for Southern Calamari. Similarly, the estimated days fished were 437,581 ± 151,429 for King George Whiting, 150,419 ± 43,617 for Blue Swimmer Crab, and 233,207 ± 50,864 for Southern Calamari (Appendix 7.2). Harvest estimates (screening and adjustments) were comparable to State-wide (probability-based) survey estimates, except for Southern Garfish and Yellowfin Whiting, likely due to their smaller sample sizes (Figure 6.4A). Raking expansion of adjusted values tended to overestimate the number of days fished for all species except for Blue Swimmer Crab and Southern Calamari (Figure 6.4B). Estimates using unadjusted data performed poorly (Figure 6.4, census, and screening only).

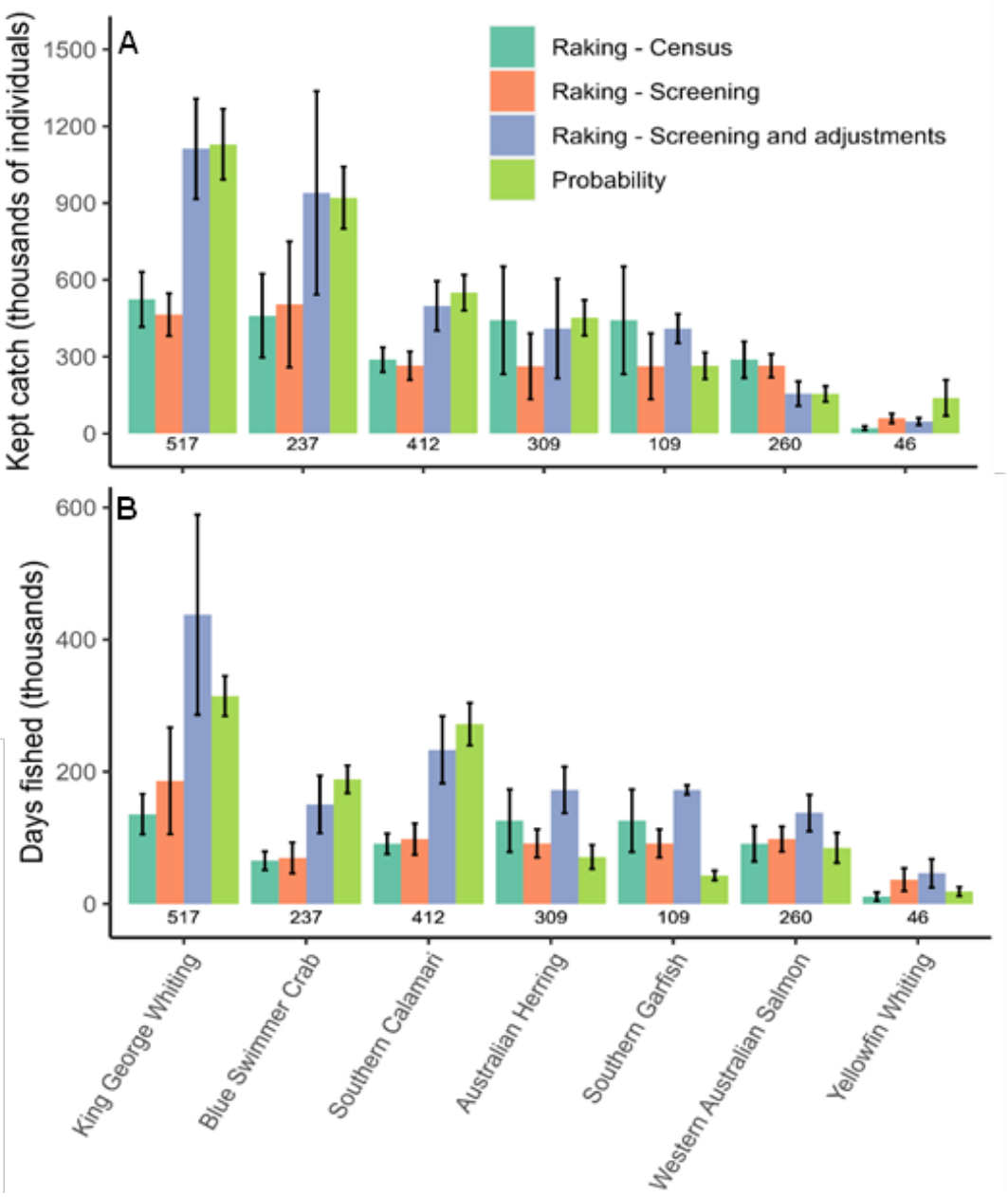

Figure 6.4 Raking expansion results of estimated (A) harvested catch and (B) days fished in 2021-22 for analysed species. The results are expanded under three scenarios: (1) ABS census data used as marginal counts for covariates, (2) screening data from the State-wide survey as marginal counts, and (3) screening data from the State-wide survey with coefficient q adjustments applied to the app-based data. State-wide survey (probability-based) results are included for comparison. Error bars represent one standard error estimated from jackknife variance. Numbers under bars indicate the number of fishers reporting fishing events in the app-based data.

6.4 Propensity scores

Generating propensity scores and expansion weights requires a probabilistic sample from the fisher population. As such, the present study used the results of the State-wide survey to provide population benchmarks given that this data is not available from the ABS census. Consequently, researchers with only access to census data cannot employ this method, unlike those using raking. Like raking, expansions using unadjusted data provided poor estimates. The expansion outcomes obtained through propensity scores show comparable results to State-wide (probability-based) surveys for most species, when using q-adjusted data. It

notably improves the accuracy of estimating days fished compared to raking results, particularly for Australian Salmon, Southern Garfish, and Yellowfin Whiting (Figure 6.5). Although the propensity score method yields smaller standard errors of estimates compared to raking, it should be noted that this is due to the absence of re-weighting at each jackknife interaction in the propensity score method.

Harvested (kept) catch after screening and coefficient q adjustments were estimated as 1,343,257± 159,482 (SE) fishes for King George Whiting, 839,884 ± 235,626 for Blue Swimmer Crab and 572,442 ± 111,441 for Southern Calamari. The estimated days fished were 433,701 ± 77,872 for King George Whiting, 129,160 ± 20,382 for Blue Swimmer Crab, and 246,219 ± 52,754 for Southern Calamari (Appendix 7.3).

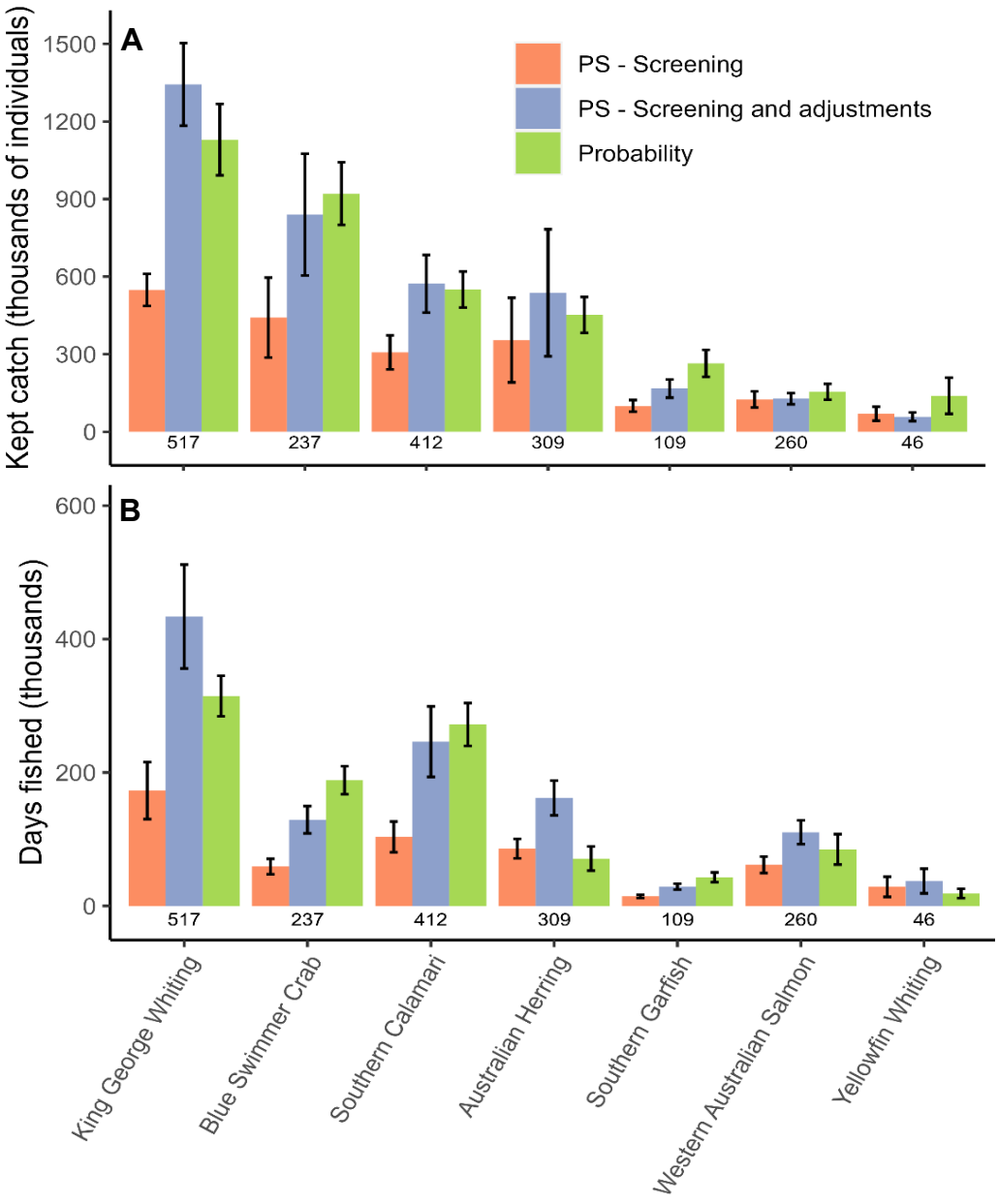

Figure 6.5 Propensity scores expansion results of estimates of (A) harvested (kept) catch and (B) days fished in 2021-22 for all species analysed. The results are expanded to two different scenarios: (1) screening from the State-wide survey, and (2) screening from the State-wide survey and coefficient q adjustments. State-wide survey (probability-based) results are displayed for comparison. The error bars represent one standard error estimated from jackknife variance. Numbers under bars indicate the number of fishers who reported fishing events for each species in the app-based data.

6.5 Statistical matching

Similar to the propensity scores method, statistical matching also relies on a probabilistic sample (screening) from the fisher population. However, in statistical matching, expansion weights are calculated for participants in the screening (probability) survey, while catch and effort estimates from the app-based data is allocated to each individual and used in the expansion. This approach leads to an increase in sample size during expansion. While statistical matching produced similar estimates of harvested catch compared to propensity scores (except for overestimating King George Whiting catch) (Figure 6.6A), it significantly improved estimates of days fished, particularly for species with limited sample sizes like Southern Garfish and Yellowfin Whiting (Figure 6.6B). Similar to propensity score expansion, the standard errors estimated during statistical matching are relatively small due to the absence of re-weighting at each jackknife interaction. Values of harvested (kept) catch and days fished after screening and coefficient q adjustments were estimated as 1,832,397 ± 179,936 (SE) fishes and 423,886 ± 30,643 days for King George Whiting, 905,205 ± 101,493 fishes and 153,409 ± 12,548 for Blue Swimmer Crab, and 772,376 ± 85,176 fishes and 282,507 ± 18,622 days for Southern Calamari (Appendix 7.4).

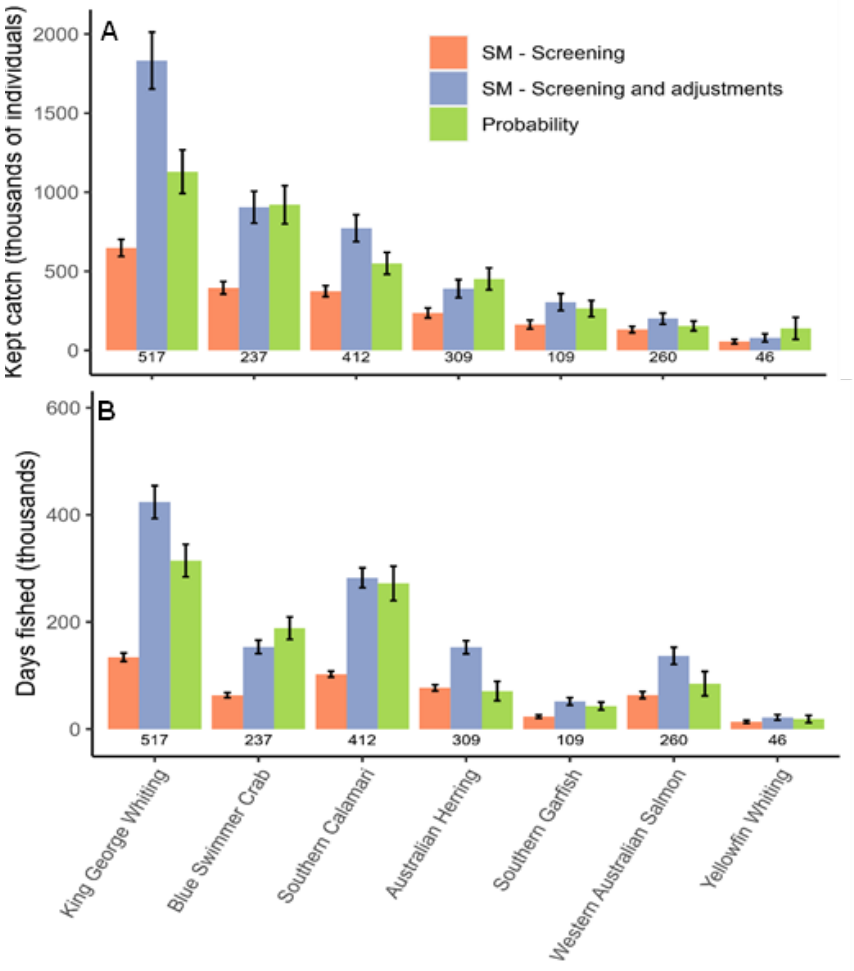

Figure 6.6 Statistical matching expansion results of estimates of (A) harvested (kept) catch and (B) days fished in 2021-22 for all species analysed. The results are expanded to two different scenarios: (1) screening from the State-wide survey, and (2) screening from the State-wide survey and coefficient q adjustments. State-wide survey (probability-based) results are displayed for comparison. The error bars represent one standard error estimated from jackknife variance. Numbers under bars indicate the number of fishers who reported fishing events for each species in the app-based data.

6.6 Model-based approaches

Expansion weights were used in previous methods to expand catch and effort. The model-based method takes a different approach by predicting catch and effort values for each fisher in the population using a model trained with app-based data. This approach is particularly suitable when a sampling design is absent, such as when using data from self-selecting apps. However, it requires individual-level covariate information for the entire fisher population. These values can be estimated from expanded probabilistic screening surveys, as done in this study. Thus, if a researcher has access to data for applying propensity scores and statistical matching methods, as well as census data, these can be transformed into the data needed for model-based expansions.

Values of harvested (kept) catch and days fished after screening and coefficient q adjustments were estimated as 1,080,241 ± 526,959 (SE) fishes and 390,557 ± 173,973 days for King George Whiting, and 538,717 ± 200,149 fishes and 284,131 ± 59,221 days for Southern Calamari (Appendix 7.5). Results from the model-based approach showed comparable outcomes to the State-wide (probability-based) survey, improving harvest estimates for many species compared to other expansion methods, with the exception of Blue Swimmer Crab (1,050,372 ± 335,648 fishes, screening and adjustments only) and Yellowfin Whiting (52,154 ±18,344) (Figure 6.7A). Estimates of days fished were similar to the State-wide (probability-based) survey results, but Australian Herring (185,015 ± 42,567 days fished) and Western Australian Salmon (138,653 ± 16,453 days fished) were significantly overestimated (Figure 6.7B). The model-based results exhibited larger standard error values than any other expansion method due to the development of new models at each step of the jackknife procedure.

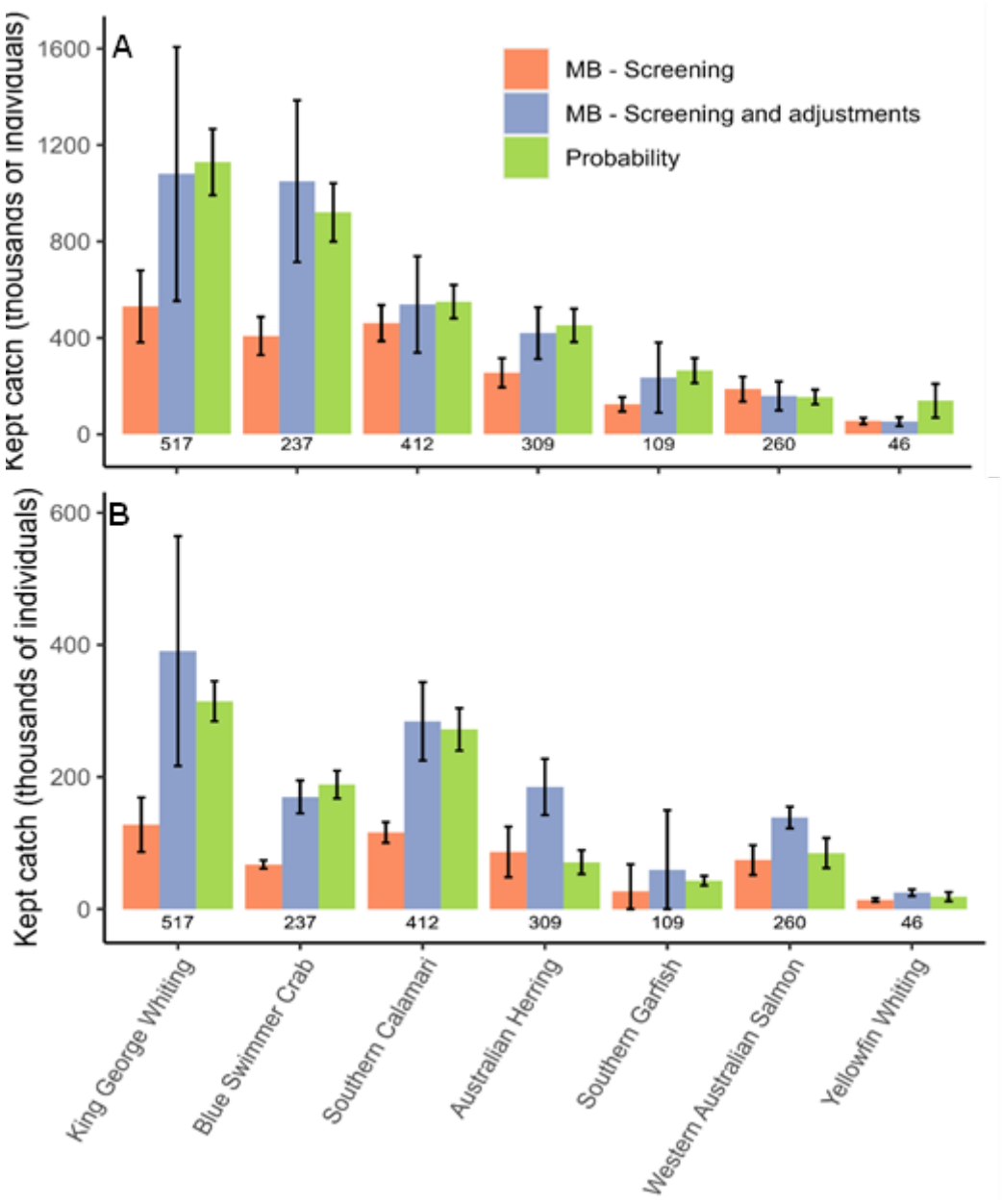

Figure 6.7 Model-based expansion results of estimates of (A) harvested (kept) catch and (B) days fished in 2021-22 for all species analysed. The results are expanded to two different scenarios: (1) screening from the State-wide survey, and (2) screening from the State-wide survey and coefficient q adjustments. State-wide survey (probability-based) results are displayed for comparison. The error bars represent one standard error estimated from jackknife variance. Numbers under bars indicate the number of fishers who reported fishing events for each species in the app-based data.

6.7 Comparisons

Due to the poor accuracy of unadjusted expansion results, only results using screening survey and app-based data adjusted using coefficient q (screening and adjustments) were compared in this section.

The accuracy of estimating harvest numbers, as measured by the absolute difference between app-based catch estimates and State-wide (probability-based) results, varied across expansion methods and species analysed (Figure 6.8, Table 6.1). Most app-based estimates

(68%) fell within a 20% range of the values estimated from the State-wide (probability-based) survey (Figure 6.8A), while 89% of estimates were within the confidence levels of the State-wide survey, calculated as the difference between estimates minus the relative standard error (RSE) values from the State-wide results (Figure 6.8B). The model-based approach outperformed other expansion methods in estimating catch values for Southern Calamari, Australian Herring, and Southern Garfish, whereas raking provided greater accuracy for King George Whiting and Western Australian Salmon. For Blue Swimmer Crab and Yellowfin Whiting, the statistical matching approach yielded the best catch estimates, although the accuracy for Yellowfin Whiting was poor (Figure 6.8A). Small sample sizes contributed to highly variable reported catches and its coefficient q adjustments for Yellowfin Whiting (Figure 6.3A). As some adjustments of catch rates were relatively large and calculated as an average of a large distribution of values (e.g., catch rates reduced by 4.97 times from a range of 0 to 20.51, for fishers with avidity of 5 to 9 days), the final expansion methods were affected by this variability.

On average, the model-based approach produced the most similar harvested number estimates to the State-wide survey, followed by raking, propensity scores, and statistical matching (Figure 6.8C). Interestingly, raking and model-based approaches correspond to the models with the lowest and highest data requirements, respectively, in terms of the amount and type of data needed to achieve estimates similar to the State-wide survey (Table 6.1). Even though, they produced similar estimates to the State-wide survey for most species, except for Southern Garfish for which model-based was more similar by a factor of 6. These results indicate that while harvest can be accurately estimated from app-based methods by expansion weights applied to the fisher population for some species, for others (like Southern Garfish) models that can describe the relationship between catch and covariates are likely to better reflect the total harvest numbers.

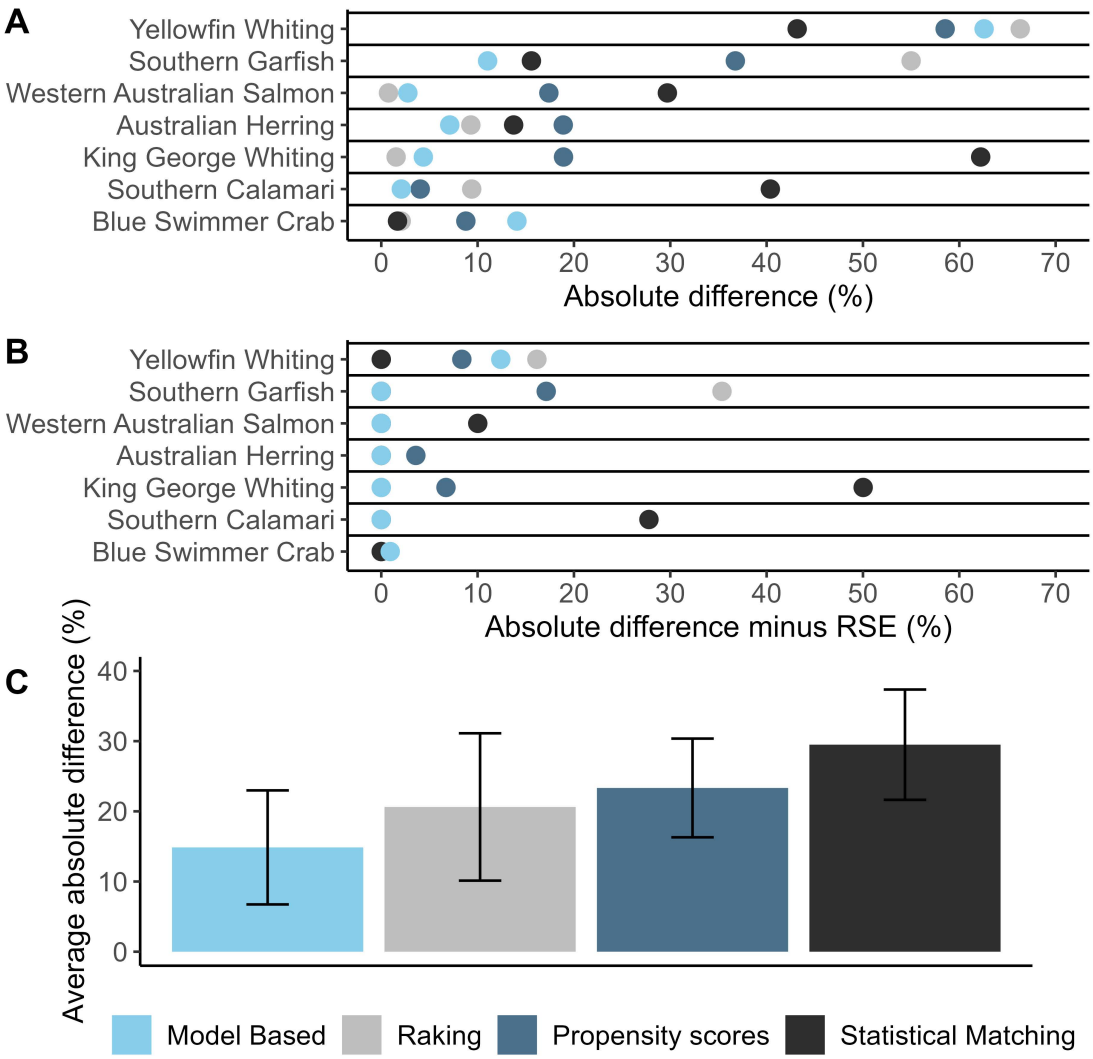

Figure 6.8 Comparison of the harvested number estimates from all expansion methods with (A) the estimated value and (B) the estimated value minus the relative standard error (RSE) from the State-wide survey (probability-based). The average of results displayed in panel A is presented in (C). The error bars represent one standard error. Models with only coefficient q adjustments were compared (screening and adjustments). The lower limit of the error bars represents the estimate minus the RSE, providing a conservative representation of the uncertainty in the estimates.

Table 6.1 Comparison of the harvested number estimates by species from all expansion methods in comparison to the State wide probability survey. Differences are expressed as a percentage of the total state wide probability survey estimate.

Species	State wide probability survey	Expansion method	Raking	Diff (%)	Propensity Scores	Diff (%)	Statistical Matching	Diff (%)	Model based	Diff (%)
King George Whiting	1,129,574	Census	523,767	-54%	NA	NA	NA	NA	NA	NA
Blue Swimmer Crab	920,721		459,907	-50%	NA	NA	NA	NA	NA	NA
Australian Herring	452,010		441,960	-2%	NA	NA	NA	NA	NA	NA
Southern Calamari	550,179		288,382	-48%	NA	NA	NA	NA	NA	NA
Western Australian Salmon	154,613		288,382	87%	NA	NA	NA	NA	NA	NA
Southern Garfish	264,506		441,960	67%	NA	NA	NA	NA	NA	NA
Yellowfin Whiting	139,359		21,204	-85%	NA	NA	NA	NA	NA	NA
King George Whiting	1,129,574	Screening	464,089	-59%	548,640	-51%	648,222	-43%	530,685	-53%
Blue Swimmer Crab	920,721		504,074	-45%	441,357	-52%	395,394	-57%	408,045	-56%
Australian Herring	452,010		261,817	-42%	354,467	-22%	236,898	-48%	255,473	-43%
Southern Calamari	550,179		264,888	-52%	306,979	-44%	374,049	-32%	461,252	-16%
Western Australian Salmon	154,613		264,888	71%	124,647	-19%	131,293	-15%	187,460	21%
Southern Garfish	264,506		261,817	-1%	99,962	-62%	163,671	-38%	124,351	-53%
Yellowfin Whiting	139,359		59,218	-58%	69,791	-50%	55,956	-60%	55,201	-60%
King George Whiting	1,129,574	Screening and adjustments	1,112,178	-2%	1,343,257	19%	1,832,397	62%	1,080,242	-4%
Blue Swimmer Crab	920,721		939,795	2%	839,885	-9%	905,205	-2%	1,050,372	14%
Australian Herring	452,010		409,982	-9%	537,400	19%	389,901	-14%	419,874	-7%
Southern Calamari	550,179		498,531	-9%	572,443	4%	772,377	40%	538,717	-2%
Western Australian Salmon	154,613		155,769	1%	127,717	-17%	200,530	30%	158,884	3%
Southern Garfish	264,506		409,982	55%	167,293	-37%	305,731	16%	235,309	-11%
Yellowfin Whiting	139,359		46,930	-66%	57,790	-59%	79,197	-43%	52,154	-63%

Similar to harvest numbers, the accuracy of estimating days fished, as measured by the absolute difference between app-based effort estimates and State-wide (probability-based) results, varied across expansion methods and species analysed (Figure 6.9, Table 6.2). Only 25% of estimates fell within a 20% range of values from the State-wide survey (Figure 6.9A), while 46% of estimates were within the confidence levels of the State-wide survey (Figure 6.9B), calculated as the difference between estimates minus the RSE values form the State-wide results. Statistical matching outperformed other expansion methods in estimating days fished for Yellowfin Whiting, Australian Herring, and Southern Garfish, while the model-based approach provided greater accuracy for King George Whiting, Blue Swimmer Crab, and Southern Calamari. Propensity scores yielded the most similar estimation of days fished for Western Australian Salmon when compared to the State-wide survey, while raking had the poorest results for several species (Figure 6.9A).

On average, statistical matching provided the most comparable effort estimates to the State-wide survey, followed by the model-based, propensity scores, and raking methods (Figure 6.9C). Raking showed significantly worse performance in estimating days fished compared to other methods, particularly for species with small sample sizes like Southern Garfish and Yellowfin Whiting. However, all methods performed poorly in estimating days fished for Australian Herring, with absolute differences exceeding 100% compared to the State-wide survey results (Figure 6.9A and B). One explanation may be the low level of targeted catch (32%) for Australian Herring, which is commonly caught while primarily targeting King George Whiting (Beckmann *et al.* 2023). This low targeting frequency leads to limited data availability, higher variability, and less predictable angler behaviour, making accurate predictions challenging. Additionally, this incidental catch can lead to underreporting or misreporting as fishers may not prioritise reporting non-targeted species. Overestimation of days fished for Australian Herring could also be attributed to misidentification with juvenile Western Australian Salmon, which have a similar appearance. We hypothesis that in cases where fishers were unsure and reported both species in the same event, the estimates would be inflated, as seen in Figure 6.4, Figure 6.5, Figure 6.6 and Figure 6.7. In fact, 28% of events reporting Australian Herring in the app-based data also reported Western Australian Salmon, higher than the 17% in the State-wide survey. Similarly, 31% of events reporting Western Australian Salmon in the app-based data included Australian Herring, compared to only 25% in the State-wide survey. While the wash-up survey did not explicitly examine whether participants reported both species in the same event, the higher co-occurrences of both species in the app-based data could partially account for the differences in estimated days fished between the non-probability and probability-based surveys.

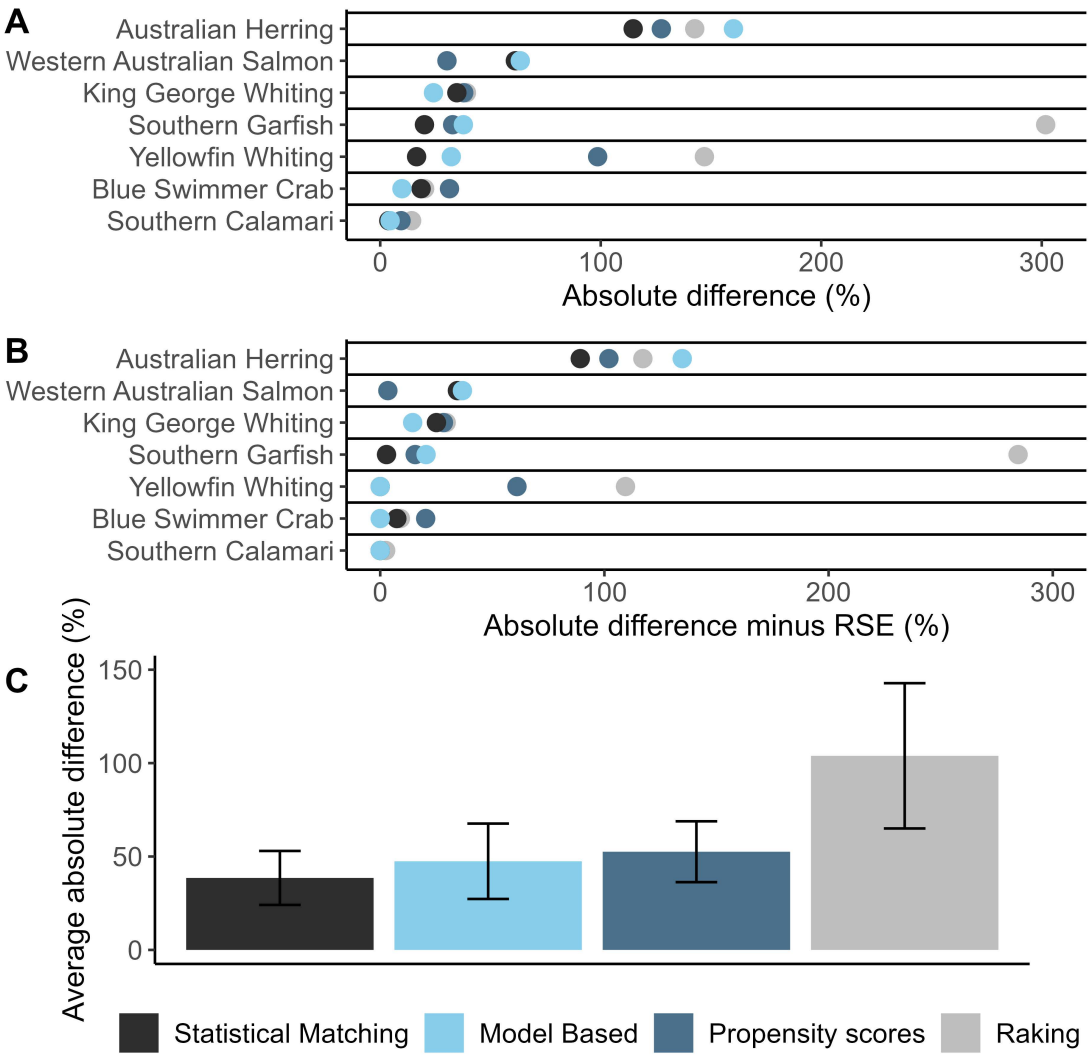

Figure 6.9 Absolute difference in percentage of the comparison of days fished estimates from all expansion methods with (A) the estimated value and (B) the estimated value minus the relative standard error (RSE) from the State-wide survey (probability-based). The average of results displayed in panel A is presented in (C). The error bars represent one standard error. Models with only coefficient q adjustments were compared (screening and adjustments). The lower limit of the error bars represents the estimate minus the RSE, providing a conservative representation of the uncertainty in the estimates.

Table 6.2 Comparison of the fishing effort (days fished) estimates by species from all expansion methods in comparison to the State wide probability survey. Differences are expressed as a percentage of the total state wide probability survey estimate.

Species	State wide probability survey	Expansion method	Raking	Diff (%)	Propensity Scores	Diff (%)	Statistical Matching	Diff (%)	Model based	Diff (%)
King George Whiting	314,568	Census	135,787	-57%	NA	NA	NA	NA	NA	NA
Blue Swimmer Crab	188,340		65,415	-65%	NA	NA	NA	NA	NA	NA
Australian Herring	71,105		125,899	77%	NA	NA	NA	NA	NA	NA
Southern Calamari	271,922		90,952	-67%	NA	NA	NA	NA	NA	NA
Western Australian Salmon	84,789		90,952	7%	NA	NA	NA	NA	NA	NA
Southern Garfish	42,940		125,899	193%	NA	NA	NA	NA	NA	NA
Yellowfin Whiting	18,778		11,019	-41%	NA	NA	NA	NA	NA	NA
King George Whiting	314,568	Screening	186,277	-41%	172,877	-45%	134,169	-57%	127,715	-59%
Blue Swimmer Crab	188,340		69,712	-63%	59,189	-69%	63,273	-66%	67,532	-64%
Australian Herring	71,105		91,540	29%	85,886	21%	76,807	8%	86,572	22%
Southern Calamari	271,922		98,073	-64%	103,570	-62%	102,709	-62%	115,905	-57%
Western Australian Salmon	84,789		98,073	16%	61,761	-27%	63,662	-25%	74,276	-12%
Southern Garfish	42,940		91,540	113%	14,540	-66%	23,363	-46%	27,027	-37%
Yellowfin Whiting	18,778		36,660	95%	28,808	53%	13,672	-27%	13,967	-26%
King George Whiting	314,568	Screening and adjustments	437,581	39%	433,701	38%	423,887	35%	390,557	24%
Blue Swimmer Crab	188,340		150,419	-20%	129,161	-31%	153,409	-19%	169,759	-10%
Australian Herring	71,105		172,526	143%	161,751	127%	152,669	115%	185,015	160%
Southern Calamari	271,922		233,207	-14%	246,220	-9%	282,507	4%	284,131	4%
Western Australian Salmon	84,789		137,670	62%	110,452	30%	136,757	61%	138,653	64%
Southern Garfish	42,940		172,526	302%	28,835	-33%	51,554	20%	59,133	38%
Yellowfin Whiting	18,778		46,386	147%	37,294	99%	21,876	16%	24,830	32%

When comparing the results of catch and effort, the model-based estimates emerged as the most similar to the State-wide survey estimates for all seven analysed species. Statistical matching followed closely, while both raking and propensity scores were classified as the least accurate methods (Table 6.3). Although the present study did not include an analysis using the multilevel regression and post stratification method, it is anticipated that the results would be similar to the model-based approach when population cell totals are available. This similarity arises because both methods rely on modelling the relationship between catch and effort, and covariates, rather than relying on expansion weights based on marginal totals or screening data.

Table 6.3 Summary of the essential (E) and desirable (D) dataset types and population totals to be used in the expansion process for different expansion methods. The methods are categorised as low (L), mid (M), and high (H) based on their data requirements and ranked (1 being the best) according to how close their catch and effort estimates were, on average, to the State-wide survey (probability-based) estimates. Abbreviated methods include propensity scores (PS), statistical matching (SM), model-based (MB) and multilevel regression and post stratification (MRP). MRP models were not used in the present study.

Expansion method	Census data	Screening data	Population totals		Data requirements			Results	
			Marg. counts	Cell counts	L	M	H	Catch	Effort
Raking	E	D	E		X			2	4
PS		E				X		3	3
SM		E				X		4	1
MB		E		E			X	1	2
MRP	E	D	E	D	X			-	-

6.7.1 Species-specific considerations

Although the model-based and statistical matching approaches were identified as the best expansion models respectively for harvested catch and effort, not all species exhibited app-based estimates that were comparable to the State-wide survey results. While the total days fished for Yellowfin Whiting was comparable to the State-wide survey estimate, the harvested catch was underestimated by a factor of 2.5 (Figure 6.6B and Figure 6.7A). This discrepancy suggests that factors beyond the number of reported events, which were successfully used to estimate total effort, influenced the catch estimates. Additionally, due to small sample size, very small catches could have easily affected the coefficient q adjustments for catch rate, resulting in smaller catches per event and, consequently, lower estimates.

Unlike Yellowfin Whiting, most species exhibited consistency between catch estimates derived from the best overall expansion methods using app-based data and the results obtained from the State-wide survey, although variations were observed in the estimation of days fished (Figure 6.6B). King George Whiting and Blue Swimmer Crab serve as examples, with the former showing an overestimation of effort in the app-based data compared to the State-wide results, while the latter displayed an underestimation (Figure 6.6B). King George Whiting is widely recognised as a favoured recreational finfish species in South Australia, whereas Blue Swimmer Crab stands out as the most commonly caught species overall (Beckmann *et al.* 2023). These two species are easily targeted by recreational anglers using rods, lines, or crab nets from boats or the shoreline. Their popularity contributes to a larger sample size in the app-based data and reduced likelihood of misidentification. The over- or under-estimation of fishing effort for these species, following adjustments, likely indicates the presence of a small number of fishers who reported significantly higher or lower effort than expected. Since the

presence of only a few fishers with large or lower reported effort would not have influenced the calculation of coefficient q, the adjustment may not have been appropriately applied. Discrepancies would be more pronounced if these fishers' demographics were under-represented in the sample, leading to a higher expansion weight assigned to them and a greater contribution to the final estimates. In such cases, the model-based approach, which does not rely on expansion weights, would yield more accurate effort estimates. In fact, the model-based approach produced the most similar effort estimates compared to the State-wide survey for King George Whiting and Blue Swimmer Crab (Figure 6.9A), suggesting that the estimates for these species may have been affected by outlier reported values from under-represented demographics.

If the same pattern holds true for catch estimates, it is plausible that the results for Southern Garfish, Australian Herring, and Southern Calamari may also have been influenced by these types of outliers, as evidenced by the model-based approach yielding the most similar estimates to the State-wide survey for these species (Figure 6.8A). Catch data reported for these species are more likely to include few extreme values, as they present smaller total catches than King George Whiting and Blue Swimmer Crab but have a larger personal bag limit, 40 for Australian Herring and 30 for Southern Garfish (compared to 10 for King George Whiting and 20 for Blue Swimmer Crab), or no minimum legal length (Southern Calamari), facilitating the catch of larger quantities (Appendix 8). In these cases, it is recommended the use of expansion methods that are not based on expansion weights, such as the model-based approach.

6.7.2 Temporal variability of catch rates and fishing events

Catch rates per fishing event from the 2007-08 State-wide survey were higher than in the 2021-22 survey (Figure 6.10A). The differences were especially higher for Western Australian Salmon (average coefficient q between 2.1 and 2.7), Southern Garfish (1.3 to 2.3) and Yellowfin Whiting (0.4 to 4.2). On the other hand, the number of fishing events reported per fisher was in general not significantly different between the two surveys, except for Western Australian Salmon (0.57 ± 0.004), Australian Herring (1.23 ± 0.007) and Yellowfin Whiting (2.28 ± 0.02) in the avidity group of 5 to 9 days (Figure 6.10B).

If coefficient q adjustments calculated from 2007-08 data were applied to the app-based data in 2021-22, the adjustments for catch rates would be different, resulting in different estimates than in the 2021-22 State-wide survey. While differences in catch rates do not appear to vary significantly among many avidity groups, indicating that temporal biases primarily affect catch rates of specific species rather than demographics. Therefore, it is crucial to identify catch rate variations if adjustments are to be made using data from older probability-based surveys. Additionally, since coefficients q did not significantly differ for the number of events reported per fisher, adjustments using old datasets can be employed for estimating fishing effort without the need for catch rate adjustments. This provides an option to correct for some of the inherent biases in non-probability surveys when only effort estimates are needed. However, all expansion methods used in the present report relied on benchmark information from the State-wide survey (e.g., participation rates and screening data), which would be different if the 2007-08 State-wide survey were used instead. This would result in different estimates of catch and effort, but likely still be more accurate than using unadjusted app-based data. This highlights the need for future research to investigate and compare the potential differences between app-based estimates and older probability-based surveys to gain a deeper understanding of temporal biases and improve the accuracy of adjustments in non-probability surveys.

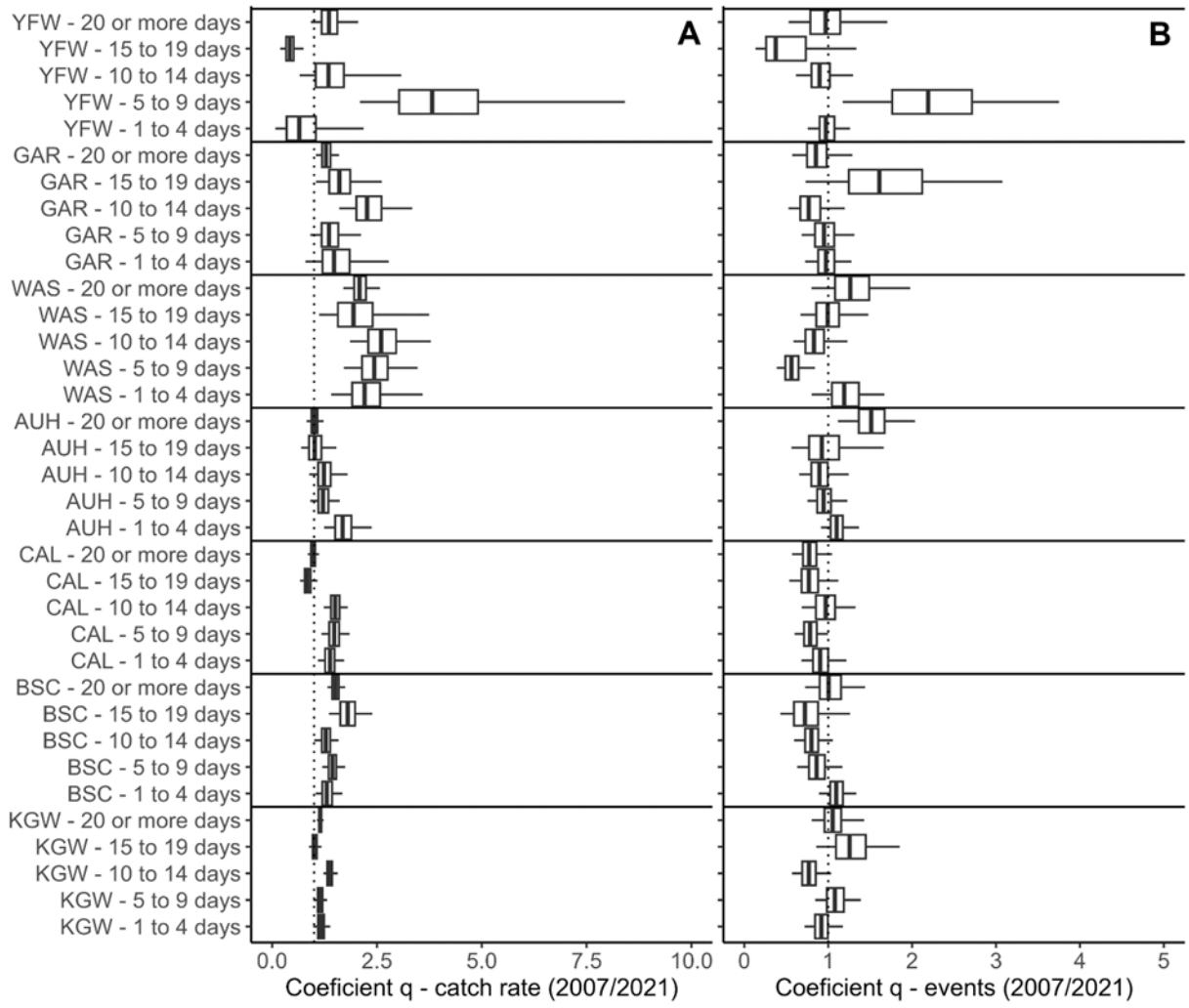

Figure 6.10 Coefficient q distribution for various species at all avidity levels between the State-wide (probability-based) survey of 2021-22 and the State-wide (probability-based) survey of 2007-08, representing (A) catch rate of harvested catch per event and (B) the number of events reported per fisher. The boxplot line indicates the median values, while the box illustrates the interquartile range with 50% of the data. The whiskers indicate the distribution of 95% of the results, and the dashed line represents the value one, which corresponds to no difference between datasets. Abbreviated species include Australian Herring (AUH), Blue Swimmer Crab (BSC), Southern Calamari (CAL), Southern Garfish (GAR), King George Whiting (KGW), Western Australian Salmon (WAS) and Yellowfin Whiting (YFW).

6.8 Key findings and implications

Key Findings:

- Significant differences in terms of catch rates and number of events were observed between the app-based data and the State-wide (probability-based) survey
    - The app-based data had higher catch rates and lower event numbers.
    - Adjustments based on coefficient q were necessary to correct for the differences, varying by species and fisher avidity.
    - Expanding the app-based data without these adjustments would lead to overestimation of catch per event and underestimation of total catch.
- Variability in reported catch rates and effort was observed across different avidity groups

    - Highly avid fishers reported significantly fewer events in the app-based data compared to the State-wide survey.
- Yellowfin Whiting, Western Australian Salmon, and Southern Garfish exhibited the largest variabilities in the coefficient q due to their lower sample sizes in the app-based data.
- The raking expansion method, combined with coefficient q adjustments, provided comparable estimates of harvest with the State-wide survey for most species but tended to overestimate the number of days fished (except for Blue Swimmer Crab and Southern Calamari).
- Estimates using unadjusted data performed poorly, highlighting the importance of applying screening and coefficient q adjustments.
- The propensity scores method and statistical matching, which rely on a probabilistic sample, yielded similar results to the State-wide survey and improved the accuracy of estimating days fished, compared to raking. Statistical matching provided improved estimates of both catch and effort for species like Southern Garfish and Yellowfin Whiting, which had smaller sample sizes.
- The model-based approach, relying on individual-level covariate information, provided catch and effort estimates that were comparable to the State-wide survey for most species compared to most other expansion methods.
    - The model-based approach outperformed other methods in estimating catch values for some species, while raking provided greater accuracy for others.
    - Statistical matching yielded the best estimates for some species but overestimated catch for others.
- Adjusting for biases in non-probability surveys and using appropriate expansion methods are crucial for obtaining reliable estimates of catch and effort.
- Further research is needed to compare app-based and probability-based survey estimates to improve adjustment accuracy, considering the impact of participant turnover on correction factors over time.
- The findings provide valuable information for management and conservation efforts by aiding in the estimation of harvested catch and days fished for different species.
- The study highlights the need for a robust methodology that combines adjustment techniques and population totals to obtain accurate estimates in non-probability surveys.

Implications:

- To improve the accuracy of catch and effort estimates across a fuller range of species, it is important to adjust the app-based data to account for differences between the app-based data and the State-wide survey.
- The raking method can be a useful expansion method when a probabilistic sample is not available, but caution should be exercised as it may overestimate the number of days fished.
- The propensity scores and statistical matching methods, which rely on probabilistic samples, provide comparable estimates to the State-wide survey and improve the accuracy of estimating days fished, especially for species with limited sample sizes.
- The model-based approach can be valuable when a sampling design is absent, such as with app-based data, but it requires individual-level covariate information for the entire fisher population (which can be estimated from expanding the probabilistic sample with census data).
- The choice of expansion method should be based on the available data and the specific species being analysed.
- Researchers should be aware of the limitations and biases associated with app-based data and respond appropriately to address them when estimating catch and effort.

7. Recommendations

7.1 Introduction

This section aims to provide overall recommendations for collecting and analysing species-specific data on recreational fishing catch and effort. It is important to note that these recommendations are based on a survey conducted in South Australia during 2021–22, using a study-specific app. As such, it is crucial to consider the suitability of these recommendations based on research goals, population parameters, recruitment methods, and available resources.

The following key recommendations are discussed in this chapter:

- **Improving survey design and data quality for accurate catch and effort estimates:** Addressing selective reporting in app-based data, adjusting for disparities in catch rates, considering temporal variations, and implementing assessment tools to enhance reporting quality.
- **Understanding human dimensions:** Exploring key variables to adjust and expand catch estimates.
- **Expanding data:** Evaluating and selecting appropriate data expansion methods, adjusting app-based data for differences with probability-based surveys, and refining techniques for accurate estimates.
- **Enhancing user engagement:** Implementing key improvements for well-designed and effectively promoted apps.
- **Streamlining data collection:** Determining necessary data for accurate catch and effort estimates, simplifying reporting processes, and ensuring validity and accuracy.

The final section provides a summary of these recommendations, underscoring their significance in improving the collection and analysis of species-specific data on recreational fishing catch and effort. By incorporating these recommendations, researchers can enhance the quality and reliability of their data, contributing to a better understanding of recreational fishing activity and supporting effective management strategies.

7.2 Improving survey design and data quality for accurate catch and effort estimates

During this study, it was evident that app-based respondents exhibited recall bias by selectively report fishing events, focusing on what they considered successful outings. Events with low or no catch were more likely to go unreported due to participant forgetfulness, loss of interest, or study dropout, resulting in higher catch rates but fewer reported fishing events. This emphasises the need for a large proportion of recreational fishers to participate in app-based reporting and continued use overtime as highlighted by Brick et al. (2022). In contrast, traditional probability-based surveys typically generate data of higher quality due to the structured nature of interviewer-led data collection, which helps to mitigate recall bias. However, traditional surveys face challenges such as declining response rates and limitations in sampling frames, which introduce additional sources of bias.

To improve the accuracy of catch and effort estimates from app-based surveys, disparities in catch rates and temporal variations must be considered. To inform the expansion of catch estimates, this study compared catch rates between the non-probability app-based survey and probability-based phone survey, revealing significant differences for most species. Specifically, estimates of catch rates were higher from the app-based survey for Western Australian Salmon, Southern Calamari, King George Whiting, and Australian Herring, while

the number of reported events for all species was significantly lower compared to the phone survey. This demonstrates that adjustments are essential to prevent over-estimation of catches per event and under-estimation of fishing frequency per fisher in app-based data. Such adjustments improve accuracy of estimates at the scale of the entire fisher population. While catch rate benchmarks displayed temporal variability, indicating the need to consider these variations in future analyses, the number of events reported per fisher did not vary between the surveys (i.e., 2007/08 and 2021/22), indicating that updated values to support adjustments were less likely to be required when estimating effort. A more comprehensive examination across multiple survey years would provide a more nuanced understanding of temporal trends and variability. Nevertheless, the findings suggest that app-based data could serve as a valuable proxy for monitoring effort between large-scale probability-based surveys, albeit with the caveat of considering the limited temporal scope of our analysis.

A key obstacle to the implementation of stand-alone app-based surveys is that non-probability surveys are reliant on probability-based surveys to provide the only available population estimates of recreational fishers which are treated as “population benchmarks” to expand app-based estimates to the population. Therefore, there is a need to consider how to use app-based data if reliable benchmarks are unavailable. While absolute estimates of catch and effort from app-based data are unlikely to be accurate or precise without adjustment, there is still potential to monitor observed variations in app-based catch estimates to examine general trends in exploitation. By maintaining consistent data collection through time, observations of trends in catch and effort could be useful to trigger additional data collection (e.g., on-site or off-site probabilistic surveys), linked to informing stock assessment and to inform adaptive management strategies.

Another important consideration is the potential under-reporting of less important species from app-based data. During this study, only 59% of fishers documented reporting all caught species, with reporting levels varying by target, retained and released species, or in an *ad hoc* manner. Assessing and incorporating reporting quality into catch and effort estimates is crucial. Wash-up surveys have addressed this issue, but integrating assessment tools and prompts within the app, potentially using AI technologies, can provide a more seamless and efficient approach.

To address these challenges, the development of tools for assessing reporting quality and their incorporation into catch and effort estimates is recommended. Obtaining species-specific catch rate data is crucial for generating app-based estimates and improving their accuracy. These data contribute to addressing missing data from different population groups and improving the reliability of catch and effort estimates. There is a need to develop cost-effective methods for obtaining these data. Such methods may include probability-based screening surveys, without the associated longitudinal (diary phase) survey, to obtain regular estimates of participation and understand fisher profiles (e.g., demographics and avidity). While large-scale general population surveys are challenging due to sampling frame limitations and low response rates, by focusing on only the screening component, the cost can be reduced. In addition, on-site survey methods such as traditional creel or access-point surveys (Lai et al. 2019), or more modern alternatives such as using remote cameras and drones (Desfosses et al. 2019, Hartill et al. 2020, Lai et al. 2021, Dainys et al. 2022), are likely to be most beneficial for gathering species-specific data or to answer specific management questions. Achieving adequate spatial and temporal coverage for on-site surveys is, however, often cost-prohibitive.

In summary, the key recommendations to improve data quality and estimates of catch rates are:

- **Recommendation 1:** Develop cost-effective methods for obtaining species-specific catch rates to improve app-based data collection, expand app-based data and improve accuracy, including the integration of ancillary data sources.
- **Recommendation 2:** Incorporate assessment tools and prompts within the app to improve reporting quality and facilitate comprehensive catch and effort estimates.
- **Recommendation 3:** Develop tools to monitor variation in catch rate over time for adaptive management strategies.

7.3 Understanding human dimensions

To improve catch estimates, it is crucial to consider the human dimensions associated with recreational fishing, such as avidity, specialisation, commitment, and skill, as identified by previous studies (Ditton et al. 1992, Oh and Ditton 2006, Beardmore et al. 2013, Gundelund et al. 2020). By exploring these key variables, adjustments can be made to expand catch estimates and capture a more comprehensive picture of recreational fishing activity. Human dimensions of fishing are highly complex, but to correct for potential biases, there is a need to understand the diversity in consumption orientation, which influences angler behaviour and choice, particularly in multi-species fisheries (Gundelund et al. 2020, Lewin et al. 2023).

While the present study considered fishing avidity as a key variable in adjusting and expanding catch estimates, the ability to characterise fisher behaviour was limited due to the lack of available behavioural data for the recreational fishing population, specifically data collected during the screening survey. The wash-up survey of app-based participants indicated that a significant proportion ranked fishing as highly important when compared to other hobbies, indicating a strong motivation for fishing and a higher proportion of advanced and expert anglers represented in the app-based data. It should, however, be noted that the sample size of the app-based wash-up survey was relatively small. Future research should prioritise achieving a more comprehensive understanding of fishers' values, beliefs, and motivations that drive their engagement in fishing with the view of using this information during adjustment and expansion, as these factors can significantly influence their behaviour and interactions with the environment. This notion was highlighted by Gundelund et al. (2020), who found that fisher behaviour, particularly specialisation and commitment, likely results in biased (higher) catch rates. However, it is worth noting that specialisation, as per the recreational specialisation theory, does not always correlate with high levels of avidity.

In summary, the key recommendations to enhance our understanding of fisher behaviour are:

- **Recommendation 4:** Collect and analyse behavioural data, including fishing duration, location, gear used, and fisher characteristics, to improve catch estimates. Consider including questions that prompt respondents to rate their fishing experience, which can help capture days spent fishing without a catch.
- **Recommendation 5:** Identify and incorporate key variables that significantly influence catch estimates into app-based surveys.
- **Recommendation 6:** Conduct targeted research to understand the relationship between behavioural data and catch estimates for different species and fishing scenarios.

7.4 Expanding data

Expanding data collection methods beyond app-based data can improve the accuracy and representativeness of catch and effort estimates. Evaluating and selecting appropriate data expansion methods, such as combining data from multiple sources, can enhance the reliability of estimates. Additionally, adjusting app-based data to align with probability-based surveys is crucial for generating accurate and comparable estimates. Despite the limitations of the current probability-based survey design, such as recall bias and declining response rates, they

are designed with rigorous methodologies to minimise biases and are widely regarded as robust tools for estimating fishing activity. While absolute estimates of catch and effort are not available, probability-based surveys allow for comparison against a statistical representation, enabling the assessment of under- or over-reporting. It is crucial to recognise that without the probability-based survey, expansion of app-based data would not be possible.

The present study drew on statistical methods which are widely implemented across the social sciences discipline but rarely applied in the context of recreational fishing surveys, as discussed by Brick *et al.* (2022).

Several key findings emerged when exploring methods to expand catch and effort estimates:

- Different expansion methods showed varying levels of accuracy (compared to the State-wide survey) and suitability for estimating catch and effort.
- The raking method (Deville and Särndal 1992, Deville et al*.* 1993), which utilises census data and participation rates, provided comparable estimates of harvest but tended to overestimate the number of days fished.
- The propensity scores (Terhanian et al*.* 2001) and statistical matching (Rivers 2007) methods, relying on probabilistic samples, yielded similar results to the State-wide survey and improved the accuracy of estimating days fished, especially for species with limited sample sizes.
- The model-based approach (Friedman et al*.* 2010), which used a trained model with app-based data, showed comparable outcomes to the State-wide survey and improved harvest estimates for many species, albeit with larger standard error values. However, it is important to note that multilevel regression with post-stratification (MRP) was not evaluated in this study due to biases in the app-based data and the lack of consistent longitudinal data.

Based on these findings, several recommendations can be made. Researchers should carefully consider the selection of an appropriate expansion method based on the available data, the species being analysed, and the nature of the estimation (e.g. catch versus effort). The raking method can be useful when census data is available, but caution should be exercised as it may overestimate the number of days fished. The propensity scores and statistical matching methods provide comparable estimates to the State-wide survey and improve the accuracy of estimating days fished, particularly for species with limited sample sizes. The model-based approach can be valuable when a sampling design is absent, such as with app-based data, but it requires comprehensive individual-level covariate information for the entire fisher population. Further research should investigate the potential of MRP in a mandatory app setting, considering the challenges associated with biases and ensuring consistent longitudinal data. Researchers should investigate limitations and biases in data obtained from app-based platforms to help decide on the appropriate measures required to improves estimates of catch and effort.

In summary, the key recommendations to improve data expansion are:

- **Recommendation 7:** Investigate and address potential recall biases in probability-based data sources to further improve the reliability of these surveys as benchmarks.
- **Recommendation 8:** Explore and incorporate data expansion methods, such as combining app-based data with other sources (e.g., creel surveys, logbook data), to improve the representativeness of catch and effort estimates. Investigate expansion models that are independent of individual fishers to reduce the influence of underreporting. Additionally, investigate adjustments using previous probability surveys to improve the accuracy of expansion models.

- **Recommendation 9:** Select appropriate expansion methods based on the suitability and availability of data (e.g., model-based approaches where expansion data are available) to enable comparability of estimates.
- **Recommendation 10:** Refine data expansion techniques to account for potential biases and uncertainties associated with different data sources. Investigate the potential of MRP for disaggregating expansion results to provide more detailed insights into catch and effort estimates.

7.5 Enhancing user engagement

To maximise recruitment and retention, app interfaces need to be well-designed, aesthetically pleasing, efficient and easy to use, well-incentivised and highly versatile (Ng and Vuong 2014, Venturelli et al. 2017, Gundelund et al. 2020). The design of the app-based data collection platform in this study was relatively simple, and even without the custom features that would be available in a bespoke app, most participants found it easy to use. The decision for a straightforward design was driven by the necessity to deploy the app concurrently with the State-wide survey, demanding rapid development. While a diverse range of communications tools were used, it was challenging to implement effective strategies given the number and diversity of stakeholders. There was a clear demand for increased engagement. Based on stakeholder feedback and expert opinions in the literature, several potential improvements could be considered for future app-based studies to enhance user engagement, data quality, and overall effectiveness. However, it's important to note that the effectiveness of these strategies in the specific context of recreational fishing apps requires further research. Potential areas for improvement and investigation include:

- **User experience:** The overall user experience of the app, including its ease of use, functionality, and design, significantly impacts recruitment, retention, and reporting (Skov *et al.* 2021) . A user-friendly app with intuitive navigation and clear instructions can attract more participants and encourage continued engagement.
- **Incentives and motivation:** Providing incentives or rewards for participation, such as discounts on fishing gear, entry into prize draws, or recognition for contributions, can motivate users to join and remain engaged with the app-based data collection platforms. Gamification techniques, including challenges, badges, and leader boards, could also enhance motivation and increase participation (Garaialde *et al.* 2021). Some popular apps like Fishbrain already utilise social networking features, logging and tracking of catches and personalised statistics and insights.
- **Communication and reminders:** Effective communication plays a crucial role in recruitment, retention, and reporting. Timely and informative push notifications, reminders, and updates through the app can encourage users to report their fishing activities regularly (Skov *et al.* 2021). Balancing the frequency and content of communication is important to avoid overwhelming users while keeping them engaged.
- **Data privacy and ownership:** Addressing concerns related to data privacy and ownership is vital for recruitment, retention, and reporting (Skov *et al.* 2021). Users need reassurance that their personal information and fishing data will be managed securely and used appropriately (e.g. survey findings will not impact their access to fishery resources). Clearly communicating data privacy policies and ensuring transparent data management practices can build trust and encourage participation.
- **Education and awareness:** Providing educational resources and information within the app about the importance of reporting and compliance with fishing regulations can increase user understanding and motivation (Skov *et al.* 2021). Outreach projects should help the public improve species identification and understand the importance of reporting all fishing events, including non-catch ones (Venturelli *et al.* 2017). Instilling a sense of social license among participants is crucial, as it educates them on how their contributions support the sustainability of recreationally important species and

overall fisheries health. Incorporating educational materials and compliance reminders within the app, along with incentives for regulation adherence, can further enhance education and rule compliance within the recreational fishing community.

- **Marketing and promotion:** Effective marketing and promotion efforts can help attract and retain users to achieve a representative sample of the target population (Brick *et al.* 2022). Promoting the app through various channels, including social media, fishing communities, fishing clubs, and relevant websites or forums, can increase awareness and encourage participation.
- **Tailored approaches:** Considering the diversity of recreational fishers, tailoring recruitment, retention strategies and perhaps survey tools/methods to specific demographic groups or user preferences can enhance engagement. Understanding the needs, interests, and cultural contexts of different user groups allows for targeted approaches that resonate with the intended audience. This could include partnerships with trusted influencers (e.g. fishing celebrities or personalities, local fishing clubs or associations, and advocacy groups like Tuna Champions (Tracey *et al.* 2023)).
- **Collaborative development:** Engage regulatory bodies, researchers, fishery managers, software developers, and recreational anglers in co-design processes to ensure that app interfaces meet diverse stakeholder needs.

By understanding and addressing these factors, app-based data collection platforms for recreational fishing can optimise recruitment, retention, and reporting, resulting in a more comprehensive and reliable dataset. Implementing effective recruitment strategies, incorporating user feedback for app design and promotion, conducting outreach projects, and increasing the sample size will contribute to overcoming the challenges associated with app-based data collection and improve the accuracy of catch and effort estimates. However, the effectiveness of these strategies will require further research in the context of recreational fishing apps.

It is also important to recognise that recruitment to both probability and non-probability surveys will continue to face challenges where suitable sampling frames are not available. Exploring different sample frame approaches, such as non-exempt registration systems, could enhance the cost efficiency of surveys, improving the accuracy and precision of the collected data.

In summary, the key recommendations to enhance app design are:

- **Recommendation 11:** Enhance app design to improve user experience and engagement, making them user-friendly and intuitive. Ensure robust privacy and security measures are in place.
- **Recommendation 12:** Implement features that promote data accuracy and completeness, such as data validation checks and reminders for reporting. Develop these features through collaborative co-design efforts to ensure they meet the needs of various stakeholders.
- **Recommendation 13:** Invest in effective promotion, outreach strategies, and alternative sampling frames like registration systems. Consider collaborations with fishing clubs and organisations to boost app adoption and user participation.

7.6 Streamlining data collection

Efficient and streamlined data collection processes are essential for accurate catch and effort estimates. Determining the necessary data elements for estimation purposes, simplifying reporting processes, and ensuring the validity and accuracy of reported data are key aspects to consider. While apps are an exciting data collection tool with much potential, it is important to develop standards and guidelines to enable scientists and managers to utilise and synthesise the data collected across multiple apps (Venturelli et al. 2017).

Many apps are already available to collect information on recreational fishing activity (see Chapter 4). The quality and availability of data on the participants who chose to report fishing activity is, however, highly variable. Where demographic information (e.g., gender, age, education, country of birth, residential stratum) is collected from app-based studies and reference data (usually from a probability-based survey) exist, it is possible to correct for any under- or over-represented groups using post-stratification or other methods (see Chapter 6). Each of the expansion methods used in this study considered demographic co-variates to account for the self-selected nature of the app-based study, to reduce the potential biases. This followed on from work by Gundelund et al. (2021) and Jiorle et al. (2016) who suggested that incorporating demographic information for the expansion of estimates, and comparing results with an extended probability-based survey would enhance the understanding of app-based data.

Although conducting large-scale probability-based surveys can be resource-intensive and may face challenges such as limited sampling frames, declining response rates, and potential sampling biases (Pollock 1994, Lyle *et al.* 2010), they remain the most statistically robust framework for making population-level inferences about recreational fisheries (Taylor and Ryan 2020, Taylor *et al.* 2021). This is because there is generally no population-wide survey, such as a census, which collects this specific information. Therefore, it will continue to be necessary to rely on large-scale probability-based surveys to provide population benchmarks. This approach aligns with the recommendations of Papenfuss et al. (2015), who suggested that due to the various biases to consider and the wide-ranging spatial trends in angler demographics, app-based data is more likely to complement probability-based surveys rather than replace them.

To address the concerns around data quality, this study highlighted the following key areas for improvement:

- **Define and collect the necessary data:** Determine the specific data elements required for accurate catch and effort estimates in app-based data and other relevant sources. This includes identifying key variables such as species caught, location, date, and fishing effort, which are essential for robust analysis.
- **Streamline data collection processes:** Simplify and optimise the reporting processes within the app to enhance user experience and encourage regular reporting. Provide clear instructions, intuitive interfaces, and options for efficient data entry to streamline the data collection process and increase user engagement.
- **Validate and verify data:** Implement validation checks and data verification processes to ensure the accuracy and quality of reported information. Consider incorporating mandatory fields, error checks, and cross-referencing with other data sources when feasible to validate and verify the collected data.
- **Align data collection tools with target population characteristics:** Tailor the design and functionality of data collection tools to match the preferences and profiles of the recreational fishing population. Consider user demographics, technological literacy, and cultural factors when developing data collection tools to enhance user engagement and participation.
- **Embrace technological advancements:** Leverage advancements such as artificial intelligence and photo recognition technologies to facilitate species identification and data collection. Investigate the potential of integrating these tools within the app to improve data accuracy and efficiency.
- **Integrate with existing data sources:** Explore opportunities to integrate app-based data with existing data sources, such as fishery management databases or citizen science initiatives, to complement the overall data collection efforts. This integration can provide a more comprehensive and robust dataset for analysis and decision-making.

- **Ensure data privacy and security:** Implement robust data privacy measures to address user concerns and build trust. Clearly communicate data protection policies, anonymise personal information, and adhere to applicable data privacy regulations to safeguard user data.
- **Regularly assess data collection methods:** Continuously evaluate the effectiveness of data collection methods and tools through user feedback, pilot studies, and iterative improvements. Regularly review and update data collection protocols based on emerging best practices and technological advancements to ensure the continuous improvement of data collection processes.

It is important to note that while this study focussed on a voluntary app-based trial, many of the above considerations would also be relevant for mandatory data collection. It is critical to ensure that any data collected is accurate to provide robust information to inform fishery stock assessment and management.

In summary, the key recommendations to streamline data collection are:

- **Recommendation 14:** Identify the essential data elements (including demographics) required for accurate catch and effort estimates, minimising reporting burden while capturing crucial information.
- **Recommendation 15:** Streamline the reporting processes within the app to make it convenient and time-efficient for users to report their fishing activities. Tailor data collection tools to user preferences, consider user feedback and conduct user research to optimise user experience.
- **Recommendation 16:** Implement quality control measures, such as data validation checks and audits, to ensure the validity and accuracy of reported data. This can involve data validation rules, automated checks, or user-driven verification processes.
- **Recommendation 17:** Leverage advancements in technology, such as artificial intelligence and photo recognition, to facilitate species identification and data collection.
- **Recommendation 18:** Continue to compare data from apps with probabilistically-derived results and develop new expansion techniques to enhance accuracy and ensure robustness in catch and effort estimates. Investigate innovative methods that integrate app-based data with other sources and consider adjustments using previous probability surveys to improve the representativeness and reliability of estimates.

7.7 Conclusion

In conclusion, the effectiveness of app-based data collection in the context of supporting fisheries stock assessment and informing management requires objective evaluation. The present study demonstrated significant differences in app-based catch rates and reported events compared to the State-wide (probability-based) survey, requiring adjustments to ensure comparable estimation. This was due to variability in reported catch rates and effort across different avidity groups, as well as limitations in estimating catches for specific species, This underscores the limitations of relying solely on app data and emphasises the importance of implementing adjustments and expansion methods to enhance the accuracy of catch and effort estimates. It is crucial to acknowledge that, despite the potential of emerging technologies and applications, we are still a long way from completely replacing (expensive) probabilistic methods. Therefore, a pragmatic approach involving both traditional and modern methods will likely be indispensable in the foreseeable future.

Among the expansion methods examined, raking, propensity scores, statistical matching, and the model-based approach, provided some comparable estimates to the State-wide survey. However, variations in their performance across different species were observed. The model-based approach showed promise in estimating catch values for some species, while statistical

matching yielded the best estimates for others. However, certain methods, including statistical matching, also resulted in over-estimated catch for some species, likely due to the application of expansion weights to underrepresented users with higher catches.

While non-probability expansion models have shown potential for providing estimates of catch and effort in recreational fishing surveys, these methods have limitations. The app-based data demonstrated significant differences in catch rates and reported events compared to the State-wide (probability-based) survey, requiring adjustments to correct for these differences. Failure to apply these adjustments would lead to overestimation of catch per event and underestimation of total catch.

Moreover, the app-based data exhibited variability in reported catch rates and effort across different avidity groups, with highly avid fishers reporting significantly fewer events compared to those from the State-wide (probability-based) survey. Additionally, catch rates were widely variable for species such as Yellowfin Whiting, Western Australian Salmon, and Southern Garfish due to their lower sample sizes in the app-based data. These findings highlight the challenges associated with using app-based data as a reliable source for accurate estimation and management of specific species.

The findings underscore the need to acknowledge the limitations of data from apps before they can be incorporated into stock assessment and fisheries management. To address the limitations, there is a need to increase sample size by focussing on improvements in recruitment and retention by incorporating user feedback to enhance app design and promotion. Exploring different sample frame approaches to build on previous work the work of Vølstad *et al.* (2011) who compared a probability-based survey with self-sampling to estimate catch and effort in Norway, and the recent work of Taylor and Ryan (2020) who compared a general population sample with a registry of boat-based licence holders in Western Australia. Additional research would contribute to a more representative understanding of recreational fishing and improve the overall effectiveness of surveys. These steps are essential for optimising app-based data collection as a valuable tool for recreational fishing data collection. While apps offer great potential for enhancing stock assessment and supporting fisheries management, it is important to recognise that ongoing oversight is necessary to validate and improve the accuracy and completeness of the data. Complementary methods should also be investigated to ensure accurate and reliable assessment, allocation, and management of recreational fisheries.

By implementing the recommendations outlined in this chapter and continuing with efforts to understand the factors influencing recruitment, retention, and reporting, researchers using apps can improve their data collection processes and provide a more comprehensive dataset for stock assessment and fisheries management. Over time, with increasing user participation and longer-term data availability, the biases associated with app-based data collection are likely to decrease, making these methods more useful for obtaining comprehensive and representative information about the recreational fishing community. Therefore, stakeholders should embrace a dual approach of probability-based surveys and app-based data collection, thereby leveraging the strengths of each method.

In addition to its implications for app-based data collection, this study is significant for the broader landscape of data collection in recreational fisheries. The findings shed light on challenges and considerations that extend beyond app-based reporting and may have implications for other apps that collect data voluntarily or under a mandatory framework. In the context of mandatory reporting this is particularly relevant as often there is not a good understanding of the level of reporting accuracy, highlighting the importance of developing robust quality control measures and validation processes. Without such measures, the reliability and usefulness of the collected data may be compromised, leading to inaccurate assessments of recreational fisheries and potentially misguided management decisions.

In particular, the observed variability in catch rates, reported events, and species-specific data adjustments required to expand app-based data may extend to other apps, potentially introducing biases and inaccuracies in the collected data. Researchers and policymakers should exercise caution when relying solely on data from apps and recognise the importance of validation and complementary data sources, including probability-based benchmark survey data. It is essential to thoroughly assess the reliability and quality of data collected through apps and consider the need for multiple sources of information to ensure robust and accurate decision-making in fisheries management. By taking a comprehensive approach that combines app-based data with other validated sources, researchers and policymakers can overcome the limitations identified in this study and gain a more complete understanding of recreational fishing catch and effort. This approach would enable them to develop effective management strategies and sustainable practices that are based on reliable and accurate data.

This study provides insights into the complexities of data collection across diverse platforms. For researchers, policymakers, and stakeholders in recreational fisheries management, it is important to evaluate the constraints, biases, and validation requirements for app-based data and other collection methods. In this study, leveraging an existing multi-purpose recreational fishing app as a survey platform provided advantages such as access to a ready-made user base and rapid development and implementation of the survey. In the future, researchers might look at alternatives like established citizen science platforms or bespoke app development. Each option entails trade-offs in terms of cost, time, data quality, user engagement, and flexibility, necessitating careful consideration to optimise data collection effectiveness in recreational fisheries.

In summary, the recommended enhancements, including improving catch rates and data quality, understanding behavioural data, expanding data collection methods, improving app design, and streamlining data collection processes, will contribute to significant improvements in the collection and analysis of species-specific data on recreational fishing catch and effort. These improvements will enable researchers and policymakers to make more informed decisions and develop effective management strategies for recreational fisheries.

8. Extension and Adoption

Below is a summary of the communications tactics used to promote extension and adoption with key stakeholders.

8.1 Project steering committee

A project steering committee was formed to guide development of this project. This committee includes scientists from South Australia and Tasmania, fisheries managers from PIRSA Fisheries and Aquaculture, representatives from the FRDC, representatives nominated by the Minister's Recreational Fishing Advisory Council (who were the peak body during the early stages of the project) and a representative from the Commercial Fishing Industry. Several invited guests also attended, representing the Australian Recreational Fishing Foundation (ARFF), and members of the project team undertaking the national recreational fishing survey. Overall, five formal meetings were held to discuss project development and progress from December 2020 to July 2021.

8.2 Stakeholder survey and workshop

A summary of the stakeholder survey and workshop is provided in Section 4.

8.3 Project information

The project was promoted across various strategies including the project website, social media, app-based reminders, and notifications (see Section 5.22), participant information sheets, brochures, flyers, and e-newsletters. See Appendix 6 for examples and links.

8.4 Media

Media releases were developed to promote the app-based study, and various articles and interviews took place as a result. In addition, articles were written for key Fishing Magazines to promote the research. See Appendix 6 for examples and links.

8.5 Presentation of findings

The initial findings of the probability-based study and on-site survey for Goolwa Pipi were presented at the World Recreational Fishing Conference in Melbourne during February 2022. Information flyers were developed to promote the results and media coverage was also achieved.

Project members attended a workshop at the World Recreational Fishing Conference ("Toward the integration of digital recreational fisheries data for research and monitoring") to discuss app-based data collection.

A range of stakeholder presentations have been provided during the project, to engage with stakeholder groups including commercial fishers (Executive Officers, Management Advisory Committees, Industry Associations), recreational fishers (Minister's Recreational Fishing Advisory Council, RecFish SA board members), fisheries managers (PIRSA), FishCare volunteers, and fishery scientists (attendance at online workshop 15/12/2022: "Can citizen science, smartphone app and social media data be used for recreational fisheries management?").

Additional stakeholder engagement will take place to promote the results of the final report.

Several draft manuscripts are being developed to promote the outcomes of this research in peer-reviewed journal publications.

Appendices

Appendix 1: References

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Appendix 2: State-Wide Survey Report

Appendix 2 is provided as a separate file and can be accessed at https://www.pir.sa.gov.au/__data/assets/pdf_file/0006/431385/survey-recreational-fishing-sa-2021-22.pdf

Appendix 3: Goolwa Pipi Survey Report

Appendix 3 is provided as a separate file and can be accessed at https://www.pir.sa.gov.au/__data/assets/pdf_file/0007/431386/survey-rec-fishing-pipi-goolwa-sa-2021-22.pdf

Appendix 4: Stakeholder Survey

Recreational fishing data collection and smartphone apps

Welcome to the recreational data collection and smartphone app survey

Smart mobile phones are owned by 83% of adult Australians (ACMA 2020) providing access to a broad suite of 'apps'. These 'apps' can be used for a range of purposes, including: communication, entertainment and data collection. There has been significant interest over the last decade in the potential for 'apps' as a means of conveying information to as well as collecting information from the recreational fishing sector. In particular, 'apps' have been proposed as an alternative to traditional probability-based off- and on-site survey methods, collecting information on participation, catch and effort from recreational fisheries, and in some cases, socio-economic information.

One of the fundamental questions to resolve in regard to the use of 'apps' to collect fisheries information is 'What can/will the data be used for?'. This question will drive the design and implementation of an app and whether the technology is 'fit for purpose'. A further consideration is the potential barriers to adoption that are common to many smartphone applications.

While there is great potential for the use of 'apps' in the recreational fishing space in the future, both for conveying and collecting information, it is important that there is a clear understanding of what the 'apps' roles are and that they are closely aligned with the needs of management agencies and stakeholder groups.

You have been identified as having a representative role in either a management, research, stakeholder group, technical or communications capacity relevant to the study topic. As such, you are invited to complete this survey questionnaire, which should take approximately 20 minutes of your time. Participation is voluntary and you may choose not to complete the survey or withdraw your survey results any time prior to publication. There are no direct benefits to you from participating in this study, however, the results will be used to facilitate an enhanced understanding of the potential utility of smartphone applications and research and management needs for recreational fishing across Australia.

The survey is split into five sections to understand 1) some information about you to set the scene for analysis, 2) information on current smart phone 'apps' relating to recreational fishing in Australia, 3) existing or alternate recreational fishing data collections methods in Australia, 4) management needs from recreational fishing data in Australia, and finally, 5) barriers to the prescribed utility of smartphone 'apps' to collect effective data from recreational fisheries in Australia.

Please carefully consider your answers and answer truthfully, this will provide a true dataset from which to guide the results and subsequent outcomes.

This study has been approved by the Tasmania Social Sciences Human Research Ethics Committee. If you have concerns or complaints about the conduct of this study, you can contact the Executive Officer of the HREC (Tasmania) Network on (03) 6226 2975 (SSHREC) or email ss.ethics@utas.edu.au. The Executive Officer is the person nominated to receive complaints from research participants. You will need to quote H0023766.

Kind regards

The Research Team

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Next

Recreational fishing data collection and smartphone apps

Profiling information

This section aims to understand a little about you. This allows us to look at some factors that may be important when analysing results.

1. Which State or Territory are you representing in this survey? Select one.

2. Which role best represents you? Select one.

- ◯ Resource management
- ◯ Fisheries research
- ◯ Communications
- ◯ App technician
- ◯ Recreational stakeholder representative
- ◯ Other (please specify)

3. How many years have you worked in the recreational fishing space? (best estimate)

4. Do you identify as a recreational fisher, and if so, how frequently do you fish? Select one.

- ◯ I am not a recreational fisher
- ◯ I rarely participate in recreational fishing activities
- ◯ I occasionally participate in recreational fishing activities
- ◯ I regularly participate in recreational fishing activities

5. Which age group are you in? Select one.

6. Do you currently have access to and use a smart phone? Select one.

- ◯ Yes
- ◯ No
- ◯ Unsure

7. Do you currently have access to and use a smart watch? Select one.

- ◯ Yes
- ◯ No
- ◯ Unsure

8. If you have ever had any of the following categories of smartphone apps on your phone, how regularly do/did you manually (type in) record your activity data? Select a response under each category.

	I don't have these kind of apps on my phone	Never	Once or twice	Occasionally	Intermittently	Regularly	Always (without fail)
Diet and health	○	○	○	○	○	○	○
Sport and exercise	○	○	○	○	○	○	○
Fishing	○	○	○	○	○	○	○
Other (please specify)	○	○	○	○	○	○	○

Other

9. If you have ever had any of the following categories of smartphone apps on your phone, what is the longest time period you persisted with manually (type in) recording your activity data? Select a response under each category.

	I don't have these kind of apps on my phone	For a day or so	Less than a week or so	Less than a month or so	Less than a year or so	More than a year
Diet and health	○	○	○	○	○	○
Sport and exercise	○	○	○	○	○	○
Fishing	○	○	○	○	○	○
Other (please specify)	○	○	○	○	○	○

Other

10. Create a unique six-digit numeric id code for your responses. Keep this number safe as you can use it to identify your survey response at a later date if you request it.

Information on current smartphone 'apps' relating to recreational fishing

This section aims to understand a little about the smart phone 'apps' that are currently used in your jurisdiction relating to recreational fishing. This allows us to set a benchmark of where Australia is currently in regard to using recreational fishing apps and their purpose.

11. Does your jurisdiction have a Government managed recreational fishing smart phone application?

- ◯ Yes
- ◯ No
- ◯ Unsure

12. What functions does your Government managed application currently have?

	Yes	No	Unsure
Information on rules and regulations	◯	◯	◯
Species identification guide	◯	◯	◯
Voluntary catch reporting	◯	◯	◯
Compulsory catch reporting	◯	◯	◯
Management of licencing/registration/permitting	◯	◯	◯
Static maps of fishing areas	◯	◯	◯
Geo-locating capabilities	◯	◯	◯
Other (please specify)	◯	◯	◯

Other

13. Rank in order of the value you feel each function of the Government managed app currently has to fisheries management in your jurisdiction? (Rank from highest (1) to lowest)

≡ ⬍	Information on rules and regulations	☐ N/A
≡ ⬍	Species identification guide	☐ N/A
≡ ⬍	Voluntary catch reporting	☐ N/A
≡ ⬍	Compulsory catch reporting	☐ N/A
≡ ⬍	Management of licencing/registration/permitting	☐ N/A
≡ ⬍	Static maps of fishing areas	☐ N/A
≡ ⬍	Geo-locating capabilities	☐ N/A
≡ ⬍	Other (please specify)	☐ N/A

14. Other

15. How effective do you think each of the functions of the current version of the Government managed application are for their purpose in your jurisdiction?

	Not at all effective	Not very effective	Somewhat effective	Very effective	Unsure	N/A
Information on rules and regulations	○	○	○	○	○	○
Species identification guide	○	○	○	○	○	○
Voluntary catch reporting	○	○	○	○	○	○
Compulsory catch reporting	○	○	○	○	○	○
Management of licencing/registration/permitting	○	○	○	○	○	○
Static maps of fishing areas	○	○	○	○	○	○
Geo-locating capabilities	○	○	○	○	○	○
Other (please specify)	○	○	○	○	○	○

Other

15. How effective do you think each of the functions of the current version of the Government managed application are for their purpose in your jurisdiction?

	Not at all effective	Not very effective	Somewhat effective	Very effective	Unsure	N/A
Information on rules and regulations	○	○	○	○	○	○
Species identification guide	○	○	○	○	○	○
Voluntary catch reporting	○	○	○	○	○	○
Compulsory catch reporting	○	○	○	○	○	○
Management of licencing/registration/permitting	○	○	○	○	○	○
Static maps of fishing areas	○	○	○	○	○	○
Geo-locating capabilities	○	○	○	○	○	○
Other (please specify)	○	○	○	○	○	○

Other

	Haven't heard of it	Aware of it	Downloaded it	Used it	Use it regularly
AFANT Research App	☐	☐	☐	☐	☐
Catchability	☐	☐	☐	☐	☐
Fishabout	☐	☐	☐	☐	☐
FishAngler-Fishing App	☐	☐	☐	☐	☐
FishBrain	☐	☐	☐	☐	☐
Fishbox – Fishing forecast App	☐	☐	☐	☐	☐
FishRanger	☐	☐	☐	☐	☐
FishSmart NSW – NSW Fishing	☐	☐	☐	☐	☐
GoFishVic	☐	☐	☐	☐	☐
Gone Fishing Day	☐	☐	☐	☐	☐
iAngler Tournament	☐	☐	☐	☐	☐
iFish Forever	☐	☐	☐	☐	☐
IGFA Catch Log	☐	☐	☐	☐	☐
Iki Jime App	☐	☐	☐	☐	☐
Movtan Fishing	☐	☐	☐	☐	☐
My Fishing Mate Australia	☐	☐	☐	☐	☐
NT Fishing Mate	☐	☐	☐	☐	☐
Pro Angler – Fishing App	☐	☐	☐	☐	☐
QLD Fishing 2.0	☐	☐	☐	☐	☐
Recfishwest App	☐	☐	☐	☐	☐
REDMAP	☐	☐	☐	☐	☐
Reel It In	☐	☐	☐	☐	☐
SA Recreational Fishing Guide	☐	☐	☐	☐	☐
Salmon Slam	☐	☐	☐	☐	☐
SCF Australia	☐	☐	☐	☐	☐
Tacklebox	☐	☐	☐	☐	☐
Tasmanian Sea Fishing Guide	☐	☐	☐	☐	☐
The Australian Fishing App	☐	☐	☐	☐	☐
TMF-Citizen Science	☐	☐	☐	☐	☐
Total Fishing Australia	☐	☐	☐	☐	☐
Track My Fish Citizen Science	☐	☐	☐	☐	☐
Track My Fish for Tournaments	☐	☐	☐	☐	☐
Yakhunters Australia	☐	☐	☐	☐	☐
WeFish	☐	☐	☐	☐	☐

18. How do you rank the value to recreational fisheries management in the future of each of the smartphone app functions below, whether on a Government or non-Government managed app? (Rank from highest (1) to lowest)

- Information on rules and regulations
- Species identification guide
- Reporting of fishing trip information
- Management of licencing/registration/permitting
- Static maps of fishing areas
- Geo-locating capabilities
- Tournament catch logging
- Other (please specify)

Existing or alternate recreational fishing participation, catch, and effort data collection methods

This section is to understand a bit more about what data collection methods are used for recreational fishing data in your jurisdiction.

19. Does your jurisdiction currently use participation, catch and/or effort data collected from smart phone apps for fisheries management?

- ◯ Yes
- ◯ No
- ◯ Unsure

20. If yes, how is it used?

21. Generally, how familiar are you with each of the following (non-app) data collection methods?

	Not at all familiar	Not very familiar	Somewhat familiar	Very familiar	Unsure
Off-site, probabilistic survey methods (State-wide or focused species/licence surveys)	○	○	○	○	○
On-site (creel) probabilistic survey methods (State-wide or area specific)	○	○	○	○	○
Non-probability-based surveys (Respondent driven/self-selecting surveys, opportunistic on-site surveys)	○	○	○	○	○
Citizen science programs (Angler diary/logbook, fish frames (skeleton) collection programs)	○	○	○	○	○

22. Has your jurisdiction collected participation, catch and effort data from recreational fishing activities using methods other than smart phone apps in the last 10 years?

	Yes	No	Unsure
Off-site, probabilistic survey methods (State-wide or focused species/licence surveys)	○	○	○
On-site (creel) probabilistic survey methods (State-wide or area specific)	○	○	○
Non-probability-based surveys (Respondent driven/self-selecting surveys, opportunistic on-site surveys)	○	○	○
Citizen science programs (Angler diary/logbook, Fish frames (skeleton) collection programs)	○	○	○

23. How confident are you in the reliability and quality of the participation, catch and effort data from a recreational fishery provided by the methods below, relative to all other methods you are familiar with?

	Not at all confident	Not very confident	Somewhat confident	Very confident	Unsure
Off-site, probabilistic survey methods (State-wide or focused species/licence surveys)	○	○	○	○	○
On-site (creel) probabilistic survey methods (State-wide or area specific)	○	○	○	○	○
Non-probability-based surveys (Respondent driven/self-selecting surveys, opportunistic on-site surveys)	○	○	○	○	○
Citizen science programs (Angler diary/logbook, fish frames (skeleton) collection programs)	○	○	○	○	○

Management needs for recreational fishing data

This section is to gain an understanding of data requirements from recreational fishing required for resource and fishery management in your jurisdiction.

24. In general, how important do you think the following types of data are to effectively manage a recreational fishery, where 'managing a recreational fishery' is defined as maximizing stakeholder experience?

	Not at all important	Not very important	Somewhat important	Very important	Unsure
Participation rates (number of fishers)	○	○	○	○	○
Catch data	○	○	○	○	○
Effort data	○	○	○	○	○
Catch rate data	○	○	○	○	○
Social dimensions (satisfaction, etc)	○	○	○	○	○
Economic dimensions (expenditure, value, etc)	○	○	○	○	○

25. In general, how important do you think the following types of data are from a recreational fishery to effectively manage a fish stock?

	Not at all important	Not very important	Somewhat important	Very important	Unsure
Participation rates	○	○	○	○	○
Catch data	○	○	○	○	○
Effort data	○	○	○	○	○
Catch rate data	○	○	○	○	○
Social dimensions (satisfaction, etc)	○	○	○	○	○
Economic dimensions (expenditure, value, etc)	○	○	○	○	○

26. Is recreational participation, catch and/or effort data currently used for any of the following purposes in your jurisdiction?

	Yes	No	Unsure
Stock status reporting	○	○	○
Stock assessment modelling	○	○	○
Resource allocation/sharing	○	○	○
Recreational fishery performance/fisher experience	○	○	○
Manage a fishery to a quota	○	○	○

27. Do you think the need for good quality recreational data (Participation, catch, effort) will increase or decrease over the next 10 years for the following purposes?

	Decrease dramatically	Decrease	Not change	Increase	Increase dramatically	Unsure
Stock status reporting	○	○	○	○	○	○
Stock assessment modelling	○	○	○	○	○	○
Resource allocation/sharing	○	○	○	○	○	○
Recreational fishery performance/fisher experience	○	○	○	○	○	○
Manage a fishery to a quota	○	○	○	○	○	○

28. In general, what do you think is the minimum frequency to collect recreational participation, catch and/or effort data for it to be used effectively for the following purposes?

	Near real time	Regular (annual or biennially)	Periodic (2+ years)
Stock status reporting	○	○	○
Stock assessment modelling	○	○	○
Resource allocation/sharing	○	○	○
Recreational fishery performance/fisher experience	○	○	○
Manage a fishery to a quota	○	○	○

29. Compared with traditional probability-based survey methods (e.g. phone, diary, mail, access point, roving creel, etc) how would you rate the potential use of phone app collected data to support recreational fisheries management in your jurisdiction?

	Not useable	Very low use	Low use	On par	High use	Very high use	Unsure
Participation rates	○	○	○	○	○	○	○
Catch data	○	○	○	○	○	○	○
Effort data	○	○	○	○	○	○	○
Catch rate data	○	○	○	○	○	○	○
Social data	○	○	○	○	○	○	○
Economic data	○	○	○	○	○	○	○

30. How do you feel about the following statements relating to the use of fisher apps to support recreational fisheries research and management in the near future?

	Very skeptical	Skeptical	Undecided	Cautiously enthusiastic	Very enthusiastic	No opinion
A great alternative to existing data collection methods	○	○	○	○	○	○
Easier to manage data collection than existing survey methods	○	○	○	○	○	○
More cost-effective than existing data collection methods	○	○	○	○	○	○
A great tool to communicate real-time fishing management regulations	○	○	○	○	○	○
A great tool to assess recreational fishing in specific areas (Commonwealth MPAs, etc)	○	○	○	○	○	○
A modern alternative to Angler Diary/Logbook programs	○	○	○	○	○	○
A source of high-quality data for specific fisheries management decisions if apps made compulsory	○	○	○	○	○	○
A useful supplementary tool to existing data collection methods	○	○	○	○	○	○
Quality data from a respondent driven/self-selecting source	○	○	○	○	○	○

31. Do you agree or disagree with the following statements?

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Unsure
Data collected for the purpose of managing a recreational fishery should be collected by the Government or an affiliated research agency.	○	○	○	○	○	○
Using a smartphone application to collect data towards assessment and management of recreational fisheries will only work effectively if reporting is mandatory.	○	○	○	○	○	○
Respondent driven 'opt in' reporting of catch data is useful for fisheries management.	○	○	○	○	○	○
An important component of managing recreational fisheries is understanding the needs and values of recreational fishers.	○	○	○	○	○	○
An important component of managing recreational fisheries is understanding the catch and effort from the sector so this can be considered for effective management of fish stocks.	○	○	○	○	○	○
Trends in recreational catches can be useful even if data quality is low.	○	○	○	○	○	○
Angler diary programs improve engagement with the sector.	○	○	○	○	○	○
Angler diary programs generate data that contribute to the management of recreational fisheries.	○	○	○	○	○	○
In general, recreational fisheries do not have a large impact on fish stocks so collecting catch and effort information is desirable but not essential.	○	○	○	○	○	○
Not everyone needs to report their catch data so long as those who do, report accurately	○	○	○	○	○	○
Smartphone apps are a great way to enhance a fishers fishing experience	○	○	○	○	○	○

32. How much of a barrier do you think the following aspects are to fully achieving the potential use of app data in support of assessing and managing recreational fisheries?

	Major barrier	A barrier	Might be a barrier	Not a barrier	Unsure
Uptake by a sufficient number of people (recruitment)?	○	○	○	○	○
Ongoing, persistent use for data reporting (retention)?	○	○	○	○	○
Data privacy concerns?	○	○	○	○	○
Perceived use of data to 'regulate' fishers?	○	○	○	○	○
Necessary complexity of app design in order to record useful data?	○	○	○	○	○
Ongoing government costs and commitment for app maintenance, upgrades, data management, analysis and reporting?	○	○	○	○	○
Compatibility of app reported data with data required to effectively manage recreational fisheries?	○	○	○	○	○
Reliability of the self-reported phone app data?	○	○	○	○	○
Institutional resistance to the use of app data (from researchers and/or managers)?	○	○	○	○	○
Longevity of the app (including institutional support to maintain and upgrade)?	○	○	○	○	○
On-going fisher support and engagement with the app platform?	○	○	○	○	○
Integration to existing data collection programs?	○	○	○	○	○
Dilution of participation in a suitable app due to too many other fishing app options available?	○	○	○	○	○

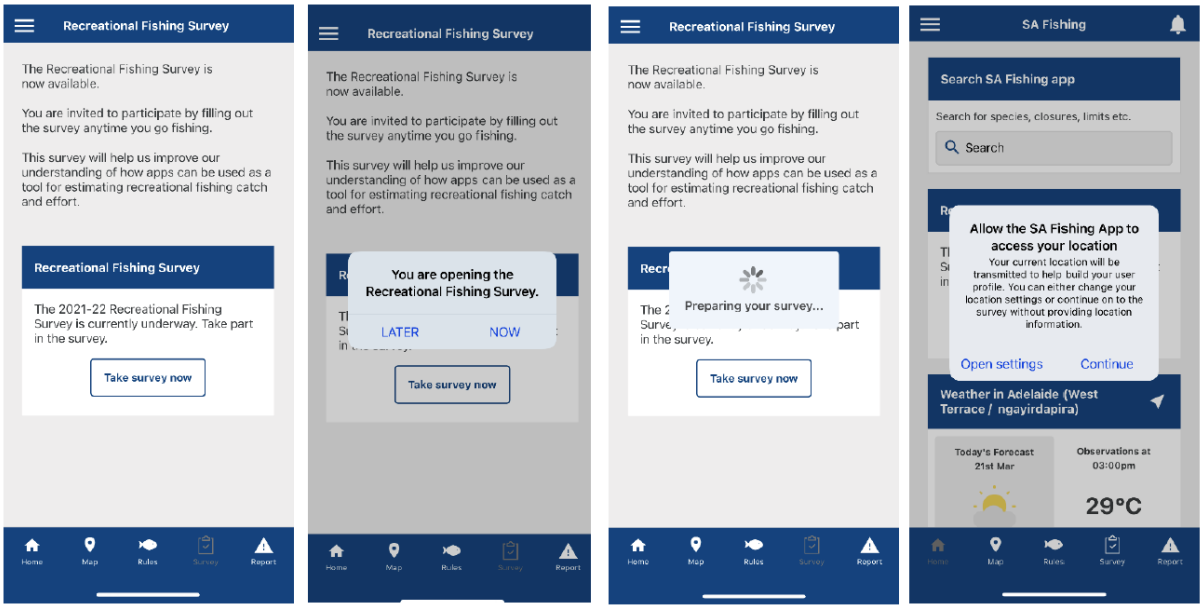
Thank you for completing the recreational fishing data collection and smartphone app survey

The results of the survey will not be identifiable by name, but we will collect information on the jurisdiction you are from, the field of work you are in and your age group. These fields will be used as factors when we consider the analysis of the survey results. No results will be presented at a resolution where it might be possible to identify an individual, without prior written consent. The non-identifiable data will be stored on password protected databases at Utas.

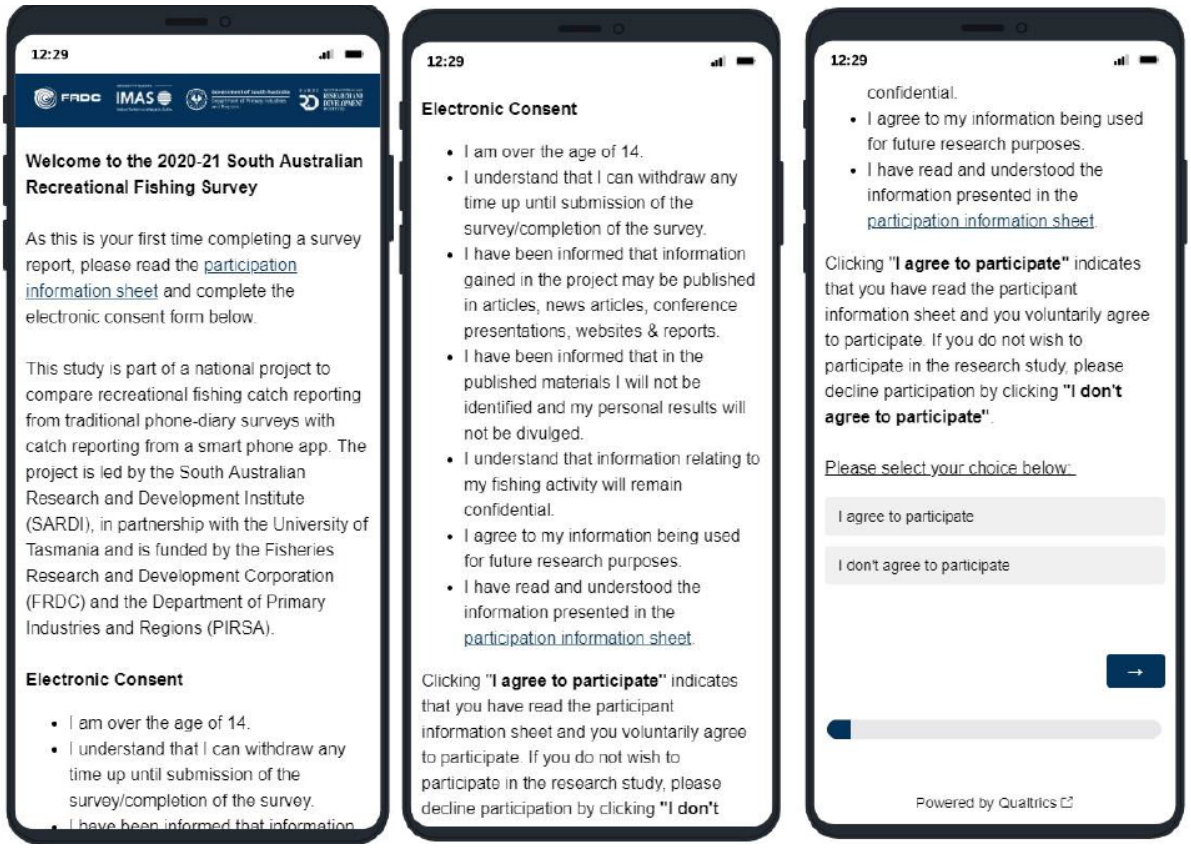
The results of the survey will be a component of the final report for the FRDC funded project: 2020-56 Evaluation of a smart-phone application to collect recreational fishing catch estimates, including an assessment against an independent probability-based survey, using South Australia as a case study. The results may also be drafted into a manuscript for submission to an international peer-reviewed journal.

Appendix 5: App-based data collection screenshots

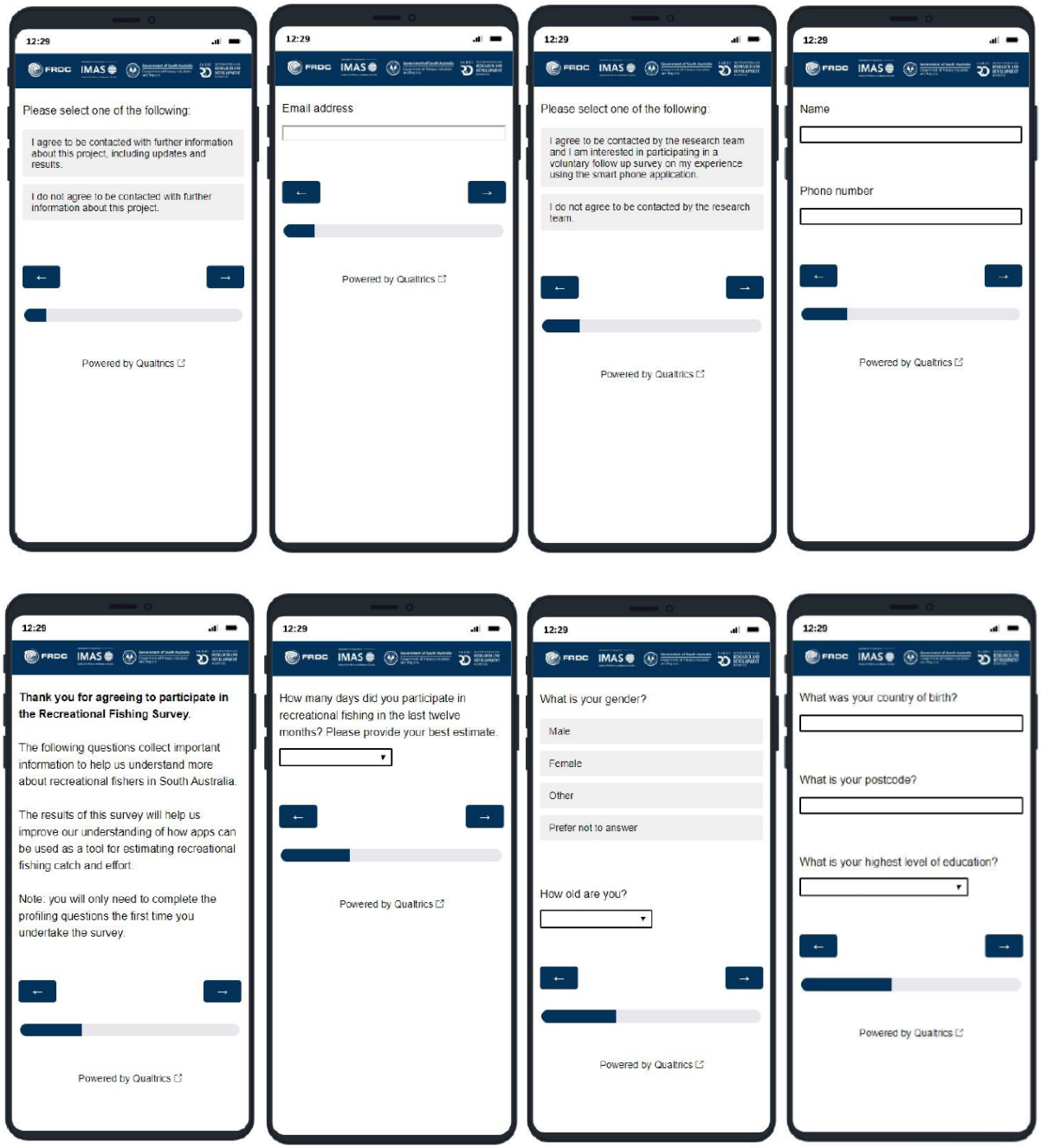
Appendix 5.1: SA Fishing app



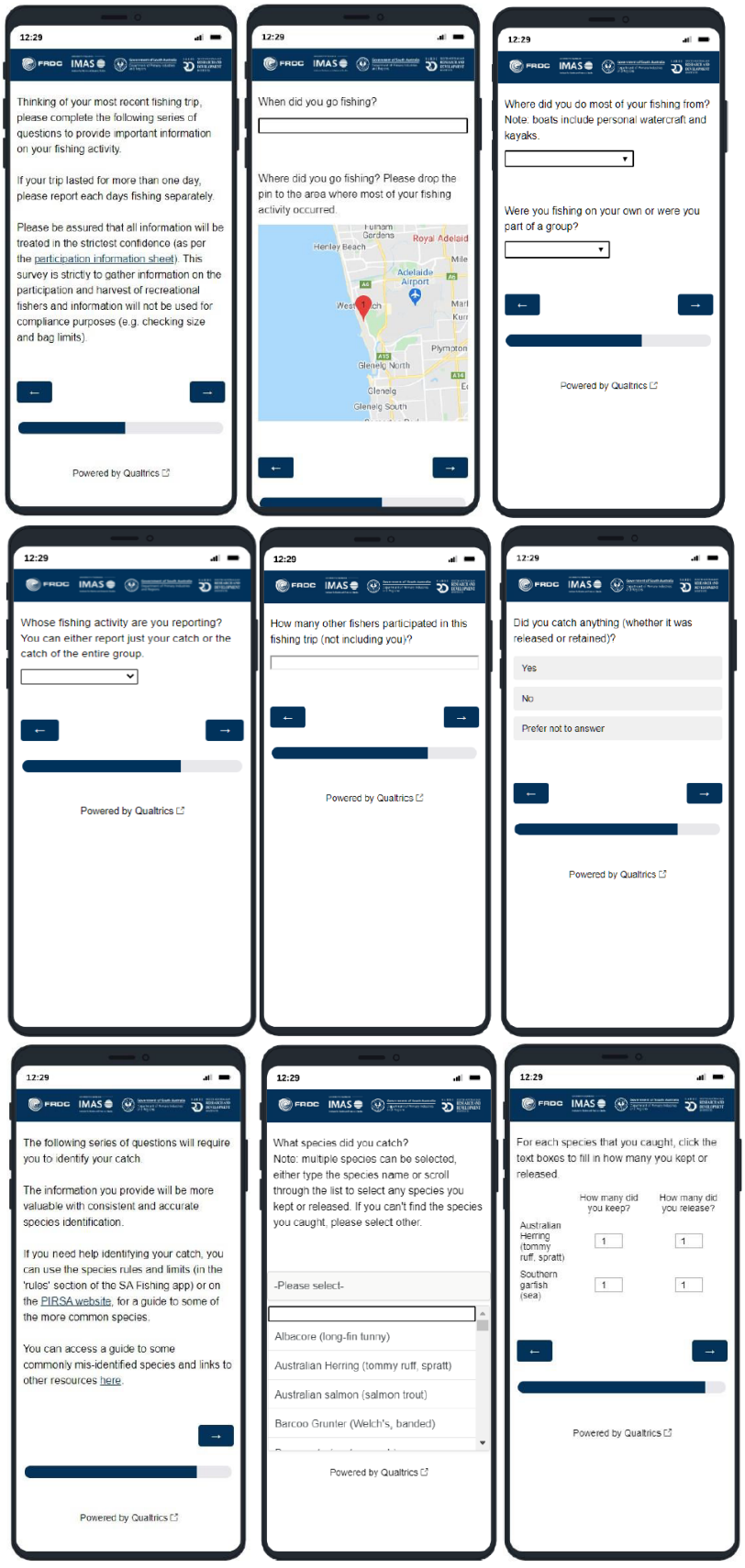
Appendix 5.2: Screenshots from the consent page of the app-based survey



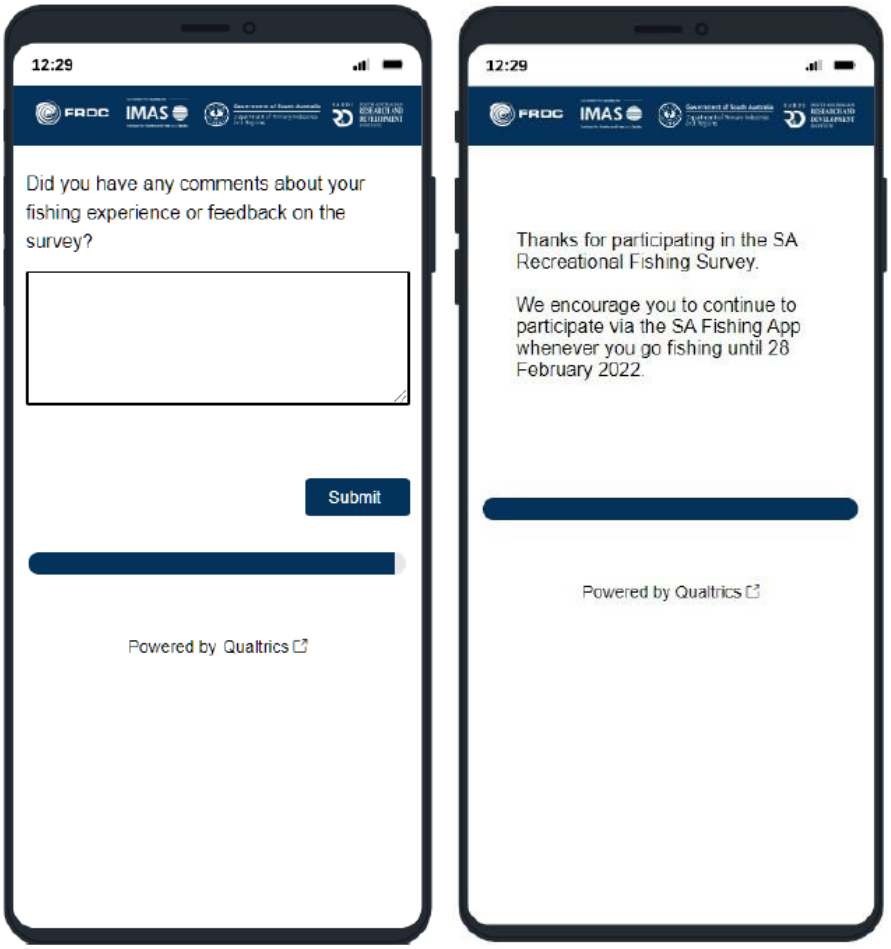
Appendix 5.3: Participant data section of the app-based data collection



Appendix 5.4: Fishing data section of the app-based data collection.



Appendix 5.5: Final question box in the app-based survey.



Appendix 5.6: App-based wash-up questionnaire

SURVEY OF RECREATIONAL FISHING IN SOUTH AUSTRALIA, 2021/22 'WASH-UP'/ATTITUDINAL SURVEY OF SMARTPHONE 'APP' USERS

A: Administrative Section and Introduction

USER ID: ☐☐☐☐☐ Person ID: ☐☐☐☐☐☐ I/viewer Initials: ☐☐

Call Details:

Day/Mth	Time	Result (C/NC/NA)	Appointments/other
...../.....	.....	.....	...../..... .....
...../.....	.....	.....	...../..... .....
...../.....	.....	.....	...../..... .....
...../.....	.....	.....	...../..... .....
...../.....	.....	.....	...../..... .....
...../.....	.....	.....	...../..... .....

Response Report

Fully responding	1
Full refusal	2
Part refusal	3
Full non-contact	4
Part non-contact	5
Number disconnected	6
Other (specify)	8
.....	

Q1. INTRODUCTION: **Good morning/etc. we're conducting a social study on behalf of the University of Tasmania and the South Australian Government. You are being contacted as you provided your phone number as part of the South Australian recreational fishing app and app-based survey trial conducted by SARDI to participate in some follow up questions about the program.** ... THEN EXPLAIN AS APPROP: ABOUT 10 MINS USUALLY; VOLUNTARY AND CONFIDENTIAL – CAN WITHDRAW AT ANY TIME; THE APP BASED SURVEY IS WHERE YOU HAVE BEEN REPORTING YOUR CATCH TO THE APP; FEW DETAILS ABOUT FISHING AND OPINIONS ON FISHING-RELATED ISSUES AND THE APP AND SURVEY ITSELF

B: Questions about you

Firstly, I am going to ask some questions about you and your fishing background.

Q1. Do you fish in saltwater, freshwater or both whether you entered the details in the app-based survey or not?

Saltwater	1
Freshwater	2
Both	3

Q2. Do you fish from a boat, the shore or both (including spear fishing) whether you entered the details in the app-based survey or not?

Boat	1
Shore	2
Both	3

Q3. How many days do you estimate you went fishing between 1st Mar 21 – 28 Feb 22, whether you entered the details in the app-based survey or not? (BEST ESTIMATE)

None	1
1 – 4 days	2
5 – 9 days	3
10 – 14 days	4
15 – 19 days	5
20 + days	6
UNSURE	7

Q4. Compared to your other hobbies, out of a score of 10 (1 being least important and 10 being most important) how important is fishing to you as an activity?

1 2 3 4 5 6 7 8 9 10

Q5. How many years have you been fishing (for any species)

<1 year	1
1-5 years	2
5-10 years	3
10-20 years	4
>20 years	5
UNSURE	6

Q6. How many hours per week do you spend researching or viewing content related to fishing (e.g. books, videos, social media forums)

<5 hours	1
5-10 hours	2
10-15 hours	3
15-20 hours	4
>20 hours	5
UNSURE	6

Q7. How do you rate your fishing skill?	**Beginner**	1
	Intermediate	2
	Advanced	3
	Expert	4

Q8. Do you identify as belonging to any of the following groups? (CAN SELECT MULTIPLE)	(a) **Charter boat operator**	1
	(b) **Bait and tackle store owner**	2
	(c) **Recreational angler**	3
	(d) **Commercial fisher**	4
	(e) **Conservationist**	5
	(f) **Fisheries or other aquatic scientist**	6
	(g) **Concerned citizen**	7
	(h) **Recreational diver**	8
	(i) **Spear fisher**	9
	(i) **Natural resource manager**	10
	(j) **Marine or freshwater tourism industry**	11
	(k) **Seafood industry**	12
	(l) **Fishing clubs/associations**	13
	(m) **Fishing representative body** (e.g. RecFish SA, SAFA, etc)	14
	(n) None of the above	15

B: Questions about the SA Fishing App

(Next) I am going to ask you some questions about the SA Fishing App that you have on your phone. These questions refer to the app itself, rather than the survey that you can access on the app.

Q9. So, how long have you had the SA fishing app installed on your phone? (BEST ESTIMATE)	**Less than 6 months**	1
	6 – 12 months	2
	1 – 2 years	3
	More than 2 years	4
	UNSURE	5

Q10. Why did you initially download the SA fishing app?	(a) **To find out regulations for recreational fishing (incl. maps)**	1
	(b) **To participate in the app-based recreational fishing survey**	2
	(c) **To report snapper, illegal fishing, shark sighting or pest**	3
	(d) **Any other reason** (specify)	4
	(e) UNSURE	5

C: Questions about the SA app-based recreational fishing survey

(Now) I am going to ask you some questions specific to the app-based recreational fishing survey

Q11. Where did you hear about the app-based recreational fishing survey? (CAN SELECT MULTIPLE)	(a) **Govt. publications**	1
	(b) **Fishing magazines**	2
	(c) **Govt. websites**	3
	(d) **Other websites**	4
	(e) **Govt. social media (FB/IG/Twitter/Youtube etc.)**	5
	(f) **Other social media (FB/IG/Twitter/Youtube/forums, etc.)**	6
	(g) **Newspaper**	7
	(h) **Television**	8
	(i) **Radio**	9
	(j) **Govt. smart phone app.**	10
	(k) **Other smart phone app.**	11
	(l) **Tackle shop**	12
	(m) **Fishing clubs/associations**	13
	(n) **Other fishers/friends (word of mouth)**	14
	(o) **Push notification sent to mobile phone**	15
	(p) **Pop-up reminder appeared in SA Fishing App**	16
	(q) **Email newsletter**	17
	(r) **During an onsite survey interview**	18
	(s) **Podcast**	19
	(t) **Any other** (specify)	20
	(u) UNSURE	21

Q12a. **Now, can I ask if you have used the app-based recreational fishing survey at least once to record your catch.**

Yes (go to Q13)	1
No (go to Q12b)	2

Q12b. **What were the reasons you did not report your fishing activities on the app** (CAN SELECT MULTIPLE)

(a) **I forgot**	1
(b) **Not enough time**	2
(c) **No internet or phone service**	3
(d) **Lost interest**	4
(e) **Found it too difficult**	5
(f) **Didn't go fishing**	6
(g) **Any other reason** (specify)	7

Sequence guide now go to Q21

Q13. **Did you use the same phone or device to participate in the app-based survey during the time period 1st Mar 21 – 28 Feb 22?**

YES	1
NO	2
UNSURE	3

Q14. **Did you need to enter your profiling information (gender, postcode etc.) not fishing activity) more than once during the app-based survey?**

YES	1
NO	2
UNSURE	3

Q15. **When participating in the survey, did you provide data on behalf of others?**

YES	1
NO	2
UNSURE	3

Q16. **If you fished as part of a group, what's the likelihood that someone else from your group may have entered the same trip data as you?**

Highly likely	1
Possibly	2
Not likely	3
Didn't fish in a group	4
UNSURE	5

Q17a. **Since you engaged with the app-based survey, did you report your fishing activity each time you went fishing?**

YES (go to Q18a)	1
NO (go to Q17b)	2
UNSURE (go to Q18a)	3

Q17b. **What were the reasons why you did not always report your fishing activities on the app** (CAN SELECT MULTIPLE)

(a) **I forgot**	1
(b) **Not enough time**	2
(c) **No internet or phone service**	3
(d) **Lost interest**	4
(e) **Found it too difficult**	5
(f) **Any other reason** (specify)	5

Q18a. **Did you log fishing trips on the app if you didn't catch any fish?**

Always (go to Q19)	1
Sometimes (go to Q18b)	2
Never (go to Q18b)	3
NA / I always catch fish (go to Q19)	4
UNSURE (go to Q19)	5

Q18b. **What were the reasons why you did not log days in the app when you did not catch fish?** (CAN SELECT MULTIPLE)

(a) **I forgot**	1
(b) **Not enough time**	2
(c) **No internet or phone service**	3
(d) **Lost interest**	4
(d) **Didn't realise I should log no catch days**	5
(e) **Any other reason** (specify)	6

Q19. **Of the species you caught, did you report...**
Note 'kept' would also relate to fish that are killed but not released (e.g. Carp)

All species (both kept and released)	1
Only the fish that I kept	2
Only your target species	3
Only the fish you released	4
Only the noteworthy fish	6
Only species you could identify	7
Only species that were listed in the survey	8
Or, was there no pattern to your reporting	9
UNSURE	10

Q20. **I'm now going to read you some statements about the app-based survey. As I read each one, please tell me whether you strongly agree or disagree, agree or disagree or are neutral about the statement in regard to your experience with the survey. Firstly ...** (INTERVIEWER: READ OUT EACH AND PROBE FOR AGREE/DISAGREE, ETC).

	Agree	Neutral	Disagree
(a) **I was comfortable providing profiling information**	1	2	3
(b) **I found it easy to enter my profiling information (age, gender etc.)**	1	2	3
(c) **I found it easy to enter information about my fishing trip/s**	1	2	3
(d) **The map made it easy for me to identify the main area where I fished**	1	2	3
(e) **I was comfortable providing the location of my fishing activity**	1	2	3
(f) **I was comfortable reporting what I caught**	1	2	3
(g) **I am confident that I could identify the species that I caught**	1	2	3
(h) **I was always able to locate species caught in the dropdown list**	1	2	3
(i) **I found it easy to navigate the dropdown menu**	1	2	3
(j) **I found it easy to add multiple species per trip**	1	2	3
(k) **I found it easy to report the number of species kept/released**	1	2	3
(l) **I would have liked to provide more information (e.g. size, gear)**	1	2	3
(m) **I would have liked the option to upload pictures**	1	2	3
(n) **I would have liked to share my survey data via social media**	1	2	3
(o) **I would have liked to be able to access my data after I submitted it**	1	2	3
(p) **I would have liked to be able to see other people's data**	1	2	3

Q21a. **Did you receive communications which reminded you to participate in the app-based survey?**

YES (go to Q21b)	1
NO (go to Q22)	2
UNSURE (go to Q22)	3

Q21b. **Of the following which communications did you receive/view?**
(CAN SELECT MULTIPLE - Circle)

Q21c. **Of the communication reminders you had, rank which ones were most likely to result in you submitting a survey response.**
(READ BACK CIRCLED RESPONSES AND RANK FROM 1...*N* IN THE BOXES)

(a) **Notification or message sent to phone**	1	☐
(b) **Reminder appeared in app**	2	☐
(c) **Email (newsletter)**	3	☐
(d) **Reminded during an onsite survey interview**	4	☐
(e) **Social media post**	5	☐
(f) **Survey website**	6	☐
(g) **Newspaper article**	7	☐
(h) **Magazine article**	8	☐
(i) **Radio or TV show**	9	☐
(j) **Podcast**	10	☐
(k) **Flyer or brochure**	11	☐
(l) **Any other reason** (specify)	12	☐

Q21d. **How frequently did you receive personal communications (notifications sent to your phone, emails etc., as opposed to broader communications such as social media posts) encouraging participation?**	**Daily**	1
	At least weekly	2
	At least monthly	3
	Rarely	4
	UNSURE	5
Q21e. **How frequently would you like to have been contacted personally to remind you to participate?**	**Daily**	1
	At least weekly	2
	At least monthly	3
	Rarely	4
	Never	5
	UNSURE	6

F: Final Comments

(And) finally I have a couple of open-ended questions for you regarding the app-based survey.

Q22. **Is there anything that might increase the chance of you continuing to participate in the app-based survey in the future?**

.....

.....

.....

.....

.....

.....

Q23. **Did anything make it difficult for you to participate?**

.....

.....

.....

.....

.....

.....

.....

Q24. **What was the main reason you chose to participate in the app-based survey?**

.....

.....

.....

.....

.....

Q25. INTERVIEWER: CLOSE INTERVIEW AND THANK RESPONDENT/S AS APPROPRIATE FOR THEIR CO-OPERATION WITH THE SURVEY (ESPECIALLY 'AVIDS').

INTERVIEWER COMMENTS .....

.....

.....

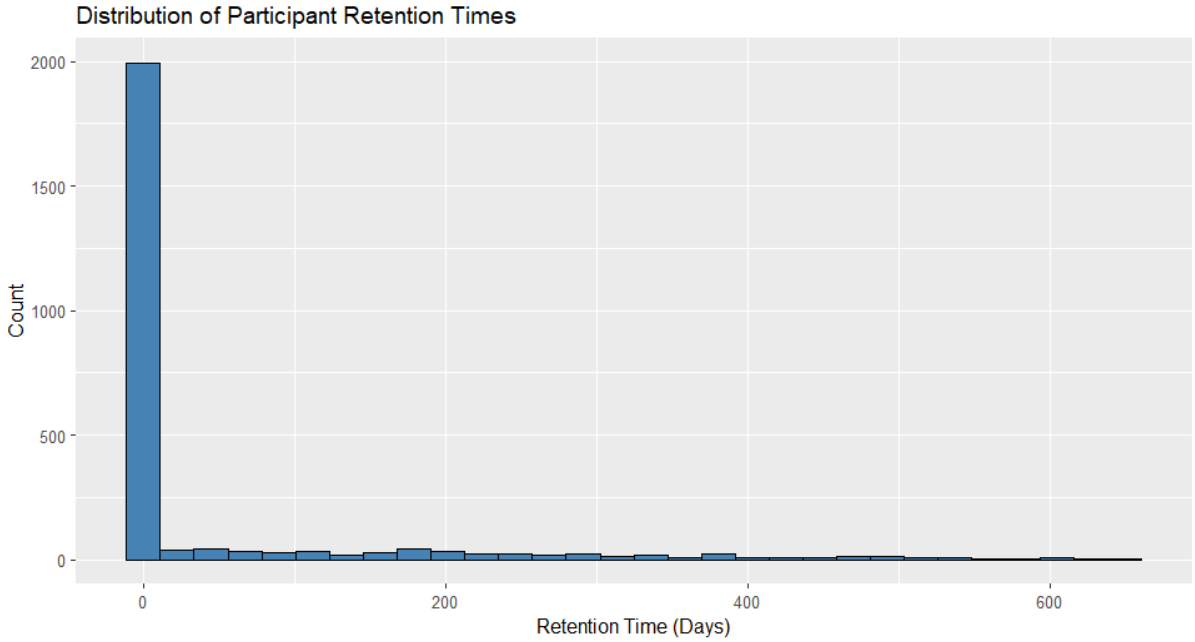
.....

.....

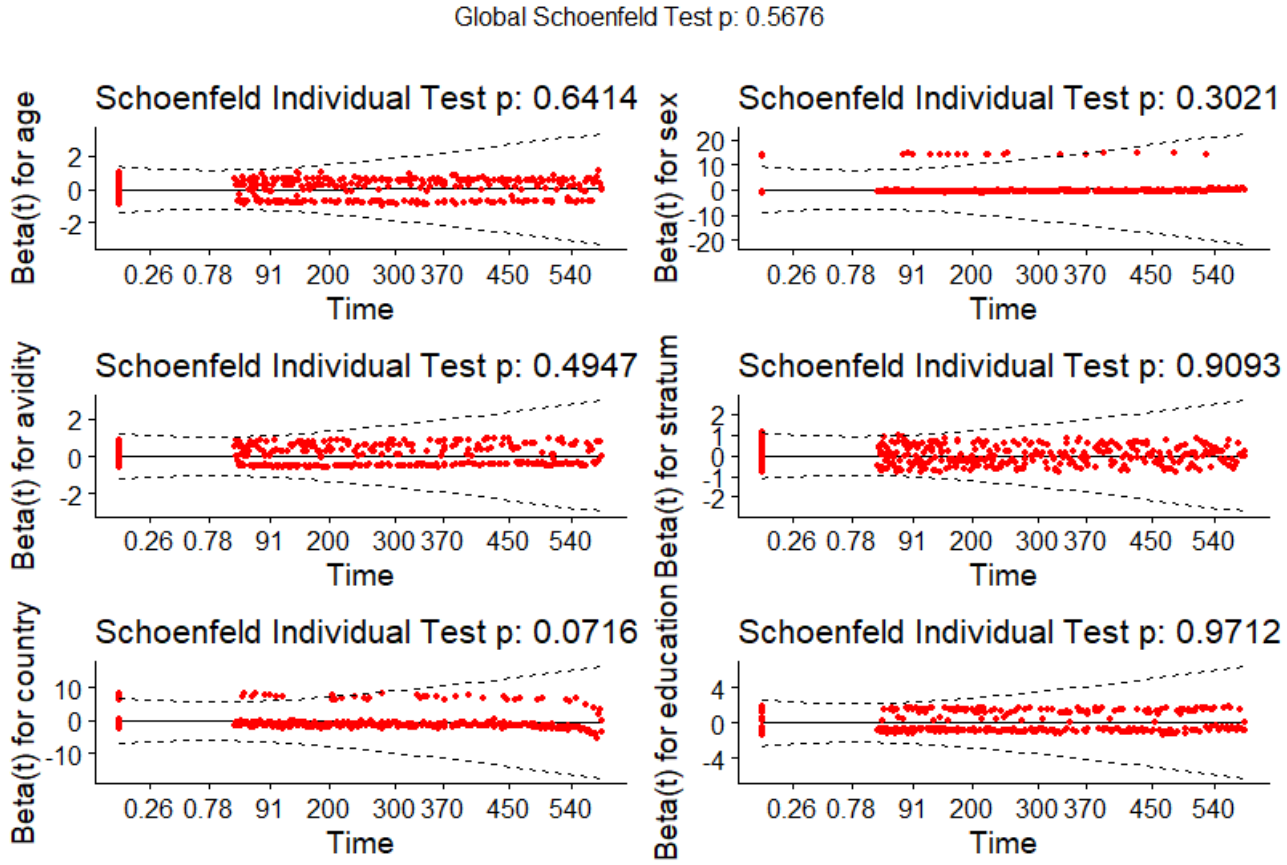
.....

Appendix 5.7: Survival (retention) analysis

Histogram of Participant Retention Times in the App-Based Data Collection Platform. The x-axis shows the retention time in days, and the y-axis represents the frequency or count of participants.



Scaled Schoenfeld residual plots for all variables in Cox Proportional-Hazard model



Proportional hazards assumption tests (using the scaled Schoenfeld residuals) for the Cox Proportional-Hazards model (log rank test). * significant < 0.005.

Predictor	x^2	P value
Age	0.217	0.641
Sex	1.065	0.302
Avidity	0.466	0.495
Stratum	0.013	0.909
Country	3.246	0.072
Education	0.001	0.971
Global	4.816	0.568

Cox proportional hazards regression coefficients for potential predictors of retention in the app-based survey. Hazard ratios (HR) and 85% confidence intervals (CIs) are shown for age, sex, avidity, stratum, education and interactions with 'country'. *significant p< 0.05

Variable	HR	CI_Lower	CI_Upper	p_value	Coefficient
Age	1.05	0.92	1.20	0.45	0.05
Sex	0.69	0.29	1.65	0.40	-0.37
Avidity	1.11	0.98	1.25	0.10	0.10
Stratum	0.99	0.96	1.02	0.67	-0.01
Country	0.55	0.21	1.47	0.23	-0.59
Education	0.99	0.93	1.07	0.86	-0.01
Sex:Country	2.14	0.99	4.59	0.05*	0.76
Avidity:Country	1.00	0.85	1.18	0.99	0.00
Age:Country	0.95	0.85	1.06	0.40	-0.05
Sex:Avidity:Country	0.92	0.81	1.04	0.19	-0.08

Appendix 6: Survey Promotion

Appendix 6.1: Project information

1. Project website: https://www.pir.sa.gov.au/fishing-survey
2. Information and project updates available at https://www.facebook.com/SARecFishingSurvey
3. App based notifications and reminders (see Section 5.22)
4. Participation Information sheet – available through the app-based data collection platform

PARTICIPANT INFORMATION SHEET

PROJECT TITLE: 2021/22 South Australian Recreational Fishing Smartphone App Survey

HUMAN RESEARCH ETHICS COMMITTEE APPROVAL NUMBER: H-2021-XXX

PRINCIPAL INVESTIGATOR: Crystal Beckmann

Dear Participant,

You are invited to participate in the research project described below.

What is the project about?
This study is part of a national project to compare recreational fishing catch estimates from traditional phone-diary surveys with catch estimates from a smart phone app. Part of this project includes trialling a survey to collect information on recreational fishing activity through the SA Fishing smart phone application.

Who is undertaking the project?
This project is being conducted by Drs Crystal Beckmann, Fred Bailleul and Jonathan Smart from the University of Adelaide and South Australian Research and Development Institute (SARDI), Associate Professors Sean Tracey and Jeremy Lyle, and Drs Kate Stark and Emily Ogier from the University of Tasmania/Institute of Marine and Antarctic Sciences (IMAS), and Mr Keith Rowling, Ms Skye Barrett and Ms Anne Russell from Primary Industries and Regions South Australia (PIRSA). This research is supported by PIRSA and funded by the Fisheries Research and Development Corporation (FRDC).

Why am I being invited to participate?
You are being invited as you are over 15 and have participated in recreational fishing in SA during the survey period.

What am I being invited to do?
You are being invited to participate by:

- Providing demographic information including gender, education and residential postcode.
- Providing information on your fishing trip including fishing location and species harvested.
- Providing your contact details to participate in a verbal follow-up survey and/or receive updates on the project and a summary of the results.

How much time will my involvement in the project take?
It is expected that pipi measuring and the survey should take about 10 minutes (depending on the range and number of species harvested).

Are there any risks associated with participating in this project?
The degree of risk and/or harm to you by virtue of your participation in this project is minimal. Should you feel anxious or uncomfortable at any point during this research please bring this to the attention of the researcher. Should you wish, you are able to stop participating in the survey at any time. This survey is strictly to gather information on the participation and harvest of recreational fishers and information will not be used for compliance purposes (e.g. checking size and bag limits).

What are the potential benefits of the research project?
The knowledge gained from this project will assist in the sustainable management of South Australia's fisheries resources and will contribute towards the development of new tools for measuring recreational catch.

Can I withdraw from the project?
Participation in this project is completely voluntary. If you agree to participate, you can withdraw from the study at any time up until you complete the survey.

What will happen to my information?
Your data will be kept confidential. Information about your fishing activity will remain anonymous. You will not be identified in any report or publication about the study. The overall results of this study may be presented and published in academic journals, presented at conferences, and published in reports. You will not be identified in any publications. Any information you provide as part of your participation in this project, hardcopy or electronic, will be securely stored at SARDI in accordance with University Policy and the Australian Code for the Responsible Conduct of Research. If consent is provided, you may be contacted by a third party to undertake a verbal follow-up survey. De-identifiable data may be made available for the purposes of designing subsequent research projects and/or expanding this project. Your information will only be used as described in this participant information sheet and it will only be disclosed according to the consent provided except as required by law. Data will be retained for a minimum of 5 years from the date of publication.

Who do I contact if I have questions about the project?
If you have any questions about this project you should contact the primary researcher, Dr Crystal Beckmann at crystal.beckmann@sa.gov.au or 08 8429 0990. The contact details of the other researchers are: Dr Fred Bailleul fred.bailleul@sa.gov.au, Dr Jon Smart jonathan.smart@sa.gov.au, Associate Professor Sean Tracey sean.tracey@utas.edu.au, Associate Professor Jeremy Lyle Jeremy.lyle@utas.edu.au, Dr Kate Stark kate.stark@utas.edu.au, Dr Emily Ogier Emily.ogier@utas.edu.au, Mr Keith Rowling keith.rowling@sa.gov.au, Ms Skye Barrett skye.barrett@sa.gov.au, Ms Anne Russell anne.russell@sa.gov.au.

What if I have a complaint or any concerns?
The study has been approved by the Human Research Ethics Committee at the University of Adelaide (approval number H-2021-XXX). This research project will be conducted according to the NHMRC National Statement on Ethical Conduct in Human Research 2007 (Updated 2018). If you have questions or problems associated with the practical aspects of your participation in the project, or wish to raise a concern or complaint about the project, then you should consult the Principal Investigator. If you wish to speak with an independent person regarding concerns or a complaint, the University's policy on research involving human participants, or your rights as a participant, please contact the Human Research Ethics Committee's Secretariat on:

Phone: +61 8 8313 6028
Email: hrec@adelaide.edu.au
Post: Level 4, Rundle Mall Plaza, 50 Rundle Mall, ADELAIDE SA 5000

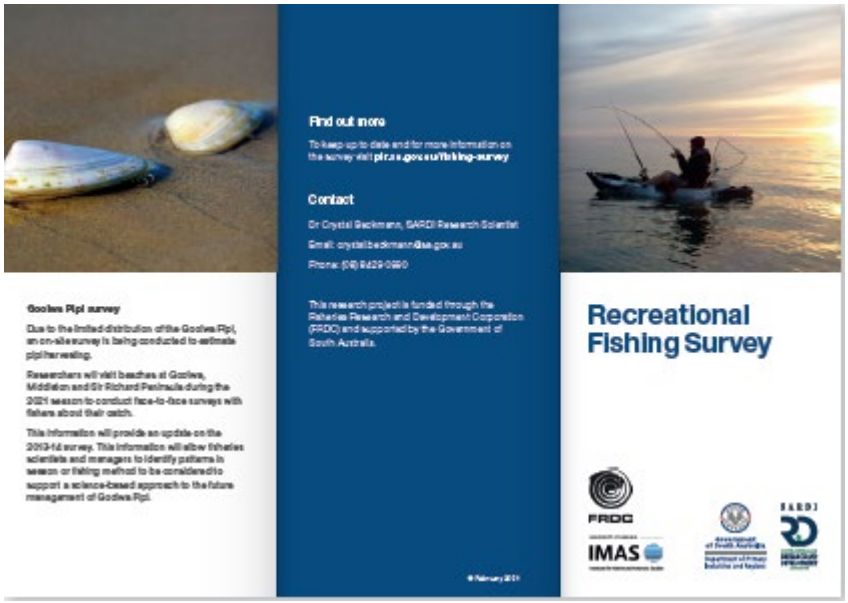
Any complaint or concern will be treated in confidence and fully investigated. You will be informed of the outcome.

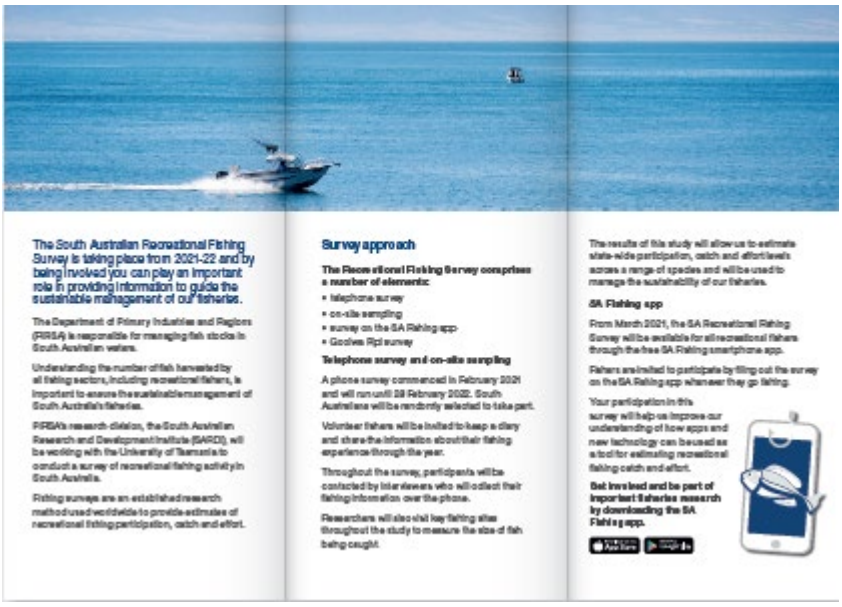
If I want to participate, what do I do?
If you are interested in participating in this research, the survey is accessible through the SA Fishing app, available for download from the App Store (Apple devices) or the Google Play Store (Android devices). Submission of your responses is considered as your consent to participate and that you have read and understood the above information

Yours sincerely,

Dr Crystal Beckmann, Dr Fred Bailleul, Dr Jon Smart, Associate Professor Sean Tracey, Associate Professor Jeremy Lyle, Dr Kate Stark, Dr Emily Ogier, Mr Keith Rowling, Ms Skye Barrett, and Ms Anne Russell.

5. Promotional brochures – distributed to key fishing outlets and stakeholders





Recreational fishing survey

Help us protect the future of your favourite past-time

Goal of the survey

Tell us what you're catching and help protect and sustain SA's fish stocks.

We recognise that the way people communicate is changing and there's a need to develop new tools to measure fishing participation, catch and effort. The recreational fishing survey is trialling the use of apps to gather information on recreational fishing activity.

Your voice is important

We want to hear from people from across our recreational fishing community. This includes people of different ages, backgrounds, locations, genders, and those who fish a couple of times a week or a couple of times a year.

Join the research

It's easy to join the survey:

- download the SA Fishing app
- select the Recreational Fishing Survey
- log your catch anytime you fish until 28 February 2022
- encourage your fishing mates to participate.

Learn more: http://www.pir.sa.gov.au/fishing-survey

SA Fishing App

Supported by:
Minister's Recreational Fishing Advisory Council

FRDC IMAS

6. Promotional video
   Available at: https://youtu.be/4NZK45Khjis

7. E-newsletters to survey participants
   Full list at:
   https://us11.campaign-archive.com/?u=5e2943f663c233bea27c9b6b9&id=f214bade48

On-site sampling

Thank you for participating in recent on-site sampling to support the 2021-22 South Australian Recreational Fishing Survey.

Surveys of recreational fishers provide important information which is used to help protect and sustain South Australia's fish stocks.

Survey clerks have been visiting popular fishing locations around South Australia to collect important size information on key recreational species. Measurements will be used to convert the estimates of fish numbers from the phone survey to a total harvest weight (biomass).

On-site sampling update

- Sampling has been undertaken at 8 key fishing locations
- Over 50 fishing parties have participated
- Over 600 measurements have been recorded

The survey to estimate the recreational catch for South Australia will run until the end of February 2022.

Thanks again for your participation and we look forward to sharing the results with you.

Fishers called on to be counted

On-site sampling survey is one part of a broader initiative to estimate recreational fishing catch.

There are other ways South Australian fishers can get involved, including volunteering to be part of a cutting-edge national research project to develop new methods to accurately estimate the catch of recreational fishers.

Some of you may have been randomly contacted to participate in a telephone survey to estimate recreational fishing activity across the state.

The information from this survey will be important to inform decision making and ensure our state's fish stocks are protected into the future.

How can you get involved?

If you haven't been contacted to be part of the telephone survey, you can still get involved by participating in the survey via the SA Fishing App.

Download the SA Fishing app from either the App Store or the Google Play Store and record your catch each time you go fishing.

This is an exciting opportunity for South Australian fishers to contribute to the development of new tools for undertaking recreational fishing surveys.

Another aspect of the survey will see survey officers and Fishcare volunteers out on-site at some of the state's key fishing locations to measure the size of the fish being caught. By participating in any aspect of the survey you will be helping provide important information to maintain the long-term sustainability of South Australian fish stocks for the benefit of all fishing communities.

The South Australian Research and Development Institute, in partnership with the University of Tasmania, is running this survey which has been co-funded by the Fisheries Research and Development Corporation.

Find out more

To keep updated with fishing news, subscribe to our Fish Facts newsletter.

On-site survey for Goolwa Pipi

ank you for participating in our recent survey of the Goolwa Pipi recreational fishery.

rveys of recreational fishers provide important information which is used to help protect and stain South Australia's fish stocks.

e to the limited geographical distribution of the Goolwa Pipi, an on-site survey was chosen to asure participation, catch and effort of fishers.

oolwa Pipi survey update

- 17 survey days completed
- over 300 fishing parties have participated
- 6 survey days remaining

e survey to estimate the recreational Goolwa Pipi harvest will run until the end of May 2021.

anks again for your participation and we look forward to sharing the results with you.

ishers called on to be counted

e Goolwa Pipi survey is one part of a broader initiative to estimate recreational fishing catch.

ere are other ways South Australian fishers can get involved, including volunteering to be rt of a cutting-edge national research project to develop new methods to accurately estimate e catch of recreational fishers.

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e South Australian Research and Development Institute, in partnership with the University of smania, is running this survey which has been co-funded by the Fisheries Research and velopment Corporation.

Find out more

To keep updated with fishing news, subscribe to our Fish Facts newsletter.

Smart-phone app survey

Thank you for participating in the 2021-22 Recreational Fishing survey via the SA Fishing app.

This is the first time researchers in Australia will compare data from the traditional phone diary survey to data from a smart phone app. Knowing the number and profile of people who use the app will help us understand how apps can be used as a tool to estimate recreational fishing catch and effort.

Smart-phone app survey update

- The survey has been live since 1 March 2021
- Over 400 people have already participated
- The most commonly encountered species during March were King George Whiting and Blue Swimmer Crabs

The app-based survey will run until the end of February 2022 and you can participate anytime you go fishing in South Australia.

Thanks again for your participation and we look forward to sharing the results with you.

Fishers called on to be counted

The smart-phone app survey is one part of a broader initiative to develop new methods for estimating recreational fishing catch. The larger project will also involve a traditional telephone/diary survey, state-wide onsite sampling and a survey for Goolwa Pipi.

The phone survey method provides the best available information on recreational fishing participation, catch and effort for the state. The information from the telephone survey will be important to inform decision making and ensure our state's fish stocks are protected into the future.

We'll compare results of the phone survey with results from the SA Fishing app to see how effective smart phone applications can be as a tool to collect information on recreational fishing.

How can you get involved?

Continue to participate in the survey by providing information about where you went and what you caught anytime you go fishing via the SA Fishing App. Whether you fish regularly, or only one or twice a year, your information is important.

This is an exciting opportunity for South Australian fishers to contribute to the development of new tools for undertaking recreational fishing surveys.

Another aspect of the survey will see survey officers and Fishcare volunteers out on-site at some of the state's key fishing locations to measure the size of the fish being caught. By participating in any aspect of the survey you will be helping provide important information to maintain the long-term sustainability of South Australian fish stocks for the benefit of all fishing communities.

The South Australian Research and Development Institute, in partnership with the University of Tasmania, is running this survey which has been co-funded by the Fisheries Research and Development Corporation.

Find out more

To keep updated with fishing news, subscribe to our Fish Facts newsletter.

Appendix 6.2: Media

1. Media Release, available at:
   https://pir.sa.gov.au/alerts_news_events/news/sardi/calling_on_fishers_to_stand_up_and_be_counted
   https://www.premier.sa.gov.au/news/media-releases/news/calling-on-fishers-to-stand-up-and-be-counted

2. Sharon Starick (MRFAC) interviewed on Rowey's Fishing Show 27/2/2021
   Available at: https://www.roweysfishingshow.com/single-post/sharon-starick-27-02-21

3. Article in The Advertiser 13/2/2021 "Angling for Information"

Angling for information

Surveys to check true size of catch

NIGEL HUNT

TWO major surveys are about begin in a bid to ascertain just how many fish recreational anglers catch.

The first is the traditional random telephone and diary survey, which has been conducted three times over the past two decades, while the second will be conducted by urging anglers to participate via the SA Fishing app.

A national project will then assess whether self-reporting via the SA Fishing app is more effective than the controversial telephone/diary survey – the accuracy of which has been questioned.

The traditional survey, which involves random people being contacted and asked to fill in a catch diary for a year, is used to help formulate bag and boat limits, despite concerns about its accuracy.

State Primary Industries and Regional Development Minister David Basham urged every recreational fisher to get involved in the project.

"Recreational fishing is incredibly important to South Australia as we know it contributes over $160m to our state every year," he said.

Garfish and pencil floats.

"Ensuring we have an accurate estimate of recreational fishers and their catch is vital because this information is considered when deciding bag and boat limits.

"Where there is low confidence in estimates of recreational fishing effort, fishery managers and fishing representatives are forced to adopt more conservative and cautious bag and boat limits to protect ... fish species.

"The more data we have, the more confident we will be to adopt bigger bag limits.

"Recreational fishers have told me they are concerned about the traditional way of estimating how many recreational fishers there are and how much they catch.

"Some fishers think past estimates overstate the number of fishers, others think it underestimates the number of fishers.

"This project will tell us if there is a better way of getting more accurate figures."

Mr Basham also revealed a second round of grants has been made available to assist charter boat businesses hit by the three-year ban on catching snapper.

Under the initiative, $500,000 will be available to operators to improve, expand and diversify their businesses.

The first grants program handed out $200,000 to charter operators around the state to help fund boat upgrades, modifications, tourist accommodation and even fund a new shuttle bus for customers.

Grant applications are open on March 1 and closing on April 16.

For more information visit pir.sa.gov.au/fishing-for-tourism

PAGE 54: FISHING

4. Article in the Stock Journal 16/2 "Fishers asked to report to app for accurate count"

   Available at: https://www.stockjournal.com.au/story/7128569/fishers-asked-to-report-to-app-for-accurate-count/

Fishers asked to report to app for accurate count

16 Feb 2021, 10:48 a.m. News

SA fishers are being asked to download the SA Fishing app and report their catch to get an accurate gauge on the numbers. Photo: SHUTTERSTOCK

FISHERS are being asked to take part in a trial, aimed at understanding the size of the recreational catch.

They can volunteer to be part of the national research project to accurately estimate the number of recreational fishers and their catch.

This will assess whether self-reporting from fishers on the SA Fishing app is more effective than the traditional phone and diary survey.

Phone and diary surveys were previously undertaken in 2000-01, 2007-08 and 2013-14, to assess recreational fishing catch and participation in SA.

Through this process, random people were selected and asked to fill in a fish catch diary for a year.

Given fishers and non-fishers participate, there has been some scepticism by recreational fishers about how accurate this method is, especially as this information is used to determine bag and boat limits.

Primary Industries and Regional Development Minister David Basham said every recreational fisher could get involved in this exciting project.

"Recreational fishing is incredibly important to SA as we know it contributes over $160 million to our state every year," he said.

"Ensuring we have an accurate estimate of recreational fishers and their catch is vital because this information is considered when deciding bag and boat limits.

"Where there is low confidence in estimates of recreational fishing effort, fishery managers and fishing representatives are forced to adopt more conservative and cautious bag and boat limits to protect sustainability of fish species.

"The more data we have, the more confident we will be to adopt bigger bag limits."

Mr Basham said feedback from recreational fishers show many were concerned about the existing ways of estimating fisher numbers and how much they catch.

"Some fishers think past estimates overstate the number of fishers, others think it underestimates the number of fishers," he said.

"This project will tell us if there is a better way of getting more accurate figures.

"A traditional phone/diary survey will commence this month and separately next month all fishers who have downloaded the SA Fishing app will be encouraged to participate in the count.

"In a year's time, the researchers will look at the data and determine the most effective method."

RELATED: Fish fines increase to target rogues

Fishing advisory council announced

Independent Chair of the Minister's Recreational Fishing Advisory Council Sharon Starick says the MRFAC has been involved in the design of the project and encourages recreational fishers to participate.

"Changes in technology provide opportunities to look at new ways of collecting data and information," she said.

"The MRFAC have been involved in the design of the project because we need our method of estimating recreational fisher numbers to also evolve so we are confident the estimates are accurate.

"I encourage anyone with a passion for fishing to download the app.

"The more people who participate, the better the end product will be.

"It's easy to volunteer, and given bag and boat limits are decided using this information, it is so important we can trust the estimates."

PIRSA staff and Fishcare volunteers will be present on boat ramps, jetties and other fishing sites collecting fishing data across the next year.

This information will also feed into determining the best data collection method.

5. Article in SA Angler Magazine June/July 2021 edition

FISHING AROUND

News & Views From The Local Scene

REC FISHING SURVEY IN SA

The 2021/22 South Australian recreational fishing survey is currently underway to help fisheries managers estimate the level of participation and recreational catch rates here in SA.

The last SA recreational survey took place back in 2013/14. The current recreational fishing survey is led by the South Australian Research and Development Institute (SARDI), the research division of the Department of Primary Industries and Regions (PIRSA) in partnership with the University of Tasmania, and jointly funded by the Fisheries Research and Development Corporation (FRDC) and the SA Government.

The recreational survey is ultimately split into four elements – a telephone diary survey, on site sampling, self-reporting via a mobile app, and a specific on-site survey for Goolwa Pipi.

The telephone sampling began on February 1, 2021 and will conclude on February 28, 2022. The participants are randomly selected through a database to offer varied representation through age demographics, gender, ethnicity and location. Eligible telephone survey participants are also invited to complete a fishing activity diary for a 12-month period, with phone interviewers following up regularly to find out where the participant went fishing and what was caught.

Anyone eager to participate in the recreational survey, but who hasn't been randomly selected for the telephone diary survey, can still log their fishing activity and catches via the SA Fishing app.

I've been logging my fishing activity through the app since March and will continue to do so over the next 12-month period. The more recreational fishers we have logging data, the greater pool of information our scientists will have to help us understand how apps can be used as a future tool for estimating recreational fishing catch.

The final element of the 2021/22 recreational fishing survey will involve on-site sampling, where PIRSA staff, along with Fishcare volunteers, will be visiting selected jetties, boat ramps and other high frequency recreational fishing sites periodically throughout the 12-month period. The on-site sampling will involve measuring retained fish and Goolwa cockles (pipi), which is later used to convert estimated numbers into an estimated harvest biomass for each species.

For more information go to www.pir.sa.gov.au/fisherscount

Jamie Crawford

ELLISTON COMP' TO RUN OVER THREE MONTHS

After a very well supported Salmon Fishing Championship in 2020 during COVID, the Elliston Community and Visitor Information Centre has again voted to hold the very popular competition for 2021 over the months of June, July and August

The beautiful, pristine beaches between Sheringa and Mount Camel will attract anglers travelling to Elliston to try their luck on a fish that could reward them with a $2000 first prize. Runner up will take home $750. However, for the angler who just wants to get out in clean, crisp air there is also a $200 weekly mystery weight prize.

The Committee thanks the Elliston Caravan Park, which will be conducting the weigh-ins between 9am-6pm daily. Centre Manager, Tracy Sampson, reminds anglers that tickets need to be purchased before they fish. They are $10 each and are valid for the entire competition to allow entrants to return for another chance of reeling the 'big one'.

For the budding photographer who just likes to wander the beach or spectacular cliffs there is also a monthly photo competition where the public gets to vote for the winning picture. So, it would pay to keep your phone handy when fishing to capture that special catch, or it could simply be the perfect sunset at Locks Well. Email your photos taken during the competition to info@elliston.com.au. Voting takes place on Facebook.

Elliston Community and Visitor Information Centre

6. Article published in Fishing SA Magazine June/July 2021 edition

FISHING FOR INFORMATION

A new State-wide recreational fishing survey is currently underway seeking updated information from South Australian fishers about their activities.

According to Dr Crystal Beckmann, Research Scientist at SARDI, the 2021-22 South Australian Recreational Fishing Survey is split into four elements – a telephone diary survey, on-site sampling, self-reporting via the SA Fishing app and a specific on-site survey for Goolwa pipi. Participation in all the survey components is voluntary.

"Data collected from this survey will help the Department gain an understanding of the current trends and habits of recreational fishers, and support fisheries management," she said.

Dr Beckmann said the first phase of the 2021-22 survey, the specific on-site Goolwa pipi survey, commenced in November 2020, while the telephone diary survey and SA Fishing app self-reporting commenced in March this year.

Due to the limited distribution of the Goolwa pipi, the on-site survey aimed at estimating recreational pipi harvests will provide an update to a similar 2013–14 survey. As part of this phase, researchers visited beaches at Goolwa, Middleton and Sir Richard Peninsula to conduct voluntary face-to-face surveys with fishers about their catch.

Fishers contacted to participate in the telephone diary survey, which will continue through to 28 February 2022, have been randomly selected through a database to ensure a varied representation across different backgrounds and locations. They have been provided with a diary to enter details of any fishing activity undertaken, including where they fished and what species they caught, which is then formally recorded during regular phone interviews.

For those who were not contacted to be a part of the telephone survey, Dr Beckmann said PIRSA is encouraging all recreational fishers to take part in the project by logging data through the SA Fishing app anytime they go fishing.

"We are encouraging all of South Australia's estimated 277,000 recreational fishers to be involved as the survey is our best chance to gather much needed data, she said.

"This is the first-time researchers in Australia will compare data from the traditional phone diary survey to data from a smart phone app.

"So, the more recreational fishers we have logging data, the greater pool of information we will have to help us understand how apps can be used as a future tool for estimating the recreational fishing catch.

"Whether you fish regularly, or only once or twice a year, your information is important. This is your chance to get involved in citizen science and contribute to important fisheries research."

The fourth element of the survey – on-site sampling – also commenced in March 2021 with PIRSA staff, along with Fishcare volunteers, periodically visiting select jetties, boat ramps and other high frequency fishing sites during the survey period. It will involve measuring retained fish and other species with the data to contribute to an estimated harvest biomass for each species.

The 2021–22 South Australian Recreational Fishing Survey is led by the Department of Primary Industries and Regions (PIRSA) through its research division, the South Australian Research and Development Institute (SARDI), in partnership with the University of Tasmania. The project is jointly funded by the Fisheries Research and Development Corporation (FRDC) on behalf of the Australian Government and the South Australian Government.

For more information on the 2021-22 South Australian Recreational Fishing Survey, visit: www.pir.sa.gov.au/fishing-survey.

7. Sharon Starick (MRFAC) interviewed on Rowey's Fishing Show 22/5/21
Available at: https://www.roweysfishingshow.com/single-post/sharon-starick-22-may-2021

8. Article in the Advertiser 21/5/21 “Poll fishing for answers”

Poll fishing for answers

CLARE PEDDIE

SARDI research officer Dr Crystal Beckmann with recreational fisherman Michael Peace, of Glenelg South, at West Beach boat ramp. Picture: Brenton Edwards

Statewide look at angling habits

RECREATIONAL fishers are being encouraged to share their angling habits, haunts and catch rates in a statewide survey.

Researchers and fish-care volunteers are targeting key fishing locations in South Australia, such as North Haven, West Beach, Wirrina, St Kilda, Coffin Bay, Ceduna, Tumby Bay, Port Lincoln, Port Hughes, Port Augusta and Port Victoria, for on-thespot surveys.

The new chairwoman of the Minister's Recreational Fishing Advisory Council, Sharon Starick, encouraged fishers to take part.

"So if you're approached by a fish-care volunteer or if you're approached by someone from PIRSA, who would just like to ask you a few questions about how you fish, a little bit about yourself and what you're actually catching or aiming to catch, I'd encourage people to actually get involved with that," she said.

Surveys are supposed to happen every five years, but the last one was in 2013-14.

In the past, the survey was just done by phone.

Now, in addition to the on-the-spot check-ins, the SA Research and Development Institute is encouraging recreational fishers to download the SA Fishing App and provide information about their fishing activity, any time they go fishing, from now until February 28.

So far, 630 participants have downloaded the app out of an estimated 277,000 recreational fishers.

Ms Starick said access to new technology enabled the researchers to explore new ways of capturing data to set sustainable limits for future generations of fishers.

Funding from the state government and the Fisheries Research and Development Corporation will assess whether self-reporting via the app is more effective then the traditional phone survey.

Michael Peace, 47, of Glenelg South, was pleased to see researchers at West Beach boat ramp yesterday.

"The fact that they're doing research is fantastic," he said. "So hopefully they can accurately predict where bag limits can be increased or decreased, for recreational fishers and commercial fishers. We need to get the balance right and the subject matter experts have the best chance to do that."

9. Articles published in PIRSA FishFacts
   March 2021: https://mailchi.mp/sa/fish-facts-march-2021?e=4c829542dc
   July 2021:
   https://pir.sa.gov.au/alerts_news_events/pirsa_newsletters/fish_facts_july_2021/fishing_for_information

10. Article published in the Regional Development Australia Eyre Peninsula (RDAEP) newsletter
    Available here: https://www.rdaep.org.au/recreational-fishing-survey/

11. Interview on the ABC regional drive program 17/2/2022

Appendix 7: App-based expansion

Appendix 7.1: Coefficient q adjustments

Average coefficient q, used as adjustments prior to expansions adjustments, per species and avidity group for both catch rate and events reported, including their standard error (SE).

Species	Avidity	Catch rate		Events reported	
		Average	SE	Average	SE
King George Whiting	1-4	1.161	0.006	0.543	0.002
	5-9	1.183	0.005	0.420	0.002
	10-14	1.344	0.004	0.307	0.002
	15-19	1.373	0.005	0.296	0.002
	20+	1.128	0.002	0.231	0.001
Blue Swimmer Crab	1-4	1.126	0.007	0.593	0.001
	5-9	1.167	0.008	0.347	0.001
	10-14	1.201	0.007	0.382	0.002
	15-19	1.245	0.008	0.456	0.005
	20+	0.868	0.003	0.342	0.002
Australian Herring	1-4	1.669	0.014	0.650	0.001
	5-9	1.331	0.011	0.500	0.002
	10-14	0.985	0.006	0.519	0.003
	15-19	1.207	0.011	0.378	0.003
	20+	1.226	0.007	0.463	0.002
Southern Calamari	1-4	0.942	0.005	0.590	0.002
	5-9	1.442	0.007	0.414	0.002
	10-14	2.057	0.009	0.416	0.002
	15-19	1.686	0.010	0.342	0.002
	20+	1.313	0.004	0.267	0.001
Western Australian Salmon	1-4	2.265	0.026	0.780	0.005
	5-9	1.002	0.010	0.410	0.002
	10-14	2.521	0.019	0.525	0.003
	15-19	2.332	0.030	0.600	0.004
	20+	1.175	0.007	0.383	0.002
Southern Garfish	1-4	1.145	0.017	0.709	0.002
	5-9	1.075	0.013	0.495	0.002
	10-14	1.292	0.009	0.488	0.004
	15-19	1.747	0.015	0.603	0.006
	20+	0.950	0.005	0.379	0.002
Yellowfin Whiting	1-4	2.022	0.025	0.820	0.003
	5-9	4.969	0.093	0.662	0.002
	10-14	2.714	0.052	0.718	0.004
	15-19	0.300	0.004	0.478	0.010
	20+	0.875	0.008	0.511	0.005

Appendix 7.2: Expansion results (raking)

Expansion results from raking method including estimates of kept catch, kept catch standard error (SE), days fished, and days fished standard error (SE) for different expansion types and species.

Type	Species	Kept Catch	Kept Catch SE	Days fished	Days fished SE
Census	King George Whiting	523,767	107,328	135,787	30,635
	Blue Swimmer Crab	459,907	163,461	65,415	14,035
	Australian Herring	441,960	209,953	125,899	47,390
	Southern Calamari	288,382	48,187	90,952	15,397
	Western Australian Salmon	288,382	71,448	90,952	26,718
	Southern Garfish	441,960	209,953	125,899	47,390
	Yellowfin Whiting	21,204	8,082	11,019	6,446
Screening	King George Whiting	464,089	83,108	186,277	80,756
	Blue Swimmer Crab	504,074	245,868	69,712	23,328
	Australian Herring	261,817	128,766	91,540	21,254
	Southern Calamari	264,888	55,564	98,073	23,661
	Western Australian Salmon	264,888	46,038	98,073	19,166
	Southern Garfish	261,817	128,766	91,540	21,254
	Yellowfin Whiting	59,218	19,137	36,660	17,420
Screening and adjustments	King George Whiting	1,112,178	195,845	437,581	151,430
	Blue Swimmer Crab	939,795	397,570	150,419	43,617
	Australian Herring	409,982	194,426	172,526	35,097
	Southern Calamari	498,531	97,002	233,207	50,864
	Western Australian Salmon	155,769	47,687	137,670	27,714
	Southern Garfish	409,982	56,593	172,526	7,129
	Yellowfin Whiting	46,930	13,720	46,386	21,466
State-wide probability survey	King George Whiting	1,129,574	137,808	314,568	30,450
	Blue Swimmer Crab	920,721	121,102	188,340	20,987
	Australian Herring	452,010	69,165	71,105	18,113
	Southern Calamari	550,179	69,332	271,922	32,101
	Western Australian Salmon	154,613	30,431	84,789	22,775
	Southern Garfish	264,506	51,926	42,940	7,408
	Yellowfin Whiting	139,359	69,915	18,778	7,062

Appendix 7.3: Expansion results (propensity scores)

Expansion results from propensity scores method including estimates of kept catch, kept catch standard error (SE), days fished, and days fished standard error (SE) for different expansion types and species.

Method	Species	Kept Catch	Kept Catch SE	Days fished	Days fished SE
Screening	King George Whiting	548,640	61,829	172,877	42,692
	Blue Swimmer Crab	441,357	154,839	59,189	11,543
	Australian Herring	354,467	163,551	85,886	14,572
	Southern Calamari	306,979	66,210	103,570	22,943
	Western Australian Salmon	124,647	31,281	61,761	12,469
	Southern Garfish	99,962	22,543	14,540	2,431
	Yellowfin Whiting	69,791	26,720	28,808	15,139
Screening and adjustments	King George Whiting	1,343,257	159,482	433,701	77,873
	Blue Swimmer Crab	839,885	235,626	129,161	20,383
	Australian Herring	537,400	245,417	161,751	26,068
	Southern Calamari	572,443	111,442	246,220	52,754
	Western Australian Salmon	127,717	21,684	110,452	17,905
	Southern Garfish	167,293	35,308	28,835	4,429
	Yellowfin Whiting	57,790	16,780	37,294	18,424
State-wide probability survey	King George Whiting	1,129,574	137,808	314,568	30,450
	Blue Swimmer Crab	920,721	121,102	188,340	20,987
	Australian Herring	452,010	69,165	71,105	18,113
	Southern Calamari	550,179	69,332	271,922	32,101
	Western Australian Salmon	154,613	30,431	84,789	22,775
	Southern Garfish	264,506	51,926	42,940	7,408
	Yellowfin Whiting	139,359	69,915	18,778	7,062

Appendix 7.4: Expansion results (statistical matching)

Expansion results from statistical matching method including estimates of kept catch, kept catch standard error (SE), days fished, and days fished standard error (SE) for different expansion types and species.

Method	Species	Kept Catch	Kept Catch SE	Days fished	Days fished SE
Screening	King George Whiting	648,222	53,785	134,169	7,798
	Blue Swimmer Crab	395,394	39,590	63,273	4,749
	Australian Herring	236,898	31,506	76,807	5,699
	Southern Calamari	374,049	34,952	102,709	5,663
	Western Australian Salmon	131,293	20,217	63,662	6,645
	Southern Garfish	163,671	27,788	23,363	3,099
	Yellowfin Whiting	55,956	13,677	13,672	2,696
Screening and adjustments	King George Whiting	1,832,397	179,936	423,887	30,643
	Blue Swimmer Crab	905,205	101,493	153,409	12,548
	Australian Herring	389,901	56,781	152,669	12,255
	Southern Calamari	772,377	85,176	282,507	18,622
	Western Australian Salmon	200,530	35,082	136,757	16,144
	Southern Garfish	305,731	53,610	51,554	7,127
	Yellowfin Whiting	79,197	25,717	21,876	5,094
State-wide probability survey	King George Whiting	1,129,574	137,808	314,568	30,450
	Blue Swimmer Crab	920,721	121,102	188,340	20,987
	Australian Herring	452,010	69,165	71,105	18,113
	Southern Calamari	550,179	69,332	271,922	32,101
	Western Australian Salmon	154,613	30,431	84,789	22,775
	Southern Garfish	264,506	51,926	42,940	7,408
	Yellowfin Whiting	139,359	69,915	18,778	7,062

Appendix 7.5: Expansion results (model-based)

Expansion results from model-based method including estimates of kept catch, kept catch standard error (SE), days fished, and days fished standard error (SE) for different expansion types and species.

Type	Species	Kept Catch	Kept Catch SE	Days fished	Days fished SE
Screening	King George Whiting	530,685	148,901	127,715	41,268
	Blue Swimmer Crab	408,045	79,095	67,532	6,351
	Australian Herring	255,473	60,472	86,572	38,348
	Southern Calamari	461,252	74,774	115,905	15,709
	Western Australian Salmon	187,460	51,470	74,276	22,612
	Southern Garfish	124,351	29,775	27,027	40,842
	Yellowfin Whiting	55,201	13,259	13,967	2,691
Screening and adjustments	King George Whiting	1,080,242	526,959	390,557	173,973
	Blue Swimmer Crab	1,050,372	335,648	169,759	25,036
	Australian Herring	419,874	107,238	185,015	42,567
	Southern Calamari	538,717	200,149	284,131	59,221
	Western Australian Salmon	158,884	60,145	138,653	16,453
	Southern Garfish	235,309	145,345	59,133	90,426
	Yellowfin Whiting	52,154	18,344	24,830	5,083
State-wide probability survey	King George Whiting	1,129,574	137,808	314,568	30,450
	Blue Swimmer Crab	920,721	121,102	188,340	20,987
	Australian Herring	452,010	69,165	71,105	18,113
	Southern Calamari	550,179	69,332	271,922	32,101
	Western Australian Salmon	154,613	30,431	84,789	22,775
	Southern Garfish	264,506	51,926	42,940	7,408
	Yellowfin Whiting	139,359	69,915	18,778	7,062

Appendix 8: South Australia recreation fishing limits brochure

Marine Species

	Size (cm)	Bag Limit (per person)	Boat Limit * (per boat)
Southern Bluefin Tuna			
	-	2	6
Southern Calamari (Squid)			
	-	15	45
Combined Cuttlefish/Squid limit. A permanent squid, cuttlefish and octopus closure area applies in Spencer Gulf in the waters of False Bay.			
Southern Garfish			
	23	30	90
Measure from the tip of the upper jaw to tip of tail			
Southern Rock Lobster			
	Southern Zone 9.85 Northern Zone 10.5	4 4	8 8
Southern Zone closure applies 6pm 31 May - 6am 1 October. Northern Zone closure applies 6pm 31 May - 12pm 1 November.			
Sweep (All species)			
	24	20	60
Trevally (All species)			
	24	20	60
Vongole (Mud Cockle)			
	Coffin Bay 3.8 All other waters 3.0	300 300	- -
Western Blue Groper			
	Min 60 Max 100	1	3
A total closure applies at all times in both Gulfs, Investigator Strait and Backstairs Passage			

Marine Species

	Size (cm)	Bag Limit (per person)	Boat Limit * (per boat)
Whaler Shark (Bronze and Dusky)			
	-	1	3
Wrasse (All species in the Labridae Family excluding Western Blue Groper)			
	Min 25 Max 35	5	15
Yellowfin Whiting			
	24	20	60
Yellowtail Kingfish			
	60	1	3

Cooper Creek & Diamantina River

	Size (cm)	Bag Limit (per person)	Boat Limit * (per boat)
Lake Eyre Golden Perch (Callop)			
	33	5	15
Catfish (Cooper Creek)			
	Fully protected		
Catfish (Hyrtl's/Silver Tandan)			
	-	10	30
Grunter (Barcoo, Welch's, Banded)			
	-	5	15
Spangled Perch			
	-	15	45

Other Freshwater Species

	Size (cm)	Bag Limit (per person)	Boat Limit * (per boat)
European Carp, Redfin, Mosquito Fish, Oriental Weatherloach, Goldfish and Marron are introduced species and must not be returned to the water.			
Freshwater Catfish			
	Fully protected		
Golden Perch (Callop)			
	33	5	15
Murray Cod			
	Catch and release 1 Jan - 31 Jul Closed season 1 Aug - 31 Dec		
Murray River Crayfish			
	Fully protected		
Silver Perch			
	Fully protected		
South-east Crayfish			
	Fully protected		
Trout (Brown or Rainbow)			
	28	-	-
Yabby (All waters)			
	-	200	600

*** The daily boat limit applies where three or more people fishing are onboard.**

The information in this brochure is a guide only. For up to date information on fishing, download the free SA Fishing app at pir.sa.gov.au/safishingapp or contact Fishwatch on 1800 065 522 or pir.sa.gov.au/fishing

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Marine Species

	Size (cm)	Bag Limit (per person)	Boat Limit * (per boat)
Abalone			
Greenlip (western zone)	14.5	5	10
Greenlip (all other waters)	13		
Blacklip (all waters)	13		
All other species	13		
Combined Greenlip/Blacklip/all other species limit.			
Albacore	-	2	6
Australian Herring (Tommy Ruff)	-	40	120
Black Cowrie	-	1	-
Bloodworm (All species)	-	4 litres	-
Blue Morwong (Queen Snapper)	38	5	15
Blue Swimmer Crab	11	20	60
Combined Blue Swimmer/Sand Crab limit. Measured side to side at the base of the largest spine.			
Bream (All species)	30	10	30
A closure applies from 1 September to 30 November in Onkaparinga River, upstream of the Main South Road bridge. Other closures may apply.			

Marine Species

	Size (cm)	Bag Limit (per person)	Boat Limit * (per boat)
Congolli	-	2	6
Cuttlefish (All species)	-	15	45
Combined Cuttlefish/Squid limit. A permanent squid, cuttlefish and octopus closure area applies in Spencer Gulf in the waters of False Bay.			
Flathead (All species)	30	10	30
Flounder (All species)	-	20	60
Giant Crab	15	-	-
Gummy Shark	45	2	6
Measured from fifth gill slit to base of tail. Combined School/Gummy Shark limit.			
Harlequin Fish	-	2	6
King George Whiting			
East of 136°E (including all Gulf waters)	32	10	30
West of 136°E	30	10	30
POSSESSION LIMIT: 72 fish or 10kg of fillets OR where in possession of fish and fillets 36 fish and up to 5kg of fillets.			

Marine Species

	Size (cm)	Bag Limit (per person)	Boat Limit * (per boat)
Mullet (All species)	21	60	180
Mulloway			
Within Coorong only			
46-82		10	30
>82		2	6
All other waters			
>82		2	6
Pipi (Goolwa Cockle)			
East of 136°E (approximately Port Lincoln)	3.5	300/person	900†
West of 136°E	3.5	100/person	300†
POSSESSION LIMIT: 1200 A closure applies statewide from 1 June to 31 October (inclusive). Recreational fishers must also comply with a closure on the Younghusband Peninsula between the Murray Mouth and 28 Mile Crossing. This is a commercial-only fishing zone.†This is a vehicle limit that applies where three or more people are present.			
Razorfish	-	25	75
POSSESSION LIMIT: 100 A closure applies from 1 October until the end of February in an area of Upper Spencer Gulf.			
Redfish / Bight Redfish / Swallowtail (Nannygai)	30	10	30
Separate limits apply to all three species.			
Salmon (Western Australian)	21-35	20	60
	>35	10	30
Samsonfish	88	1	3

Marine Species

	Size (cm)	Bag Limit (per person)	Boat Limit * (per boat)
Sand Crab	10	20	60
Combined Sand/Blue Swimmer Crab limit.			
Scallop (All species)	6.5	50	150
School Shark	45	2	6
Measured from fifth gill slit to base of tail. Combined School/Gummy Shark limit.			
Sea Urchin (All species)	-	20	60
Snapper			
juvenile — South East waters	38	1	3
adult — West Coast / Spencer Gulf / Gulf St Vincent waters. Closed in all waters until 31 January 2023			
Mandatory catch reporting applies for Snapper through the SA Fishing App. A release weight should be used to release undersized or unintentionally caught Snapper.			
Snook	45	20	60