Assessing new technologies and techniques that could improve the cost-effectiveness and robustness of recreational fishing surveys

Proceedings of the national workshop, Adelaide, South Australia, 10-12 July 2018

C. Beckmann, S. Tracey, J. Murphy, A. Moore, B. Cleary and M. Steer

March 2019

FRDC Project No 2017-198

ISBN: 978-1-876007-13-3

Assessing new technologies and techniques that could improve the cost-effectiveness and robustness of recreational fishing surveys. Proceedings of the national workshop, Adelaide, South Australia, 10-12 July 2018.

2017-198

2019

Ownership of Intellectual property rights

This publication (and any information sourced from it) should be attributed to: Beckmann, C., Tracey, S., Murphy, J., Moore, A., Cleary, B. and Steer, M. South Australian Research and Development Institute (Aquatic Sciences) 2019, *Assessing new technologies and techniques that could improve the cost-effectiveness and robustness of recreational fishing surveys. Proceedings of the national workshop, Adelaide, South Australia, 10-12 July 2018*. Adelaide, March.

Creative Commons licence

Disclaimer

Researcher Contact Details

Name: Mike Steer
Address: SARDI Aquatic Sciences
PO BOX 120 Henley Beach SA 5022
Phone: 08 8429 0342
Fax:
Email: Michael.steer@sa.gov.au

FRDC Contact Details

Address: 25 Geils Court
Deakin ACT 2600
Phone: 02 6285 0400
Fax: 02 6285 0499
Email: frdc@frdc.com.au
Web: www.frdc.com.au

Contents

Figures

Acknowledgments

The editors would like to thank everybody who attended the workshop for their valuable input in discussing the current and future technologies and techniques that could improve the cost-effectiveness and robustness of recreational fishing surveys. A special thank you to all those who presented for sharing their expertise in the area of survey design, emerging technologies, engagement strategies and options for the national social and economic survey. We are grateful to Dr Sean Tracey for facilitating the workshop discussions. Thank you to Steve Taylor and Karina Ryan for their valuable contribution to the report. This project was funded by the Fisheries Research and Development Corporation.

Abbreviations

ABARES Australian Bureau of Agricultural and Resource Economics and Sciences

ACMA Australian Communications and Media Authority

ANPR Automatic Number Plate Recognition

ARFF Australian Recreational Fishing Foundation

CATI Computer Assisted Telephone Interview

CRAGS CSIRO's ruggedised autonomous gigapixel camera system

CSIRO Commonwealth Scientific and Industrial Research Organisation

DAF Department of Agriculture and Fisheries

DPIRD Department of Primary Industries and Regional Development's

FRDC Fisheries Research and Development Corporation

G-NAF Geocoded National Address File

GPS Global Positioning System

IGFA International Game Fish Association

IMAS Institute for Marine and Antarctic Studies

IPND Integrated Public Number Database

NIWA National Institute of Water and Atmospheric Research

PIRSA Primary Industries and Regions South Australia

RDD Random Digit Dialling

SARDI South Australian Research and Development Institute

SAPS Supplemented Access Point Surveys

VMS Vehicle Monitoring System

Executive Summary

Currently, the most significant gap in our knowledge in assessing the status of community-shared fisheries is determining the relative contribution by the recreational sector. To explore this issue, a two-day national workshop was held from 10-12 July 2018 at the South Australian Research and Development Institute (SARDI). The key focus was advancing the 'best practice' approach in design, execution, and analysis of recreational fishing surveys as described in Georgeson et al. (2015; FRDC 2007-014). This project also builds on recent work by Griffiths et al. (2014; FRDC 2011-036) and Moore et al. (2015; FRDC 2012-022.20). The overarching aim of this workshop was to assess the usefulness of new technologies and techniques for enhancing the cost-effectiveness and reliability of recreational fishing surveys. The attendees included recreational fisheries scientists, managers, a national peak body representative, an international expert, representatives from Deckhand© and a Fisheries Research and Development Corporation (FRDC) representative.

The specific objectives of the workshop were to:

1. explore options to improve the precision and cost-effectiveness of recreational fishing surveys;

2. assess whether emerging technologies can be feasibly integrated into future surveys; and

3. identify strategies that positively engage the recreational sector in fisheries science and management.

Recently, changes to the availability of traditional phone and address listings and rapid transformations in the way people communicate, have led to a need to re-evaluate how recreational fishing is assessed. The telephone directory (e.g. White Pages©) has traditionally been the primary sampling frame for large-scale recreational fishing surveys; however, it has become less representative of the overall population. The workshop identified that the most cost-effective option for future large-scale surveys is to gain access to a national register of recreational fishers (without exemptions). This would allow probabilistic sampling of the target population, improved precision of catch and effort estimates and alleviate the reliance on broad-scale population sampling. Where a complete registry is not available, other general population databases, such as; the Geocoded National Address File (G-NAF), the Integrated Public Number Database (IPND), boat registration databases, commercial databases, and online panels may provide alternative sampling frames, or a multi-frame design using combinations of these may be employed.

It was recognised that face-to-face screening is an effective method to reduce non-response bias and soft refusals. However, face-to-face sampling can be prohibitively expensive due to the time and effort required to adequate sample recreational fishers, which typically comprise a small component (<20%) of the general population. Face-to-face sampling methods are more likely to be effective if they target small geographic areas (e.g. boat ramps, marinas, popular shore-based fishing locations). Where face-to-face screening is not practical, phone screening is likely to be the preferred method.

At the data collection phase of surveys, phone-surveys provide a cost-effective method to survey a large number of fishers over broad spatial and temporal scales. Future surveys may utilise smartphone applications and/or the internet as a more cost-efficient and modern alternative to data collection. It is important to note, however, that web-based and smartphone technologies are more likely to complement probabilistic based survey designs rather than replace them, by offering another platform to obtain extra information about recreational fishing activities and an avenue to increase sectorial engagement.

Wash-up attitudinal surveys, undertaken following the completion of the large-scale survey, remain an important tool to assess awareness of regulatory and educational information, gauge the sector's attitudes towards fisheries management, determine the social values of recreational fisheries, and to collect additional economic information that may relate to expenditure or contingency evaluation. These surveys also have considerable flexibility to gain information at a regional level, where questions can be formulated around specific jurisdictional issues such as biosecurity (i.e. White Spot Disease in Queensland's prawn fisheries, or Pacific Oyster Mortality Syndrome in southern Australia). Consumptive orientation, socio-demography,

social licence and choice modelling surveys are also likely to be relevant for future national and or State wide surveys.

On-site surveys should continue to complement large-scale off-site methods by providing an important avenue to collect necessary biological information (e.g. fish length and weight data). This level of biological information is important as it is relied upon to convert fish numbers to weight, and subsequently the estimated total harvest of the recreational fishing sector. In situations where the objective of the survey is to quantify a specific regional component of the recreational fishing community such as the reopening of a spatial closure, an on-site survey may be sufficient and preclude the need to undertake a larger off-site investigation. Workshop participants agreed that the accuracy and precision of data obtained from large-scale offsite surveys could be improved with complementary and innovative technologies. On-site surveillance techniques such as static boat ramp cameras, aerial surveys, thermal imaging, automated traffic counting systems, Automatic Number Plate Recognition (ANPR) software, and targeted drone surveys may be particularly useful for developing proxies of fishing effort in between off-site surveys.

Recreational fishing surveys provide key information used to inform fisheries management. In some jurisdictions (e.g. South Australia), recreational catch estimates are used to determine shares against pre-described allocations that underpin resource management. Improving the accuracy and precision of these estimates was a key focus of this workshop. However, the currently available sampling frames and survey methods mean that it is generally cost-prohibitive to increase the amount of sampling coverage to reduce bias and increase precision for many species. This is particularly relevant for niche species that are rarely caught (i.e. Southern Bluefin Tuna in southern Australia), and consequently their estimated catches are often bounded by large error variances. Such imprecise estimates for these species can erode stakeholder confidence in the science and undermine the integrity of the entire survey. Educating stakeholders about how recreational fishing surveys are undertaken, why only a small proportion of the population is surveyed, and how the numbers are scaled up regionally to provide an estimate of total catch (and effort), is fundamental in rebuilding their trust in the process. However, this remains a significant challenge. Modern and rapidly advancing communication platforms may provide an appropriate avenue to bridge the 'education' gap. Social media platforms, smartphone applications or internet chat forums have quickly infiltrated the population as a reliable means for mainstream communication, and currently provide a vehicle to engage the recreational fishing community in fisheries related issues.

Keywords

Recreational fishing, survey, phone-diary, online-panel, creel, smart-phone, technology, engagement.

1. Introduction

Assessing and managing community-shared fisheries resources among various user groups and stakeholders is challenging particularly where knowledge gaps exist surrounding the relative contribution by the recreational sector. To enable effective and sustainable management of these shared resources, fisheries scientists need to account for the combined total harvest of individual species across the different sectors. Most commercial fishers are obligated to report their catch and fishing activity as part of their licence conditions and consequently their impact can be assessed and regulated, whereas fishing activity amongst the recreational sector is largely unknown and can be difficult to assess. Recreational fishers are unlikely to report their catch at the same level of detail or frequency as the commercial sector, so in order to obtain an estimate of their total catch, a representative sample of the population needs to be surveyed periodically. The key focus of this workshop was advancing the ‘best practice’ approach in design, execution, and analysis of recreational fishing surveys as described in Georgeson et al. (2015). The overarching aim of this workshop was to assess the usefulness of new technologies and techniques for enhancing the cost-effectiveness and reliability of recreational fishing surveys.

In Australia, the most commonly used method for estimating the total catch from the recreational sector is through phone-diary interviews and associated on-site creel surveys (Georgeson et al. 2015). Phone-diary surveys typically involve randomly sampling the general population, screening and interviewing a sub-set of the sampled population, recruiting intending fishers to participate in a telephone-diary survey, regularly assessing their fishing activities over a defined time period, and scaling-up the data to obtain a population estimate. These off-site surveys are often complemented with on-site investigations that aim to intercept anglers at boat ramps, jetties, marinas and prominent shore-based fishing locations (e.g. breakwaters) to obtain useful information about their catch and fishing experiences.

While these types of recreational fishing surveys are considered to adopt ‘world’s best practice’, they typically rely on sampling the general population, which recreational fishers often account for a small proportion. For jurisdictions that require recreational fishers to have a licence, or register prior to undertaking any fishing activity, their sampling frame becomes refined to a more representative population that can be surveyed more cost-effectively. When sampling a subset of the population, the sample selection can be either random (probabilistic sampling) or non-random (non-probabilistic sampling). Random sampling is preferred as the precision of the estimates can be assessed by calculating associated confidence intervals or margins of error (Georgeson et al. 2015). However, as recreational fishers represent a small proportion of the population (~20%) and a small proportion of recreational fishers catch the majority of fish, catch estimates are usually bounded by large confidence intervals (Henry and Lyle 2003). Levels of error can be reduced by increasing the sample size; however, for species caught infrequently, or from niche recreational fisheries, it can be difficult to achieve precise estimates using large-scale survey designs. The dynamic nature of the recreational fishing sector, both within and between jurisdictions, means that there is unlikely to be a single survey design that can provide accurate and precise estimates of recreational catch and effort for all species.

Changes in the availability of traditional sampling frames and rapid transformations in telecommunication have increased the need to re-evaluate the way recreational fishing is assessed. For example, large-scale population surveys have traditionally relied on the telephone directory (e.g. White Pages©) as a representative sampling frame, however, it is becoming less representative as the population continues to shift away from landline telecommunications to become increasingly reliant on unlisted mobile devices (Griffiths et al. 2017). As such, there is a need to investigate alternative sampling frames and associated methodologies to ensure that survey designs continue to provide the highest quality information in the most cost-effective way. This includes assessment of available sampling frames, suitable screening surveys, data collection platforms, validation methods and follow-up attitudinal (‘wash-up’) surveys. As recreational fishing surveys are generally conducted periodically (e.g. every 5 years in South Australia, SA), they are limited in their ability to capture the highly dynamic nature of the recreational fishing sector. Therefore, there is also a need to identify appropriate proxies for estimating catch between surveys. This may include the use of emerging technologies (e.g. static cameras, drones and thermal imaging), data processing systems (e.g. machine learning and image recognition software) and data collection platforms (e.g. smart phone applications). Increasing the frequency of catch and/or effort estimates is an important step in improving the accuracy and precision of data. The result would likely be increased stakeholder confidence in recreational survey estimates, which support management decisions and assessments.

2. Objectives

The objectives of the National Recreational Fishing Workshop were to:

1. Identify options to improve the precision and cost-effectiveness of recreational fishing surveys.
2. Identify strategies that positively engage the recreational sector in fisheries science and management.
3. Assess whether emerging technologies can be feasibly integrated into future surveys.

3. Method

The South Australian Research and Development Institute (SARDI) hosted a technical workshop from 10–12 July 2018 at the South Australian Aquatic Sciences Centre, West Beach. The workshop was combined with a workshop for another national project ‘Determining the design, output specifications and sample size for a national social and economic survey of recreational fishers in Australia’ (FRDC 2016-126). Participants at the workshop included recreational fisheries scientists, managers, a national recreational peak body representative and an international expert in recreational fishing surveys from New Zealand. The New Zealand representative provided valuable case studies and insights into optimising survey designs. A list of attendees is available in Appendix 2 and the workshop agenda is available in Appendix 3. The workshop, which was chaired by Dr Sean Tracey (IMAS), was broken into several sessions to align with the workshop objectives; (i) improve the precision and cost-effectiveness of surveys, (ii) emerging technologies and engagement strategies, and (iii) national social and economic survey of recreational fishers. During these sessions, 11 presentations were given (six of which were provided by attendees and have been presented in Appendices 4-9), followed by a discussion session.

This report provides a synthesis of the standard methods currently used, as well as considering new and emerging methods for conducting off-site surveys (i.e. sampling frames, screening survey methods, data collection methods and wash-up attitudinal surveys) and on-site surveys (i.e. access point, roving, complementary). The intention of this report is to provide a suite of options for researchers conducting future large-scale off-site surveys and to assess emerging technologies to improve the accuracy and precision of on-site surveys.

3.1 Presentations

1. “Don’t throw the baby out with the bath water” presented by Dr Jeremy Lyle- IMAS, Tasmania (Appendix 4).
2. “Applying innovation to off-site survey designs and statistical methods” presented by Dr Karina Ryan- DPIRD, Western Australia (Appendix 5).
3. “Use of internet surveys” presented by Mr Andy Moore- ABARES, Canberra (Appendix 6).
4. “Surveys in a changing social landscape: Addressing the challenges of achieving representative population samples” presented by Dr Jacki Schirmer- University of Canberra.
5. “What role can digital camera monitoring of boat retrievals play in informing fisheries management” presented by Mr Bruce Hartill- NIWA, New Zealand (Appendix 7).
6. “Integrating remote camera data and aerial surveys into the monitoring of two WA recreational fisheries” presented by Dr Stephen Taylor- DPIRD, Western Australia (Appendix 8).
7. “High resolution camera works (CRAGS)” presented by Dr Tim Lynch- CSIRO, Tasmania.
8. “Can ‘Deckhand’ transition from the commercial to the recreational sector” presented by Mr Simon Dick- Deckhand, South Australia.
9. “Improved data on Aboriginal and Torres Strait Islanders fisheries resource use to better inform community planning and agency decision-making” presented by Mr Shane Holland- PIRSA, South Australia.
10. “Expectations of the recreational sector” presented by Mr Brett Cleary- ARFF, Tasmania.
11. “A national social and economic survey: options” presented by Mr Andy Moore- ABARES, Canberra (Appendix 9).

4. Results

4.1 Survey Objectives

On-going data collection is important to measure the relative impact of fishing mortality to allow for sustainable resource management. Therefore, the primary objective of many large-scale surveys is to quantify catch and effort for a range of species. While catch and effort information is typically available through mandatory reporting in commercial fisheries, it is challenging to collect equivalent data from recreational fisheries (Georgeson et al. 2015). The size and complexity of survey methodology varies depending on the scale and objectives of the study (Pollock et al. 1994). Most commonly, off-site survey methods are used for these large-scale surveys. Off-site surveys are also suited to social and economic objectives including participation, demographic profiling, expenditure, and attitudes and awareness related to fisheries management issues. While on-site surveys can collect similar information, they are often targeted at estimating catch or effort related to specific activities (e.g. shore-based or boat-based), areas/water bodies or species of interest. Such studies frequently examine spatial and temporal trends in catch and effort and can be complementary to large-scale off-site surveys. Achieving these objectives, often results in a trade-off between the accuracy and precision required and the cost of an appropriate method (Georgeson et al. 2015).

4.2 Off-site Recreational Fishing Surveys

Off-site methodologies are often utilised for large-scale surveys where the target population is widely dispersed and on-site sampling is unlikely to be cost-effective. The most commonly used off-site methods include telephone, mail, internet or modern surveillance surveys. Following the identification of the objectives and scope of the survey, six key steps were identified as the preferred approach to undertaking an off-site recreational fishing survey: (1) select a representative population sampling frame under either a single or multi-frame design; (2) establish a probability-based sampling procedure; (3) contact the selected sampling units to conduct a screening survey and recruit eligible participants to the data collection phase; (4) collect off-site data from the selected sample using the most appropriate survey method; (5) conduct 'wash-up' attitudinal surveys; (6) complement off-site surveys with on-site surveys to obtain additional information about catch and fishing experiences; and (7) assess sample representation to provide weightings for expanded population estimates (Figure 1).

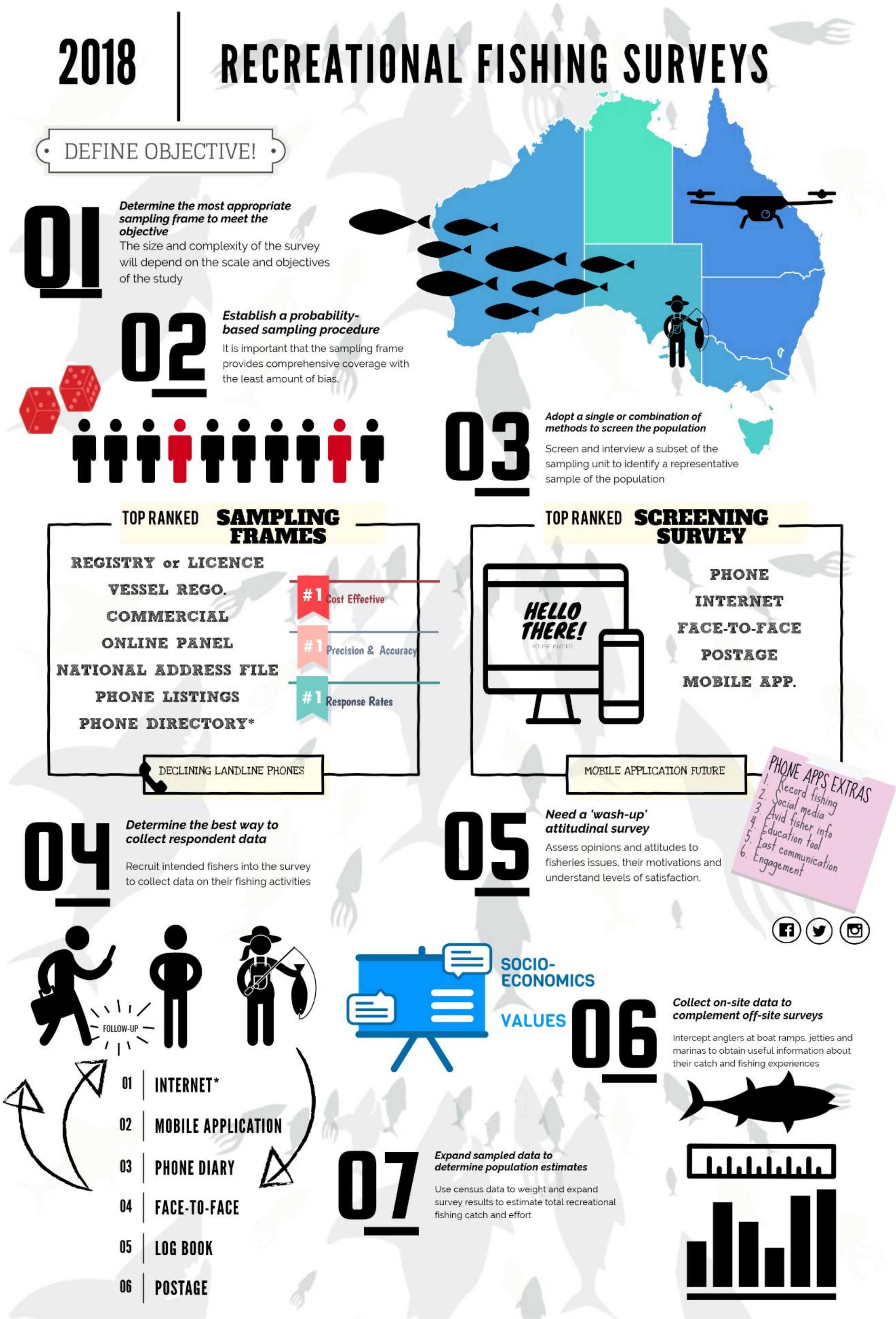


Figure 1: Summary of the seven key steps in designing a recreational fishing survey

4.2.1 Sampling frames

To access the target population, sampling frames of addresses, phone numbers or geographical areas need to be identified. Sampling frames are a list of sampling units from which samples are selected. For each frame, the primary sampling unit (e.g. household, person, fishing location, etc.) also needs to be determined. Sampling the entire population (census) is problematic as some individuals will be hard to locate, the population is always changing and it is unlikely to be cost-effective. To overcome this, methodologies have been developed to select a segment of the population and apply appropriate weightings to expand results to population estimates. Therefore, it is important that the chosen sampling frame will provide comprehensive coverage with the least amount of bias to avoid high levels of variation or error.

The level of bias for each sampling frame will vary depending on the sampling methodology. The quota sampling method (non-probability) pre-defines groups (e.g. demographics) using existing information and involves selecting a specified number of cases (quota) from each group. This is a lower cost method compared to probability sampling, but can result in biased estimates due to discrepancies in fisher contact availability (Griffiths et al. 2010). Probability sampling involves randomly drawing samples from list frames or area frames, whereby all samples or sampling units have a known probability of being drawn and confidence intervals can be calculated (Pollock et al. 1994). Cluster sampling is commonly used for recreational fishing surveys, particularly where there is no frame listing (Schaeffer et al. 1996).

General population sampling

Population databases provide a broad and representative sample of the population. The general population has traditionally been sampled using address-based sampling frames (ICES 2010; Armstrong et al. 2013) or phone numbers as a proxy for private dwelling listings (Henry and Lyle 2003; Lyle et al. 2002; Coleman 2003; Jones 2009; Giri and Hall 2015). Phone numbers are commonly sourced from a telephone directory (e.g. the White Pages ©). In recent Australian examples, large-scale recreational fishing surveys have relied on physical random sampling of public telephone directories, as it is currently illegal to use digital listings (Georgeson et al. 2015). Future surveys could explore the use of the Geocoded National Address File (G-NAF), a database of all 14.1 million Australian addresses compiled by the Public Sector Mapping Agencies (Public Sector Mapping Agencies, 2013). This database includes address data and coordinate references (or geocode) for street addresses in Australia. The Australian Communications and Media Authority (ACMA) manage an equivalent database for phone-listings in the Integrated Public Number Database (IPND). This includes all domestic and mobile phone numbers (over 80 million) in Australia (Georgeson et al. 2015).

The advantage of general population sampling frames is the potential to conduct probabilistic sampling over any defined geographic area. The key challenge is obtaining access to a complete and accurate database. Until recently, telephone directories were a relatively cost-effective way to achieve good coverage of the general population. However, the rise in unlisted numbers and mobile phone usage has reduced the overall coverage of traditional telephone directories, raising concerns around coverage bias particularly in relation to some socio-demographic groups (i.e. under- or over-coverage of particular groups). As the White Pages© contains only 81% of all residential households in Australia and the electronic version is no longer available, it is unlikely to be the most effective sampling frame for future surveys (Ryan et al. 2013, Georgeson et al. 2015). The IPND provides a more complete database, although this can only be accessed through Commonwealth Government Research, unlisted numbers cannot be contacted, and random sampling of listed domestic numbers within each postcode is not possible (Georgeson et al. 2015). Of these general population-sampling frames, the G-NAF appears to provide the most tractable option for random sampling geocoded to the dwelling level.

4.2.2 Screening surveys

Screening surveys involve interviewing a representative subset of the sampling units, which can be stratified and weighted based on a number of criteria, e.g. residential statistical division. This allows the identification and recruitment of subjects who participate in recreational fishing to take part in a follow-up diary survey. Screening surveys can also be used to collect demographic information (e.g. age, gender, ethnicity, previous and future levels of participation in recreational fishing, association memberships, recreational fishing licence status, and socio-economic information (Henry and Lyle 2003).

Phone

Phone-based screening surveys involve either using random digit dialling (RDD) or contacting directory-listed phone numbers, usually using a stratified random sampling approach. Historically, geographical regions could be targeted based on landline prefix or address data listed in the phone directory. Phone surveys are preferable to written surveys as it reduces issues associated with illiteracy, vision impediments, and respondent burden. In Australia, response rates have typically been high (75% to 85%) for phone-based surveys, however, non-response (non-contact or refusal) rates are increasing (Georgeson et al. 2015).

Face-to-face

The face-to-face (or door-to-door) method of screening is likely to be the most effective method to reduce non-response bias and soft refusals. This is because the ease of response is attractive to respondents that have difficulty in answering mail, or telephone surveys, due to lack of time/interest, poor literacy levels, disability or infirmity. However, face-to-face surveys can be cost prohibitive due to the labour and training required to undertake them. Consequently, this method is often limited to a small geographic area and may be appropriate for some targeted studies.

Postage/mail

Generally, mail surveys are used to make initial contact and follow-up surveys can be undertaken using alternative data collection methods. The advantage of using mail surveys is that a cover letter can be included to provide additional information on the study. The level of non-response bias is likely to be higher for mail survey methods compared to phone or face-face surveys, as response rates are generally much lower due to respondent burden.

4.2.3 Collection of respondent catch and effort data

Following the screening survey, intending recreational fishers are identified and recruited into the data collection phase (catch and effort) of the recreational fishing survey. This generally involves a longitudinal panel survey, which collect repeated observations of the same variables over a defined period. This survey consists of a carefully designed sequence of questions that are developed in-line with the survey objectives. The data collected usually includes catch and effort information such as species targeted, species caught, number of fish landed by species, fishing location, water body type and catch and release details.

Face-to-face

The face-to-face (or door-to-door) method typically involves trained personnel conducting regular interviews over a pre-determined period. While this method is likely to be expensive, it provides a high level of engagement resulting in more precise data and limited bias (Pollock et al. 1994). Due to the high cost of face-to-face surveys, the key application is likely to be as a benchmark to corroborate results obtained through other methods.

Postage/mail

Mail surveys are a type of self-reporting diary or logbook, which participants return at the end of a pre-determined survey period. While this method is likely to be cost-effective, without telephone or face-to-face contact, workshop participants generally agreed that the level of engagement can be low, resulting in sub-optimal response rates, infrequent reporting and reduced data quality.

Phone diary

A combination of phone and respondent diaries are the most common method used in Australia to conduct large-scale recreational fishing surveys. Diaries, logbooks or ‘memory joggers’, can be used to assist in data collection by encouraging participants to record key information for all their fishing activity. Respondents are contacted periodically to retrieve data and anglers who are more avid are contacted more frequently to reduce recall bias. The phone-diary method is a cost-effective way to survey a large number of fishers over extensive spatial and temporal scales (Griffiths et al. 2010; Georgeson et al. 2015). Computer Assisted Telephone Interview (CATI) systems, where interviewers follow a script provided by a software application, could provide a more efficient data collection platform, but connection delays can lead to high refusal or hang-up rates. Response rates for this method are generally higher than mail surveys but lower than on-site creel surveys (Griffiths et al. 2010; Georgeson et al. 2015). Where diaries are used, surveys have a higher level of response burden but the accuracy and precision of data are likely to be increased. In New Zealand, the respondent burden is lower as there is no requirement to complete a diary, and phone contact is more regular (Heinemann et al. 2015). Similarly, in Tasmania, diarists are regularly contacted with the frequency of contact tailored to the needs and behaviour of the individual respondent (Lyle and Morton 2004). These examples highlight the importance of trained interviewers to ensure quality and completeness of surveys.

4.2.4 Wash-up attitudinal surveys

Wash-up attitudinal (post-enumeration) surveys are often conducted at the end of the diary survey to assess awareness and attitude, and detect differences among respondents. Wash-up surveys can verify recreational fishing behaviour (i.e. fished or not), collect additional expenditure data, collect profiling information (such as boat ownership details, use of technologies), and assess opinions and attitudes to fisheries issues (Georgeson et al. 2015). In particular, it is important for fisheries management agencies to understand levels of satisfaction, motivating factors and influences on fishing activities. Generally, jurisdictions also conduct a separate survey for a sub-sample of non-intending fishers who were not included in the main survey, allowing the identification of any unexpected fishing to correct for participation rates when data are expanded to the population level (Georgeson et al. 2015).

The questions included in wash-up surveys are likely to be largely jurisdiction-specific and will depend on the overall objectives of the survey. Often stakeholder consultation is required to formulate the specific questions and the right balance of questions is established to ensure the level of respondent burden is not too high. Socio-demographic profiling is likely to be relevant across all jurisdictions as different values, beliefs, behaviours and preferences may influence the population through time. The key advantage of collecting socio-demographic data is disaggregating survey results by demographic groups and linking wash-up results to identifiers in the main survey. Questions about fisher motivations are also likely to be relevant across all jurisdictions as they provide insight into what recreational fishers expect of their fishing experience and can vary significantly. This can include factors associated with satisfaction such as their consumptive orientation, or the degree to which fishers value the catch-related aspects of the fishing experience. A successful fishing experience may also be linked to attitudes around fisheries management and policy. Depending on the survey objectives, wash-up surveys can provide an opportunity to gauge opinion on representation and communication, and to determine which strategies are successful in engaging the recreational fishing community. Questions concerning the community perceptions of fishing (social licence), may also be important in reflecting the opinions and expectations of the broader community. These questions may be more relevant at the Commonwealth level. Finally, wash-up surveys can provide an opportunity to investigate topical jurisdictional issues such as determining the awareness of biosecurity threats, changes in fisheries management, or community-based initiatives.

Wash-up attitudinal surveys may also provide an opportunity to incorporate questions using a choice modelling approach. Choice modelling involves posing a series of questions about preferences and the outputs can be used to estimate ‘use’ and ‘non-use’ values of recreational fishing (Georgeson et al. 2015). While use values are associated with the direct use of the resource, non-use values are those that people derive from the existence of a species or ecosystem even if they do not use it. The advantage of choice modelling is that it provides a more structured approach to predict behaviour and estimate economic value compared to expenditure based questions. Nevertheless, choice modelling would increase the level of respondent burden, hence would be most appropriate as a separate survey to the standard wash-up attitudinal survey. Depending on the length of the choice modelling questionnaire, consideration should be given to delivery through a respondent-directed method such as the internet. This method involves existing sample members recruiting new members to the sample from their social network. To avoid bias, it would be important to sub-sample identifiable members of the respondent sample representing the population.

4.2.4 Options for improvements to off-site surveys

Registry sampling frames

General population surveys are unlikely to be the most efficient method of collecting data, as recreational fishers are relatively rare in the population. The most effective solution would be the creation of a comprehensive registry of all recreational fishers. This would provide a targeted sampling frame improving efficiency, precision and cost-effectiveness.

Currently, recreational fishing licences exist in New South Wales (NSW), Victoria (Ryan et al. 2009; Ford and Gilmour 2013), and Western Australia (WA) (Ryan et al. 2009; 2017). Residents primarily purchase a recreational fishing licence, however, a small number of interstate or overseas visitors also take out licences. Some of these licence schemes have exemptions (e.g. pensioners, under 18s) and only apply to shore-based fishers in Western Australia (Georgeson et al. 2015). Additional licence frames that could be accessed include recreational rock lobster pot licences in WA (DeLestang et al. 2012), species and gear specific licences in Tasmania (Melville-Smith and Anderton 2000; Lyle and Morton 2004; Lyle et al. 2005) and rock lobster pots registrations in South Australia (SA, Currie et al. 2006). The major concern with registry sampling frames is potential non-response bias related to avidity, meaning that follow-up surveys or adjustments may be required. Vessel registration, or boat licence databases, are also likely to provide an effective alternative sampling frame, as people who own a boat are more likely to participate in recreational fishing. While such licence frames may not provide full coverage of the target population, they can be effective for targeting particular species or fishing methods (e.g. boat-based fishing for offshore species).

Commercial databases and online panels

Commercial databases, such as those used for healthcare and market research, contain records from a sample of the population and can be purchased, or leased, from commercial vendors. The types of data generally include specific identifiers, i.e. names and addresses, and key demographic variables. They may also contain indicators of wealth, purchasing behaviour, and leisure or professional activities. While coverage in these databases is generally good, the accuracy and completeness of data available can be variable. The biggest challenge presented by commercial databases is the lack of information available on data source and quality control procedures. Further work is required to understand the potential biases in these datasets to aid interpretation of outcomes when used for recreational surveys.

As it is often difficult to source a suitable sampling frame, online panels can provide access to a pool of subjects who have agreed to take part in online studies on a regular basis. Non-probability panels are open for anyone to join, this means that the probability of selection for each member is unknown and so it is not possible to calculate confidence intervals. Probability-based online panels, where samples are randomly drawn from list or area frames, are the preferred option to target recruits from either the general population or a pre-recruited panel. The key advantages of online-panel data frames are ease of access, relative cost-effectiveness, and increased likelihood of accurate and honest responses. With ongoing survey participation, it is also possible to collect comprehensive demographic background information on panel members. One of the potential biases of this method is that respondents may provide inaccurate answers to complete a survey faster, particularly if there are, incentives involved (Hillygus et al. 2014). In addition, coverage bias, where a research sample is not representative, can occur where the internet is the source of panel member recruitment. The quality of online panels is likely to be highly variable between providers. More research is required to develop robust methods for sampling and weighting to improve representativeness where this method is to be used in recreational fishing surveys.

Internet surveys

The internet provides an online platform for the completion of surveys, which is a cost-efficient and modern alternative for data collection. The main concerns are around the precision and bias of the data collected. Specifically, not all of the target population will have access to the internet and levels of computer literacy are likely to vary among socio-demographic groups. In addition, biases towards anglers that are more avid may occur and overall response rates can be low, particularly in relation to zero catch reporting (Georgeson et al. 2015). The Netherlands successfully implemented monthly online diary surveys between 2010 and 2011, demonstrating the potential of online surveys for cost effective data collection (van der Hammen 2016). Some of the key issues to consider relate to designing questionnaires to reduce non-response bias, adjusting for avidity and respondent bias, and exclusion of dropouts (those who were intending to fish but did not).

Smartphones

Smartphone applications (apps) may provide a cost-effective method to collect supplementary data on recreational catch (Gutowsky et al. 2013, Papenfuss et al. 2015; Venturelli et al. 2017). As most app subscriptions are self-selected, sampling is non-probability based and it is not possible to calculate confidence intervals and margins of error. The unknown level of non-response bias has major implications in the expansion of catch data from the sample of fishers who opt-in to the survey and the broader population. Selection bias towards fishers who own and effectively operate smartphones and may belong to specific socio-demographic groups can also occur. For this reason, apps are unlikely to be suitable as a stand-alone method to collect accurate and precise information on recreational fishing at this point in time.

Modern smartphones have potential to provide accurate spatial and species-specific data assisted by technologies such as the Global Positioning System (GPS), high-resolution digital cameras, accelerometers and gyroscopes. The supplementary data that apps can provide may be useful in engaging the recreational sector and as an educational tool. Examples of currently used apps include iAngler (Muller and Taylor 2013) and the International Game Fish Association Catchlog (IGFA 2018) in Florida, iFishWatcher in Europe (Abou-Tair et al. 2013), and iSnapper in Texas (Stunz et al. 2014). Potential biases associated with app-based data collection include transiency (short-term use), avidity, accuracy (exaggerated catches) and avoidance (lack of trust or reluctance to share), as well as design issues in relation to user demographics (Papenfuss et al. 2015). As apps generally rely on voluntarily, self-reported data, supplementary data from on-site surveys may be required to corroborate catch estimates.

In addition, apps can provide a more efficient data collection method where traditional paper logbooks are currently in place. This transition has already occurred in some commercial fisheries. For example, the Deckhand app has replaced paper logbooks in the Southern Rock Lobster Fishery in SA (Phillips 2015), The Institute for Marine and Antarctic Studies (IMAS) has recently engaged Real Time Data to modify the commercial reporting app to be used by on-site creel clerks during Southern Bluefin Tuna surveys (Tracey pers. comm). If used appropriately, app-based data collection can increase cost-efficiency, improve quality assurance and quality control by reducing double handling and incorporating inbuilt redundancy checks, and provide Work Health and Safety advantages though GPS monitoring capabilities for on-site survey interviewers.

4.3 On-site recreational fishing surveys

On-site recreational fishing surveys are frequently conducted to validate components of large-scale off-site methods or assess specific fisheries in defined areas (Georgeson et al. 2015). On-site surveys can be useful for collecting information to monitor change between survey periods and collect additional biological information on catch composition (e.g. length and weight of fish caught). This level of biological information is important as it is relied upon to convert fish numbers to weight, and subsequently the estimated total harvest of the recreational fishing sector. As interviews take place either during, or directly after, a fishing trip, a key advantage of on-site surveys is improved accuracy and precision of data. On-site surveys also provide an opportunity to assess residential location and access information from interstate or overseas visitors who may not be accessible within State-based sampling frames where they exist.

4.3.1 Access point surveys

Access-point surveys focus on boat ramps, jetties and marinas where interviewers intercept anglers immediately after a fishing trip is completed (Pollock et al. 1994). This method is most appropriate where there are defined access points where fishers enter the fishery, usually places where anglers can park vehicles. Stratified sampling is typically required due to higher recreational fishing effort on weekends and holidays. Access points are usually chosen at random from a current and complete list to ensure that effort is not over- or under-estimated. In Australia, access-point surveys using the ‘bus-route’ design are commonly used as fishing generally occurs over a broad geographic area with many access points (Conron and Coutin 1995, 1998; McGlennon and Kinloch 1997; Murray-Jones and Steffe 2000; Sumner et al. 2002, 2008; Webley et al. 2009).

4.3.2 Roving Surveys

Where access is more widely dispersed and particularly for shore-based fisheries, interviewers can conduct roving surveys either by boat or on foot (Pollock et al. 1994). Sampling methodology is similar to access-point surveys, however, the main difference is the spatial extent of the sampling frame (i.e. there are no discrete sites) and that interviews are conducted with anglers who have not yet completed their fishing trip. Roving surveys can provide wider spatial coverage away from access points, however, trip data are often incomplete or influenced by avidity and 'length of stay bias' as the probability of intercepting a fisher is proportional to the length of their fishing trip (Pollock et al. 1994).

4.3.3 Complementary surveys

Complementary survey methods can improve the accuracy and precision of fishing effort and harvest estimates (Steffe et al. 2008). While traditional creel surveys provide an opportunity to collect fishing effort information and interview individual fishers, there is often a trade-off between sample coverage and cost. Increased temporal coverage can be achieved by collecting supplemented auxiliary effort data, generally quantifying the number of fishers or boats to calculate total effort.

For boat-based fishing activity, interviewers at boat ramps commonly undertake direct counts of boats or trailers. Increased temporal coverage can be achieved by incorporating surveillance methods such as automatic traffic counters at choke points to provide an indirect measure of boat movements, recording all vehicles entering or leaving an area (Steffe et al. 2008). This is particularly useful in high traffic, or remote areas, providing a cost-effective option for continuous monitoring which is important for highly variable recreational fisheries. While they provide a low cost, low maintenance, and theft resistant option, they are unable to distinguish between fishing and non-fishing vehicles and on-site validation is generally required (van Poorten et al. 2018). Similarly, static boat ramp cameras can enable counts of boats launching and retrieving, however, information on the proportion of boats that recreationally fish is required to measure recreational fishing effort as opposed to overall boating activity. These cameras are commonly used to monitor trailer boats returning to high traffic boat ramps in New Zealand (Hartill et al. 2016) and in Western Australia, boat ramps and groins have also been surveyed (Smallwoood et al. 2012; Ryan et al. 2013, 2015, 2017; Steffe 2017). Future work should look to automate the boat counting process from video footage to ensure consistent and repeatable analysis. This could be facilitated by incorporating Automatic Number Plate Recognition (ANPR) software.

Shore-based fishing presents different challenges for surveyors to boat-based fishing as activity often extends into the night. Sampling during the night has historically been challenging due to visibility and the safety of observers. In Western Australia, dual lens cameras incorporating a thermographic lens have been trialled at several locations to identify night-time shore-based crabbing effort (Steffe et al. 2017; Taylor et al. 2018). Shore-based fishers are being identified in remote, unlit sections of the Peel-Harvey Estuary foreshore enabling 24-h monitoring of recreational fishing effort. This approach could be applied to other small-scale recreational fisheries where fishing at night occurs. Future advances in this technology will likely see it become more readily available and widely used as costs decrease.

Increasing the spatial coverage of on-site recreational fishing surveys is also important in areas where fishing may occur over a large area, or is difficult to access by a vehicle. Aerial surveys using fixed-wing aircraft are considered a useful tool for measuring the spatial distribution of effort providing estimates of fishing effort on a selection of days at high-effort areas (Holdsworth et al. 2018; Hartill et al. 2011, 2013; Smallwood et al. 2012). They can provide instantaneous counts of shore-based anglers and identify spatial distribution and aggregations of fishers. The main disadvantage is cost-effectiveness over large spatial or temporal scales.

An alternative to fixed-wing aircrafts is the use of drones which can provide video/photographic data with high spatial accurately. A trial drone survey of recreational fishing activity is currently underway in Freycinet Estuary, a remote area in Shark Bay, Western Australia (Taylor pers. comm.). This is part of a 12-month survey to assess the status of local fish stocks and the effect of changes to management of pink snapper in the estuary. Footage collected from drones is being compared to that collected from simultaneous aerial surveys using fixed-wing aircraft to assist in evaluating the efficacy of this emerging technique (Taylor, pers. comm.). Some of the limitations of drones are the certification requirements to pilot drones heavier than 2 kg (remotely piloted aircraft), costs of equipment, intrusive/privacy concerns, limited flying time/range, local and/or national park operating restrictions and access, and/or perception bias. Availability biases occur when not all subjects in the area are observed, while perception biases are inherent with the sampling methodology and can include biases associated with observers, flight characteristics or environmental conditions (Colefax et al. 2018). Another alternative, which is particularly suitable to remote and isolated areas, is the use of satellite imagery tools to measure recreational fishing effort (Keramidas et al. 2018). In the Mediterranean, satellite images were used to count the number of vessels and this was compared against physical counts of recreational vessels at ports and marinas. High correlations between in situ and satellite data were observed. A similar method that may be employed in the future is the vessel monitoring system (VMS) which is commonly used to track commercial fishing vessels (Toonen and Bush 2018).

5. Discussion

5.1 The future of large-scale off-site recreational fishing surveys

A comprehensive national registry of all recreational fishers would be the ideal sampling frame to undertake cost-effective and robust large-scale recreational fishing surveys. A registry would provide access to a representative sample of the target population and enable comprehensive sampling coverage while minimising bias. From this, a robust offsite probabilistic sampling protocol can be implemented. While a national registry would result in some cost savings due to increased sampling efficiency, there would likely be some additional cost to maintain the database. However, the benefits of this approach would likely outweigh the cost due to increased quality and quantity of data and improved public confidence in survey outputs.

The currently available registry databases are restricted to State-issued fishing licences, such as those available in New South Wales, Victoria and Tasmania, or the Western Australian Recreational Fishing from Boat Licence database. These sampling frames are generally subject to a range of exemptions (e.g. under 18, concession card holders, pensioners, people fishing in private waters, Aboriginal or Torres Strait Islander people). This may result in a sampling frame that does not capture all of the potential respondents affecting the robustness of any estimates. In some instances, a dual-frame approach may be an appropriate option to reduce biases introduced by relying on a single incomplete sampling frame (Georgeson et al. 2015).

Under a dual-frame approach, a general population database would be used as the primary sampling frame and this would be supplemented with other existing licence databases where available. General population databases such as phone, or address, listings provide a convenient sampling frame to choose random samples for surveys. The most commonly used phone-based general population database is the White Pages©, although in recent years this has become less representative of the overall population (Griffiths et al. 2017). While the IPND, would provide a more complete phone-based list, it can only be accessed by Commonwealth Government research agencies. Therefore, commercial databases, or probability-based online panels, which are frequently used in social science and medical research, were identified as a potential alternative to traditional telephone directories. As commercial databases and online panels do not cover the entire population, it will be important to account for potential high levels of bias when scaling up results to the target population level. Where face-to-face or mail-based surveys are acceptable as a primary contact method, the G-NAF would provide the most complete address-based listing of Australian households.

Regardless of the sampling frame selected, longitudinal diary surveys are currently the most common platform for collecting recreational fishing data in Australia (Georgeson et al. 2015). The required level of engagement to achieve accurate and precise responses is likely to vary depending on personal preferences (of respondents) related to factors such as age, language, literacy and technical ability. While phone-surveys are the most commonly used method to undertake the diary surveys, respondent-driven methods such as online surveys may become more popular in the future due to the speed and convenience offered by this platform. An internet platform may provide a more cost-effective alternative with suitable flexibility to design surveys that will likely appeal to a broader range of respondents. As internet-based surveys are respondent driven (i.e. they are completed voluntarily), the key challenge is likely to be participant apathy towards surveys which can result in bias and inaccuracy. Smartphone, or tablet apps, may provide another convenient method for data collection and could replicate online surveys. Similar technology is already in place in the commercial sector in Australia, where e-logbooks are submitted using apps that replace traditional paper logbooks (e.g. the South Australian Southern Rock Lobster Fishery). Some fisheries also offer the option of submission manually or by using electronic logbooks (e.g. fisheries managed by the Australian Fisheries Management Authority).

Following the main data collection surveys, wash-up attitudinal surveys are generally conducted to assess awareness and attitude of recreational fishers and detect differences among respondents. As there are a large number of recreational fishers, there are many potential biases that can influence recreational harvest estimates. In particular, socio-demographic characteristics (e.g. age, race, ethnicity, gender, socio-economics), fisher profile (boat size/power, use of technology), attitudes, values and motivations are all highly variable. Workshop participants generally agreed that standard questions similar to those used in the Tasmanian wash-up survey could easily be adapted to suit other jurisdictions. It is unlikely that all jurisdictions would include choice modelling, as this sophisticated approach would be more suitable as a federal survey analysed by

Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) but potentially distributed by the states/territories. In addition, wash-up surveys may provide an opportunity to explore Aboriginal, Indigenous and traditional fishing which would be relevant to inform allocation policies and decisions around native title claims.

5.2 Improving accuracy and precision of information through on-site surveys

On-site recreational fishing surveys can provide cost-effective methods to collect catch, effort and biological data for small-scale, or specific, recreational fisheries. Traditional creel surveys, using established roving or access point methods, provide a mechanism to repeatedly survey important areas to identify changes through time (Pollock et al. 1994). On-site surveys have also been used to complement off-site surveys providing additional information that improve cost effectiveness (Georgeson et al. 2015). Compared to off-site surveys, on-site surveys have the advantage of reduced recall bias and can provide opportunities for interviewers to measure and weigh catch.

As recreational fishing activity is complex and highly variable over large spatial and temporal scales, it can be difficult to sample all access points where fishing occurs. Where large geographical areas need to be covered, aerial surveys are sometimes used to determine effort (counts of boats or shore-based fishers). Emerging technologies such as drones and satellite imagery may provide a future alternative suitable to remote and hard to access areas. Increased coverage can also be achieved with new and emerging on-site methods such as static boat ramp cameras, ANPR and thermal imaging cameras. These technologies are being trialled in several Australian jurisdictions and New Zealand as complementary methods to improve data on fishing effort. Camera based surveillance methods are becoming more commonly used and this will likely continue to increase as more cost-effective methods of data and image/video analysis are developed. Further comparative studies using dual or multi-survey approaches will require collaboration across jurisdictions with a view to build Australia’s capability in this area.

As effort and catch rates can be spatially and temporally structured and subject to different sources of variability (Cabanellas-Reboredo et al. 2017), there is a clear need to develop cost-effective methods to improve the accuracy of recreational harvest estimates and address specific management questions. As large-scale surveys are generally undertaken infrequently, on-site methods may also provide a suitable proxy for effort and could serve to capture the variation in fishing activity between off-site surveys.

5.3 Engaging the recreational fishing community

Recreational fishing surveys provide key information used to inform fisheries management. In some jurisdictions (e.g. SA and WA), recreational catch estimates are used to determine shares against pre-described allocations that underpin resource management (PIRSA 2011; 2017; Ryan et al. 2016). Improving the accuracy and precision of these estimates was a key focus of this workshop. However, it has been identified that stakeholders’ lack of understanding of survey methodologies when interpreting survey results can undermine their integrity. As a result, the strategies to engage the recreational sector in fisheries science and management were discussed. Workshop participants agreed that for future surveys, it would be important to engage with the recreational fishing community at all stages of planning, implementation and delivery to ensure understanding and acceptance of the outcomes. An example of this was the recent “Recfishing Champions” workshop hosted by Recfish SA. This provided an opportunity for 15 recreational fishers to learn more about managing our valuable fisheries resources with training from fishery managers and scientists. Increasing recreational fisher involvement in fisheries management will likely require the development of programs to build a sense of community (Copeland et al. 2017).

One way to engage the recreational fishing community is by developing citizen science capacity and spreading educational messages through social media platforms and smartphone apps. Social media (e.g. Facebook, Instagram) provides a platform for networks of individuals to share information in real-time. Social media forums and smartphone apps provide opportunities to improve fishing experiences and are already popular within the recreational fishing community. Social media and apps facilitate the sharing of fishing locations through integrated mapping software, provide communication forums (brag boards, photo sharing), weather and tide information, boat ramp locations and details, fish identification guides, fishing tips and tricks, competitions, fishing rules and regulations, news and other information. There may be some situations where social media and apps can provide a cost-effective mechanism for community monitoring. However, they are unlikely to be representative of the entire population and biases such as avidity will be difficult to account for. In order to answer management questions and collect reliable data that are comparable to previous surveys, the most tractable approach would be to undertake probabilistic sampling with a specifically designed app. Other more active engagement approaches, such as the 'Send in your Skeletons' initiative implemented in Western Australia and the King George Whiting (KGW) frame donation project in SA (FRDC 2016-003), have been positive exercises in engaging more broadly with the sector, as they enabled fishers to collect and contribute important biological information on their catches.

In addition to harvest estimates, effective recreational fishing surveys provide important insights into the social and economic contribution of recreational fishing. Understanding the motivations of the recreational fishing community is important to ensure that fishing is not only sustainable but also satisfying. As fishing motivations are likely to differ between the commercial and recreational sector, a sustainable fishery may not be the sole focus of the recreational sector, but more so the availability of target species (positive fishing experience). This is complicated where allocation issues exist within shared access fisheries. An improved understanding of recreational fisher attitudes and motivations is important when implementing changes to fishing rules and regulations and to interpret fisher's behaviour through time. Recreational fishing surveys play a key role in understanding this shifting landscape as they provide an opportunity to understand fishing motivations that can be either catch- or non-catch related (Finn and Loomis 2001).

6. Conclusion

Rapid evolution in the way people communicate is occurring due to technological change and cultural shifts towards less personalised communication. This presents challenges for undertaking future recreational surveys and surveyors need to adapt to this changing landscape. The results of this workshop re-inforce the importance of designing surveys to explicitly deal with fishery-management related issues. For large-scale surveys, the most suitable and clearly defined sampling frame for future surveys is a national database of recreational fishers. Where a complete sampling frame is not available, a dual-frame design incorporating a commercial database or online panel should be investigated. It is likely that internet-based surveys will provide a cost-efficient mechanism for undertaking recreational fishing surveys in the future. On-site surveys were identified as a tool to provide a useful proxy for estimates of catch and effort between large-scale surveys. On-site surveys should continue to be used to collect important catch, effort and essential biological information, particularly where surveys occur over small-scales or where specific fisheries are being investigated. The accuracy and precision of data collected during on-site surveys will likely be improved through use of new and emerging technologies.

Wash-up attitudinal surveys, which are generally undertaken after the main survey, remain as an important tool to provide insights into the socio-economic contribution of recreational fishing. Understanding the motivations of recreational fishers continues to be an important component of recreational fishing surveys. Smartphone apps were identified as a potential way to engage the recreational fishing community; however, they are unlikely to replace robust non-probability survey methods. While this workshop was an important first step in engaging with the recreational fishing community through their peak body, further engagement will be required at the jurisdictional level to identify engagement strategies relevant to their user groups.

7. Implications

The main constraint to undertaking recreational fishing surveys is the lack of a complete sampling frame. Establishing a national registry of recreational fishers would avoid the need to investigate alternative sampling frames. Until a national database becomes available, alternative sampling frames (e.g. existing licence frames and/or population databases), will continue to be used to conduct large-scale recreational fishing surveys. The use of these sampling frames is likely to introduce bias and for State wide surveys, interstate visitors are unlikely to be sampled. There are potential opportunities to improve the accuracy and precision of data through on-site sampling using modern sampling techniques and use of innovative technologies, although the utility of such approaches required further investigation. A collaborative approach, across jurisdictions, will build Australia's capability in this area.

8. Recommendations

8.1 Recommended approach

The workshop identified that the most cost-effective option for future large-scale surveys is to gain access to a national register of recreational fishers (without exemptions). This would allow probabilistic sampling of the target population, improved precision of the catch and effort estimates and alleviate the reliance on broad-scale population sampling. Where a complete registry is not available, other general population databases, such as; the Geocoded National Address File (G-NAF), the Integrated Public Number Database (IPND), boat registration databases, commercial databases, and online panels may provide alternative sampling frames, or a multi-frame design using combinations of these may be employed. Future surveys should consider the use of internet-based data collection as a cost-efficient alternative to phone-surveys. Standard wash-up attitudinal surveys should be developed using questions similar to the Tasmanian wash-up survey (Lyle 2018), which could easily be adapted to suit all jurisdictions.

On-site surveys are recommended as a tool to provide useful proxies for estimates of catch and effort between large-scale surveys. They also provide important catch, effort and essential biological information over small-scales or where specific fisheries are being investigated. Consideration needs to be given to new and emerging technologies to improve the accuracy and precision of data. Smartphone applications should be considered as a tool for increasing engagement with the recreational community but are unlikely to replace more robust survey methods. It is recommended that further engagement of the recreational fishing community is required at the jurisdictional level to identify strategies relevant to their user groups.

8.2 Further development

The need to develop closer cross-jurisdictional collaborations to improve the cost-effectiveness and precision of State-based recreational fishing surveys was acknowledged during the workshop. In particular, there is a need to compare the effectiveness of new and emerging sampling frames, such as commercial databases or online panels, given the decreasing coverage phone directories offer and the lack of a comprehensive registry of recreational fishers. Whilst the needs of the various jurisdictions are likely to differ, there is overall agreement regarding the underlying principles of recreational fishing surveys and the need to tailor the surveys accordingly. It was the consensus of the workshop participants that a research proposal be developed to explore the cost-effectiveness and precision of various data-collection methods. A comparison of direct interviews and online data gathering techniques, along with combining both methods, would be the underlying objective, however, these collection methods would need to be applied within the same sample frame. Applying this comparative method analysis across the jurisdictions would add considerable value. For example the vessel registration database could be used in WA, whereas a commercially purchased data-base could be assessed in other jurisdictions (e.g. Qld, SA). This would lead to multiple experiments across the different states that can be tailored to their respective situations and needs, while collectively contributing to improving Australia's overall understanding of recreational catch and effort, participation rates, and value.

From this workshop, it was recommended that periodic off-site State wide surveys be supplemented with more regular, targeted, on-site investigations to establish a continuous proxy for recreational catch and effort. Emerging surveillance technology is beginning to be used in some jurisdictions to support fisheries management. These technologies include, static boat ramp cameras, aerial surveys, and thermal imaging, and they are typically supported with on-site creel surveys to gain further insight into the dynamics and behaviour of recreational fishers. Further research should aim to build upon the expertise from Australia and New Zealand by assessing whether emerging technologies (e.g., ANPR and targeted drone surveys) can be effectively integrated with small-scale boat-ramp surveys. By coupling passive long-term surveillance with periodic State wide surveys such research will be able to develop proxies for catch and effort, determine the relative fishing capacity (i.e. use of fishing technologies), and explore the underlying motivation that is driving the recreational fishing sector.

The use of apps as a simple means of collecting recreational fishing data is often touted by the broader community as the 'panacea' to surveying and assessing recreational catch and effort. However, reliance on this technology is problematic. There may be opportunities to investigate the potential of this technology, but this should be undertaken from the standpoint of recreational fisher engagement and education to support the sector's understanding of the need for statistically rigorous, probabilistic, surveys.

9. Extension and Adoption

There are clear benefits to establishing a national registry of recreational fishers to be used as the primary sampling frame for off-site recreational fishing surveys. This would avoid the need for general population sampling and enable a targeted approach to sampling. Where incomplete licence frames exist and general population sampling is required, probabilistic (random) sampling will ensure appropriate representation and reduce bias. While commercial databases present an opportunity for general population sampling under a dual-frame approach, uncertainty around data sources and quality control procedures means that further work is required to understand the potential biases in these datasets. As preferences in communication are changing, we are likely to see a switch from traditional phone-surveys to online surveys. Similarly, on-site survey methods continue to evolve with the advent of new technologies. The benefits are likely to be increased sampling efficiency and reduced costs. As jurisdictions prepare for future recreational fishing surveys, the results of this workshop provide a toolbox for building on the ‘best practice’ approach described in Georgeson et al. (2015).

References

Abou-Tair, D., Bourimi, M., Tesoriero, R., Heupel, M., Kesdogan, D., and Ueberschär, B. (2013). An end-user tailorable generic framework for privacy-preserving location-based mobile applications. Applied Mathematics & Information Sciences 7:2137–2148.

Armstrong, M., Brown, A., Hargreaves J., Hyder K., Pilgrim-Morrison S., Munday, M., Proctor, S., Roberts, A., & Williamson K. (2013). Sea Angling 2012 – a survey of recreational sea angling activity and economic value in England. Department for Environment Food and Rural Affairs, Manchester, UK. 16pp.

Cabanellas-Reboredo, M., Palmer, M., Alós, J., & Morales-Nin, B., (2017). Estimating harvest and its uncertainty in heterogeneous recreational fisheries. Fisheries Research 188, 100–111. https://doi.org/10.1016/j.fishres.2016.12.008

Colefax, A.P., Butcher, P.A., & Kelaher, B.P. (2018). The potential for unmanned aerial vehicles (UAVs) to conduct marine fauna surveys in place of manned aircraft, ICES Journal of Marine Science. 75(1) 1-8.

Coleman, A. P. M. (2003). The National Recreational Fishing Survey: The Northern Territory. Northern Territory Department of Business, Industry and Resource Development. *Fishery Report* **72**.

Conron S., Coutin P.C. (1995). 'A pilot survey of the recreational snapper fishery of PPB 1994/95.' Progress Report No. 1. Victorian Fisheries Research Institute, Queenscliff.

Conron S., & Coutin P.C. (1998). 'The recreational snapper catch from PPB: A pilot study of the boat–based fishery 1994/1995.' Marine and Freshwater Resources Institute Internal Report No. 11. Marine and Freshwater Resources Institute, 11, Queenscliff.

Copeland, C., Baker, E., Koehn, J.D., Morris, S.G., & Cowx, I.G., (2017). Motivations of recreational fishers involved in fish habitat management. Fisheries Management and Ecology 24, 82–92. https://doi.org/10.1111/fme.12204

Currie, D.R., Sorokin, S.J., Ward, T.J.M., (2006). Survey of recreational rock lobster fishing in South Australia during 2004/05. South Australia Research and Development Institute Research Report Series.

De Lestang, S., Caputi, N., How, J., Melville-Smith, R., Thomson, A., & Stephenson, P. (2012). Stock Assessment for the West Coast Rock Lobster Fishery. Fisheries Research Report No. 217. Department of Fisheries, Western Australia. 200pp.

Finn, K.L., & Loomis, D.K. (2001). The Importance of Catch Motives to Recreational Anglers: The Effects of Catch Satiation and Deprivation. Human Dimensions of Wildlife 6, 173–187. https://doi.org/10.1080/108712001753461275

Ford, J., & Gilmour, P. (2013). The state of recreational fishing in Victoria: a review of ecological sustainability and management options, a report to the Victorian National Parks Association, Melbourne.

Georgeson, L., Moore, A., Ward, P., Stenekes, N., Kancans, R., Mazur, K., Curtotti., R Tracey, S., Lyle, J., Hansen, S., Chambers, M., Finn, M., & Stobutzki, I. (2015). *A framework for regular national recreational fishing surveys*, ABARES, Canberra, November . CC BY 3.0.

Giri, K., & Hall, K. (2015). South Australian recreational fishing survey. Fisheries Victoria Internal Rep ort Series No. 62.

Griffiths, S., Lynch T., Lyle J., Wotherspoon S., Wong L., Devine C., Pollock K., Sawynok W., Donovan A., Fischer M., Tickell S., & Moeseneder C. (2017). Trial and validation of Respondent-Driven Sampling as a cost-effective method for obtaining representative catch, effort, social and economic data from recreational fisheries

Griffiths, S.P., Pollock, K.H., Lyle, J.M., Pepperell, J.G., Tonks, M.L., & Sawynok, W., (2010). Following the chain to elusive anglers. Fish and Fisheries 11, 220–228. https://doi.org/10.1111/j.1467-2979.2010.00354.x

Gutowsky, L.F.G., Gobin J., Burnett N.J., Chapman J.M, Stoot L.J., & Bliss, S. (2013). Smartphones and Digital Tablets: Emerging Tools for Fisheries Professionals, Fisheries, 38:10, 455-461, DOI: 10.1080/03632415.2013.838133

Hartill, B., Bian, R., Rush, N., & Armiger, H., (2013). Aerial-access recreational harvest estimates for snapper, kahawai, red gurnard, tarakihi and trevally in FMA 1 in 2011–12. New Zealand Fisheries Assessment Report 70, 44.

Hartill, B.W., Payne, G.W., Rush, N., & Bian, R., (2016). Bridging the temporal gap: Continuous and cost-effective monitoring of dynamic recreational fisheries by web cameras and creel surveys. Fisheries research 183, 488–497.

Hartill, B.W., Watson, T.G., & Bian, R. (2011). Refining and Applying a Maximum-Count Aerial-Access Survey Design to Estimate the Harvest Taken from New Zealand's Largest Recreational Fishery, North American Journal of Fisheries Management, 31:6, 1197-1210, DOI: 10.1080/02755947.2011.646454

Heinemann, A., Wynne-Jones, J., Gray, A., & Hill, L., (2015). National Panel Survey of Marine Recreational Fishers 2011–12: Rationale and Methods. New Zealand Fisheries Assessment Report 2015/48

Henry, E.W., & Lyle, J.M. (2003). *The National Recreational and Indigenous Fishing Survey*. Fisheries Research and Development Corporation, Project No. 99/158. Canberra, Australia: Australian Government Department of Agriculture, Fisheries and Forestry.

Hillygus, D.S., Jackson, N., & Young, M. (2014). Professional respondents in non-probability online panels. In M. Callegaro, R. Baker, J. Bethlehem, A. S. Goritz, J. A. Krosnick, & P. J. Lavrakas (Eds.), Online panel research: A data quality perspective (pp. 219–237). Chichester: John Wiley & Sons.

Holdsworth, J.C., Hartill, B.W., Heinemann, A., & Wynne-Jones, J. (2018). Integrated survey methods to estimate harvest by marine recreational fishers in New Zealand. Fisheries Research 204, 424–432. https://doi.org/10.1016/j.fishres.2018.03.018

ICES (2010). Report of the Planning Group on Recreational Fisheries (PGRFS), 7-11 June 2010, Bergen, Norway. ICES CM 2010/ACOM:34. 168 pp.

International Game Fish Association (IGFA). (2018) "What is IGFA CatchLog?" August 2018. http://www.igfacatchlog.org/About.aspx

Jones, K. (2009). *South Australian Recreational Fishing Survey 2007/08*. South Australian Fisheries Management Series Paper No. 54. Adelaide, Australia: Primary Industries and Resources South Australia (Fisheries).

Keramidas, J., Dimarchopoulou, D., Pardalou, A., & Tsikliras, A.C. (2018). Estimating recreational fishing fleet using satellite data in the Aegean and Ionian Seas (Mediterranean Sea). Fisheries Research. 208, 6pp. https://doi.org/10.1016/j.fishres.2018.07.001.

Lyle, J.M. (2018). Tasmanian recreational rock lobster and abalone fisheries: 2017–18 fishing season. Institute for Marine and Antarctic Studies, University of Tasmania, Hobart, Tasmania. 33pp.

Lyle, J., & J Morton, A., (2004). Survey of the 2002/03 Tasmanian recreational rock lobster and abalone fisheries. TAFI Technical Report 22. Tasmanian Aquaculture and Fisheries Institute, Hobart, Tasmania. 33pp.

Lyle, J.M., Coleman, A.P.M, West, L., Campbell, D., & Henry, G.W. (2002). New large-scale survey methods for evaluating sport fisheries. In: Recreational Fisheries: Ecological, Economic and Social Evaluation, Pitcher, T.J., and Hollingworth, C.E. (eds). pp 207-226. Fish and Aquatic Resources Series No. 8, Blackwell Science, Oxford, UK

Lyle, J.M., Morton, & A.J., Forward, J. (2005). Characterisation of the recreational fishery for southern rock lobster, *Jasus edwardsii*, in Tasmania, Australia: Implications for management, New Zealand Journal of Marine and Freshwater Research, 39:3, 703-713, DOI: 10.1080/00288330.2005.9517346

McGlennon D., & Kinloch M.A. (1997). Evaluation of the bus-route creel survey method in a large Australian marine recreational fishery II. Pilot surveys and optimal sampling allocation. Fisheries Research 33, 89–99

Melville-smith, R., & Anderton, S.M., (2000). Western rock lobster mail surveys of licensed recreational fishers 1986/87 to 1998/99. Fisheries Research Report No. 122. Fisheries Research Division, WA Marine Research Laboratories, Perth, WA. 39 pp.

Murray-Jones, S., & Steffe, A.S., (2000). A comparison between the commercial and recreational fisheries of the surf clam, Donax deltoides. Fisheries Research 44, 219–233. https://doi.org/10.1016/S0165-7836(99)00095-8

Muller, R.G., & Taylor, R.G. (2013). The 2013 Stock Assessment Update of Common Snook, *Centropomus Undecimalis*. Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute Report 2013-004, 157 pp.

Papenfuss, J.T., Phelps, N., Fulton, D., & Venturelli, P.A. (2015). Smartphones Reveal Angler Behavior: A Case Study of a Popular Mobile Fishing Application in Alberta, Canada, Fisheries, 40:7, 318-327, DOI: 10.1080/03632415.2015.1049693

Phillips J. (2015). Southern Rock Lobster IPA: Assessing functionality and suitability of the iPhone [iPad] application 'Deckhand' for on-board electronic data capture in Southern Australian Rock Lobster (*Jasus edwardsii*) fisheries. FRDC Report No 2011/250.

PIRSA. (2011). Allocation Policy- Allocation of Access to Fisheries Resources between Fishing Sectors, Primary Industries and Regions South Australia, 39p, Primary Industries and Regions South Australia.

PIRSA. (2017). Management Plan for Recreational Fishing in South Australia, 56p, Primary Industries and Regions South Australia.

Pollock, K.H., Jones, C.M. & Brown, T.L. (1994). *Angler survey methods and their applications in fisheries management*, American Fisheries Society, Special Publication 25, Bethesda, Maryland.

Public Sector Mapping Agencies. (2013). G-NAF Data Product Description Version 2.9

Ryan K.L., Hall N.G., Lai E.K., Smallwood C.B., Taylor S.M., & Wise B.S. (2017). Statewide survey of boat-based recreational fishing in Western Australia 2015/16. Fisheries Research Report No. 287, Department of Primary Industries and Regional Development, Western Australia. 205pp.

Ryan, K.L., Hall, N.G., Lai, E.K., Smallwood, C.B., Taylor, S.M., & Wise, B.S. (2015). State-wide survey of boat-based recreational fishing in Western Australia 2013/14. Fisheries Research Report No. 268, Department of Fisheries, Western Australia. 208pp. Final report to Fisheries Research and Development Corporation Project No. 2012/021. CSIRO, Hobart. 145 pp.

Ryan K.L., Morison A.K., & Conron S. (2009). Evaluating methods of obtaining total catch estimates for individual Victorian bay and inlet recreational fisheries. Final report to Fisheries Research and Development Corporation Project No. 2003/047. Department of Primary Industries, Queenscliff.

Ryan K.L., Trinnie, F.I., Jones, A., Hart, A.M., & Wise, B.S (2016). Recreational fisheries data requirements for monitoring catch shares. Fisheries Management and Ecology. 23, 218–233.

Ryan, K.L., Wise, B.S., Hall, N.G., Pollock, K.H., Sulin, E.H., & Gaughan, D.J. (2013). An integrated system to survey boat-based recreational fishing in Western Australia 2011/12. Fisheries Research Report No. 249, Department of Fisheries, Western Australia. 168pp.

Schaeffer, R.L., Mendenhall, W., & R.L. Ott (1996) *Elementary survey sampling*, fifth edition. Duxbury press, Belmont California

Smallwood, C.B., Pollock, K.H, Wise, B. S., Hall, N. G., & Gaughan, D. J. (2012) Expanding Aerial–Roving Surveys to Include Counts of Shore-Based Recreational Fishers from Remotely Operated Cameras: Benefits, Limitations, and Cost Effectiveness, North American Journal of Fisheries Management, 32:6, 1265-1276, DOI: 10.1080/02755947.2012.728181

Steffe, A.S., Murphy, J.J., & Reid, D.D. (2008). Supplemented access point sampling designs – a cost-effective way of improving the accuracy and precision of fishing effort and harvest estimates derived from recreational fishing surveys. North American Journal of Fisheries Management 28, 1001-1008.

Steffe, A. S., Taylor, S. M., Blight, S. J., Ryan, K. L., Desfosses, C. J., Tate, A. C., Smallwood, C. B., Lai, E. K., Trinnie, F. I., & Wise, B. S. (2017). Framework for Integration of Data from Remotely Operated Cameras into Recreational Fishery Assessments in Western Australia. Fisheries Research Report No. 286, Department of Primary Industries and Regional Development, Western Australia. 36pp.Sumner, N.R., Williamson, P.C., Blight, S.J., & Gaughan, D.J. (2008). A 12-month survey of recreational boatbased fishing between Augusta and Kalbarri on the West Coast of Western Australia during 2005-06. Fisheries Research Report No. 177, Department of Fisheries, Western Australia, 44p.

Sumner, N. R., Williamson, P. C., & Malseed, B. E. (2002). A 12-month survey of recreational fishing in the Gascoyne bioregion of Western Australia during 1998-99, Fisheries Research Report No. 139, Department of Fisheries, Western Australia, 54p.

Stunz, G.W., Johnson, M. J., Yoskowitz, D., Robillard, M., & Wetz, J. (2014). iSnapper: Design, Testing, and Analysis of an iPhone-based Application as an Electronic Logbook in the for-hire Gulf of Mexico Red Snapper Fishery. National Oceanic and Atmospheric Administration Final Report NA10NMF4540111. 64 pp.

Taylor S.M., Blight, S.J., Desfosses, C.J., Steffe S.S., Ryan, K.L., Denham, A.M., & Wise, B.S. (2018). Thermographic cameras reveal high levels of crepuscular and nocturnal shore-based recreational fishing effort in an Australian estuary, ICES Journal of Marine Science. doi:10.1093/icesjms/fsy066

Toonen, H.M., & Bush, S.R. (2018). The digital frontiers of fisheries governance: fish attraction devices, drones and satellites, Journal of Environmental Policy & Planning, DOI: 10.1080/1523908X.2018.1461084

Van der Hammen, T., de Graaf, M, & Lyle, J.M. (2016). Estimating catches of marine and freshwater recreational fisheries in the Netherlands using an online panel survey. ICES Journal of Marine Science. 73(2) 441-450p.

van Poorten., B.T., & Brydle,S. (2018) Estimating fishing effort from remote traffic counters: Opportunities and challenges. Fisheries Research, 204:231-238p.

Venturelli, P.A., Hyder, K., & Skov, C., (2017). Angler apps as a source of recreational fisheries data: opportunities, challenges and proposed standards. Fish and Fisheries 18, 578–595. https://doi.org/10.1111/faf.12189

Webley, J., Taylor, S., Mayer, D., Dew, K., & Olyott, L., (2009). Survey of marine boat-based recreational fishing in south-eastern Queensland (2007–08). Queensland Government. 61 pp.

Appendix 1: Project Staff

Dr Mike Steer:	South Australian Research and Development Institute (SARDI)
Dr Sean Tracey:	Institute for Marine and Antarctic Studies (IMAS)
Mr Andy Moore:	Department of Agriculture & Water Resources (DAWR)
Mr Brett Cleary:	Game Fishing Association of Australia (GFAA)
Dr Crystal Beckmann	SARDI

Appendix 2: List of workshop attendees

Name	Affiliation	State/Country
Mike Steer	SARDI	SA
Keith Rowling	PIRSA	SA
Shane Holland	PIRSA	SA
Gavin Begg	SARDI	SA
Crystal Beckmann	SARDI	SA
Jason Earl	SARDI	SA
Paul Rogers	SARDI	SA
Simon Dick	Real Time Data	SA
Roger Edwards	Real Time Data	SA
Jacki Schirmer	University of Canberra	ACT
Joshua Fielding	FRDC	ACT
Anthony Moore	ABARES	ACT
Sean Tracey	IMAS	TAS
Jeremy Lyle	IMAS	TAS
Brett Cleary	ARFF	TAS
Tim Lynch	CSIRO	TAS
Stephen Taylor	DPIRD	WA
Karina Ryan	DPIRD	WA
Jeff Murphy	DPI	NSW
Faith Ochwada-Doyle	DPI	NSW
Kane Dysart	NT Fisheries	NT
James Webley	DAF	QLD
Laurie West	Kewagama Research	QLD
Michael O’Neil	DAF	QLD
Bruce Hartill	NIWA	NZ

Appendix 3: Agenda

NATIONAL WORKSHOP:

ASSESS NEW TECHNOLOGIES AND TECHNIQUES THAT COULD IMPROVE THE COST-EFFECTIVENESS AND ROBUSTNESS OF RECREATIONAL FISHING SURVEYS (FRDC 2017/198)

In-conjunction with

DETERMINING THE DESIGN, OUTPUT SPECIFICATIONS AND SAMPLE SIZE FOR A NATIONAL SOCIAL AND ECONOMIC SURVEY OF RECREATIONAL FISHERS IN AUSTRALIA (FRDC 2016/126)

TUES 10TH TO THUR 12TH JULY 2018

SOUTH AUSTRALIAN RESEARCH & DEVELOPMENT INSTITUTE (SARDI)

2 HAMRA AVE, WEST BEACH, SOUTH AUSTRALIA

WORKSHOP CHAIR: DR SEAN TRACEY (IMAS)

NEED:

It is proposed that a national workshop is needed to:

1. Identify options to improve the precision and cost-effectiveness of recreational fishing surveys;
2. Assess whether emerging surveillance technologies can be feasibly integrated into future surveys;
3. Identify strategies that positively engage the recreational sector in fisheries science and management.

Although all States are expected to benefit from the outcomes of the proposed workshop, South Australia is particularly reliant on the shared expertise, transfer of knowledge and advice regarding the execution of scientifically robust, routine recreational fishing surveys. The South Australian Government is committed to undertaking a recreational fishing survey every five years. All previous surveys have been carried out by interstate experts, however, there is a commitment by PIRSA/SARDI to develop recreational fisheries science capability at a sufficient level to undertake all future State-based surveys. It is expected that the workshop will establish South Australia’s role as an active participant in the national assessment of recreational fisheries, increase data harmonisation opportunities across the jurisdictions, and contribute in advancing recreational fisheries science.

The second part of the workshop will focus on options for implementing a national social and economic survey. Various options will be discussed in the hope on adopting a way forward that is beneficial to all jurisdictions.

OUTCOMES:

It is anticipated that a discussion paper will be a key output of this national recreational fishing workshop. Ideally, it would be beneficial to structure this paper as a ‘survey instrument’ that serves as a best-practice guideline to undertake a contemporary recreational survey. It may contain a series of decision rules based on the situation cascading from an established data-frame scenario to a lack of an appropriate sampling framework. As a group, it will be good to determine how prescriptive this will need to be and what should be incorporated into the tool box.

PROGRAM

TUES 10TH JULY

10:00	**ARRIVAL/MORNING TEA**
	DAY 1 - IMPROVE THE PRECISION AND COST-EFFECTIVENESS OF SURVEYS
10:30	WELCOME/OBJECTIVES/INTRODUCTIONS (ROWLING – PIRSA)
	DON'T THROW THE BABY OUT WITH THE BATH WATER (LYLE - IMAS)
	APPLYING INNOVATION TO OFF-SITE SURVEY DESIGNS AND STATISTICAL METHODS (RYAN – DPIRD)
	USE OF INTERNET SURVEYS (MOORE – ABARES)
	SURVEYS IN A CHANGING SOCIAL LANDSCAPE: ADDRESSING THE CHALLENGES OF ACHIEVING REPRESENTATIVE POPULATION SAMPLES (SCHIRMER – UNI. CAN)
13:00	**LUNCH**
	GENERAL/OPEN DISCUSSION – SURVEY INSTRUMENT DEVELOPMENT **HOW TO DEAL WITH DIFFERENT SCENARIOS**
15:30	**AFTERNOON TEA**
	GENERAL/OPEN DISCUSSION – SURVEY INSTRUMENT DEVELOPMENT… ***CONTINUED…***
17:00	**CLOSE – DAY 1**

WEDS 11TH JULY

09:00	**ARRIVAL/COFFEE/BISCUITS**
	DAY 2 - EMERGING TECHNOLOGIES AND ENGAGEMENT STRATEGIES
	WHAT ROLE CAN DIGITAL CAMERA MONITORING OF BOAT RETRIVALS PLAY IN INFORMING FISHERIES MANAGEMENT (HARTILL – NIWA)
	INTEGRATING REMOTE CAMERA DATA AND AERIAL SURVEYS INTO THE MONITORING OF TWO WA REC FISHERIES (TAYLOR- DPIRD)
10:30	**MORNING TEA**
	HIGH RESOLUTION CAMERA WORK (CRAGS) (LYNCH – CSIRO)
	CAN 'DECKHAND' TRANSITION FROM THE COMMERCIAL TO THE RECREATIONAL SECTOR? (DICK – DECKHAND)
13:00	**LUNCH**
	GENERAL/OPEN DISCUSSION – SURVEY INSTRUMENT DEVELOPMENT **WHY AND WHEN TO USE TECH**

15:30	**AFTERNOON TEA**
	IMPROVED DATA ON ABORIGINAL AND TORRES STRAIT ISLANDERS FISHERIES RESOURCE USE TO BETTER INFORM COMMUNITY PLANNING AND AGENCY DECISION-MAKING (HOLLAND – PIRSA)
	EXPECTATIONS OF THE RECREATIONAL SECTOR (CLEARY – ARFF)
	GENERAL/OPEN DISCUSSION – SURVEY INSTRUMENT DEVELOPMENT **ENGAGEMENT STATEGIES, EXPERIENCES, SUCCESSES**
17:30	**CLOSE – DAY 2**
19:00	**MOSELEY BAR & KITCHEN (DINNER – *****EXCLUDING ALCOHOL*******)**

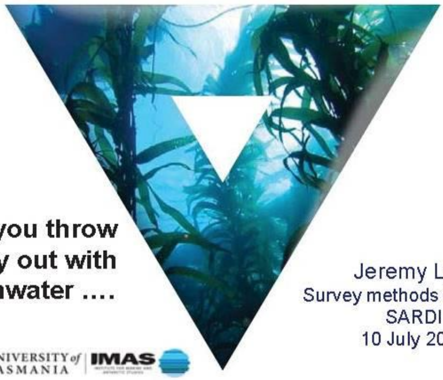
THURS 12TH JULY

09:00	**ARRIVAL/MORNING TEA**
	DAY 3 - NATIONAL SOCIAL AND ECONOMIC SURVEY OF RECREATIONAL FISHERS
	A NATIONAL SOCIAL AND ECONOMIC SURVEY: OPTIONS (MOORE – ABARES)
10:30	**MORNING TEA**
	GENERAL/OPEN DISCUSSION - BEST WAY FORWARD FOR A NATIONAL SOCIAL AND ECONOMIC SURVEY
13:00	**LUNCH**
	GENERAL/OPEN DISCUSSION - BEST WAY FORWARD FOR A NATIONAL SOCIAL AND ECONOMIC SURVEY ***CONTINUED…***
14:30	**END**

Appendix 4: Don't throw the baby out with the bath water

Dr Jeremy Lyle- IMAS, Tasmania

Recreational fishing surveys



Before you throw the baby out with the bathwater ….

Jeremy Lyle
Survey methods workshop
SARDI
10 July 2018

New, innovative, novel, cutting edge, smart technology, cost-effective

Established, traditional, proven, statistically robust, value for money

2

Designing a survey

– Instrument needs to be consistent with the survey objectives, including spatial and temporal scale & scope

– Statistically robust and reliable information data needs to be representative – ie probability basis for sampling (or at least the capability to adjust)

– There is no panacea

Horses for courses

3

Recreational surveys

– Quantitative surveys are designed to collect robust and representative information to address specific questions
  – invariably involve sub-sampling rather than census

4

Off-site fishing surveys

Most Australian states use phone-based surveys for large spatial scale surveys

Multi-phase design
- Screening (profiling and eligibility) – phone (demographics and avidity)
- Panel survey – phone-diary (catch and effort)
- Supplementary components – economic activity, social factors, attitudes & awareness

5

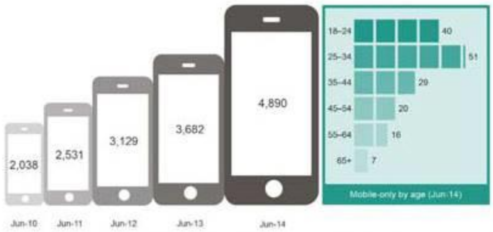
Survey challenges

- Sampling frames – under-coverage
  - Licence frames typically involve exemptions
  - Phone surveys (directory): non-phone owners & mobiles
- Response rates declining
  - Non-response
    - Refusals
    - Unavailability/ non-contact
- Data quality issues (self-reported)

6

Mobiles

By 2014, 27% of the adult population - 4.9 million Australians aged 18 and over - were mobile-only users



Number of persons ('000s) in the 12 months to June of each year. Mobile-only data relates to percentage of people in each age group

Landlines v Mobiles

– Intercept surveys – generally no significant avidity or CPUE bias for Landline v Mobile only respondents

– a clear demographic (age) bias - correct by reweighting?

BUT

Question remains – do participation rates for Landline v Mobile-only respondents different?

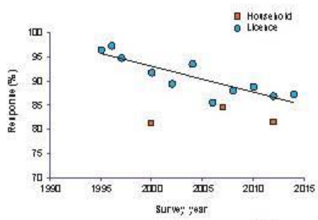
2017-18 Tasmanian general fishing survey

- Sample frame: commercial database including mobiles (household coverage approx. 70%).
- Landline v Mobiles
  - No sign. difference in screening response rates
  - No sign. difference in avidity profiles of fishers
  - Demographic bias (landline biased to older age groups, mobiles to younger ages)
  - Participation rates higher for mobile owners
    - mainly due to a demographic difference - 60+ age group participation rate 1.7 times higher for mobile owners

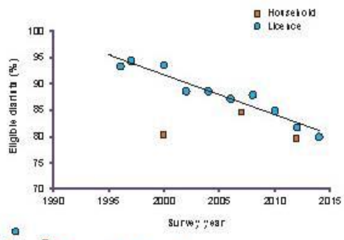
More work needed

Response rates

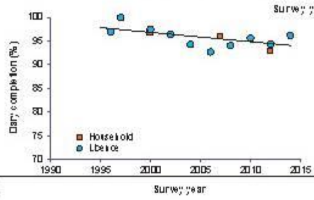
Screening



Panel survey



Panel survey completions



Observations on non-traditional methods

Internet / online surveys

internet Recreational Effort and Catch (*iREC*) - Canada

- annual catch estimates (and associated precision) across all tidal water Pacific Fishery Management Areas (PFMA's), licensed fishing methods, species and fates (retained or released) at a monthly resolution
- email contact information provided by fishers (condition of licensing) used to create a sampling frame.
- random selections of licences active in a given month are invited, via email, to provide details about their fishing activity and catch through a web-based survey tool.
- Fishing information from survey respondents is expanded to estimate total effort and catch
- Actual response rates (monthly) around 30%
- Patterns consistent with expectations but some data biased

Rob Houtman, DFO Canada

Online survey

National recreational fishing survey Netherlands

- Conducted biennially
- Screening Survey (online, once, ~100 000 participants)
  - Estimate the number of fresh and marine fishermen
- Logbook Survey (online, monthly)
  - Catch rates per fisher per year (~2500)
- Onsite Survey (field survey)
  - Length frequency distribution

Van der Hammen et al (2016), ICESJMS 73: 441-450.

Challenges

Recruitment and retention (if reporting is non-mandatory)

Solution(s): well-designed app, feedback, transparency

Fisheries integration

Protocols? Structure? Ownership? Legal?

Solution(s): understand tool and question(s), benefits and limitations; a lot of research

Need for standards

Venturelli PA, K Hyder, CK Skov. 2017 Angler apps as a source of recreational fisheries data: opportunities, challenges, and proposed standards. *Fish and Fisheries*

So … it is getting harder to conduct surveys, yet the need for information grows

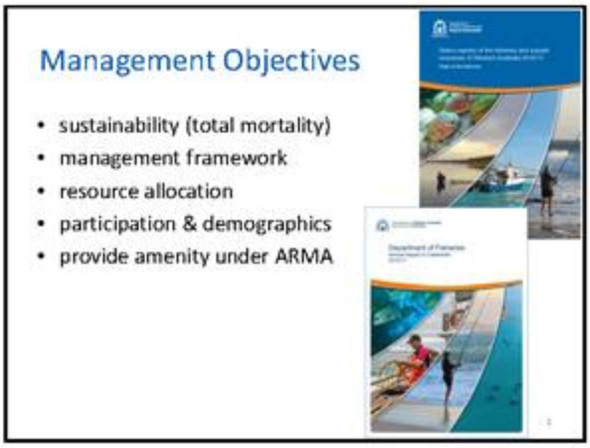
- In the absence of a comprehensive registry of fishers, there is a need to explore multi-frame and alternate contact methods:
  - dual frame landline / mobile surveys;
  - dual frame household / licence frame surveys;
  - face to face household surveys
  - mail surveys using (back to the future!)

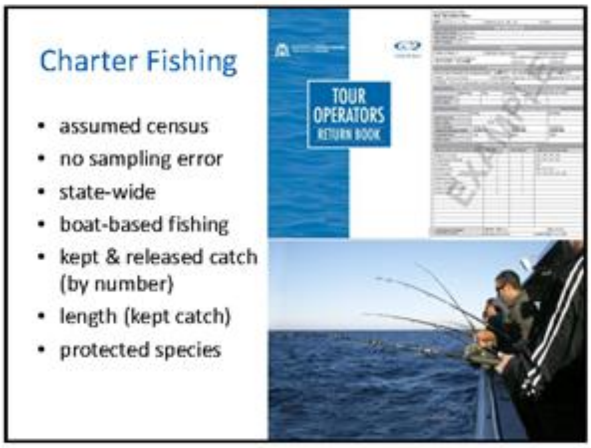
Technology – smart phones, internet, social media data mining – can play a role in data collection but not as a substitute for probability-based sampling

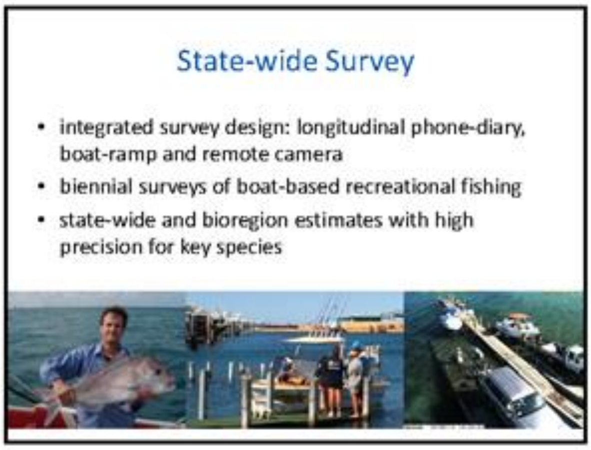
Let's not throw the baby out with the bath water.

Appendix 5: Applying innovation to off-site survey designs and statistical methods

Dr Karina Ryan- DPIRD, Western Australia (Appendix 5)







Objective	Estimate total effort and catch by boat-based recreational fishers
Survey period	Mar 2011 – Feb 2012; May 2013 – Apr 2014; Sep 2015 – Aug 2016; Sep 2017 – Aug 2018 *
Sampling frame	Recreational Boat Fishing Licence holders * Includes WP* for shore-based fishers
Stratification	Regional Development Commission Boundaries
Sample size	Random sample of RBFL holders, ~ 3,000 diarists
Data	Boat-based effort (hours and days fished), catch (retained and released)
Fishing method	All boat-based fishing methods
Species	200+ species
Spatial	State-wide, bioregions, zones
Temporal	Annual, seasons

Survey Instruments

- question wording & responses comparable to surveys in other states, but appropriate for WA
- Computer Assisted Telephone Interviewing (CATI)
- phone (data collection), sms & email (reminders)

Complex Surveys

- '*raw*' person-based sample data to '*weighted*' population estimates
- WhitePages SF to ABS ERP
- licence SF to RBFL population
- point estimates & uncertainty in R
- disaggregation at species, spatial & temporal levels

8

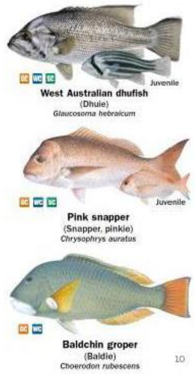
Opportunities

- DPIRD cooperation and coordination
- multi-agency cooperation and coordination
- advice for management & resource assessments
- biennial surveys allow comparisons of estimates
- integrating economic & human dimensions' research

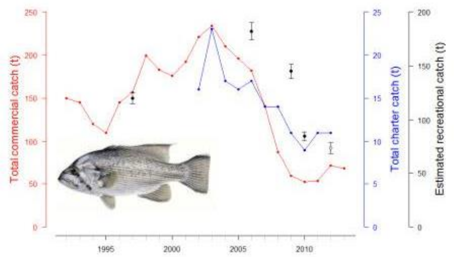
9

West Coast Demersal Scalefish

- mainly boat-based fishing
- large spatial & temporal scale
- ~200 species, 15 key species, 80% catch from 3 species
- RBFL in 2010 (~150,000 / year)
- estimates of catch (by number)
- average weights (on-site surveys & charter)
- sustainability assessments, management advice, IFM



10



Fisheries Management and Ecology

Fisheries Management and Ecology, 2016, 23, 218–233

Recreational fisheries data requirements for monitoring catch shares

K. L. RYAN, F. I. TRINNIE, R. JONES, A. M. HART & B. S. WISE

Department of Fisheries, WA Fisheries and Marine Research Laboratories, Hillarys, WA, Australia

11

Multi-agency cooperation & coordination

- Research Agreement with ECU
- Survey Research Centre & post-graduate research

Department of Primary Industries and Regional Development
GOVERNMENT OF WESTERN AUSTRALIA

ECU EDITH COWAN UNIVERSITY

recfishwest

Fisheries Research 181 (2016) 1–13

Contents lists available at ScienceDirect

Fisheries Research

journal homepage: www.elsevier.com/locate/fishres

The effects of measurement uncertainty on spatial characterisation of recreational fishing catch rates

Eric N. Aidoo, Ute Mueller, Glenn A. Hyndes, Karina L. Ryan

12

Collaboration – emerging priorities

- ramp usage for boating facilities planning (DoT)
- spatial management (state & commonwealth)
- economic valuation (RFIF)
- shark depredation


Contents lists available at ScienceDirect

Marine Policy

journal homepage: www.elsevier.com/locate/marpol

Differences in perception of a newly created Marine Park in south-west Western Australia by boat-based recreational fishers and the broader community

Kirrily Hastings*, Karina L. Ryan

Department of Fisheries, Western Australia, Australia

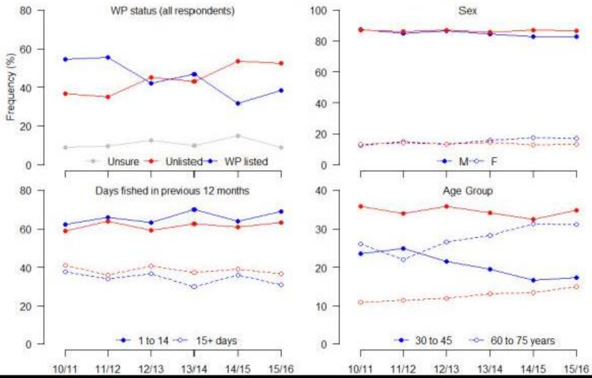
13

Challenges

- maintaining response rates
- out-of-scope – shore-based fishing
- maintaining quality sampling frames – White Pages
- under-coverage – low participation fisheries, can be captured with species specific licence, e.g. Rock Lobster Fishing Licence (nil exemptions)
- respondent management
- contact methods - Internet and Web-based surveys
- funding (2 to 3 years, required for IFM), cost-effective alternatives

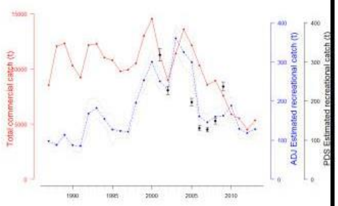
14

Maintaining quality sampling frames



Western Rock Lobster

- ~40,000 licences / year
- large spatial & temporal
- annual mail surveys, supplemented with phone-diary surveys



16

Future Directions

- dual-frame surveys (white pages / licences)
- simulation modeling (bias, precision, sample size)
- integrated surveys
- low (frequent) & high (infrequent) monitoring
- catch reconstruction
- geostatistical methods
- small area estimation
- multi-modal contact methods
- post-stratification and calibration (RBFL – ABS)

17

Multi-modal Contact Methods

- single platform with multi-mode contact methods
- increase respondent engagement
- integration of phone, online and offline
- single questionnaire
- data storage, sample management & extracts

18

Post-stratification and calibration

- auxiliary variables
- investigate alternative expansion factors.
  e.g. post hoc stratification using auxiliary variables to improve matches between sample & population
- post-stratification process based on strata and appropriate weighting cell information,
  e.g. avidity, bioregions fished & species targeted

19

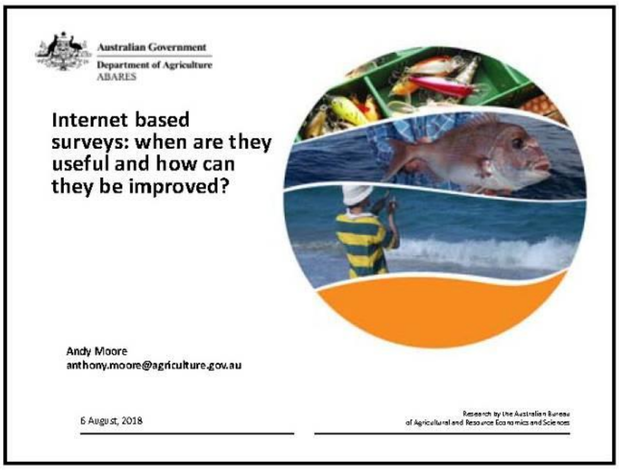
Future Proofing

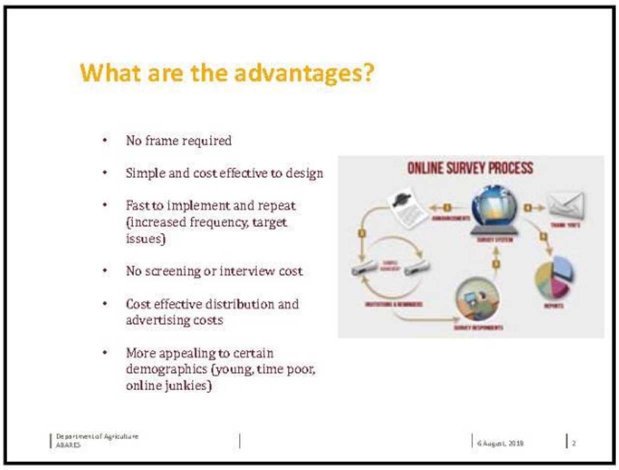
- increasing technology & connectivity
- where possible run old and new methods concurrently to demonstrate effectiveness (true measure) of improvements
- objectives – design – then incorporate technology as part of the design (data collection tool)

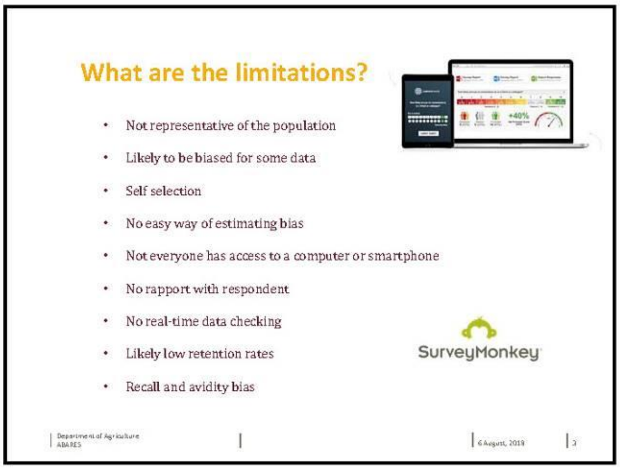
20

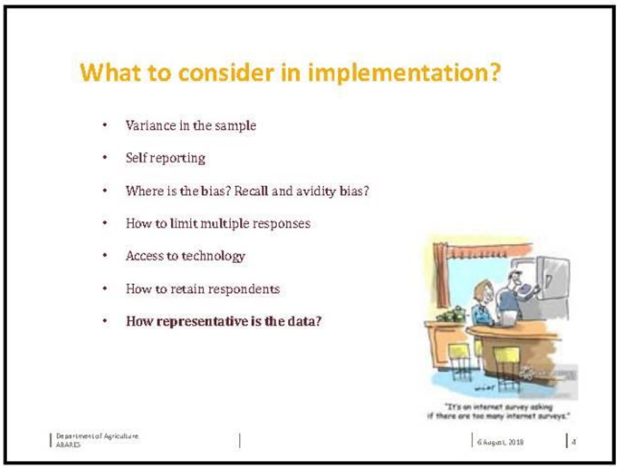
Appendix 6: Use of internet surveys

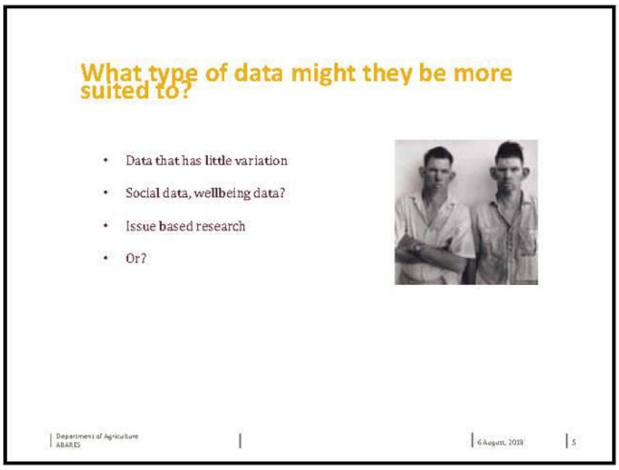
Andy Moore- ABARES, Canberra

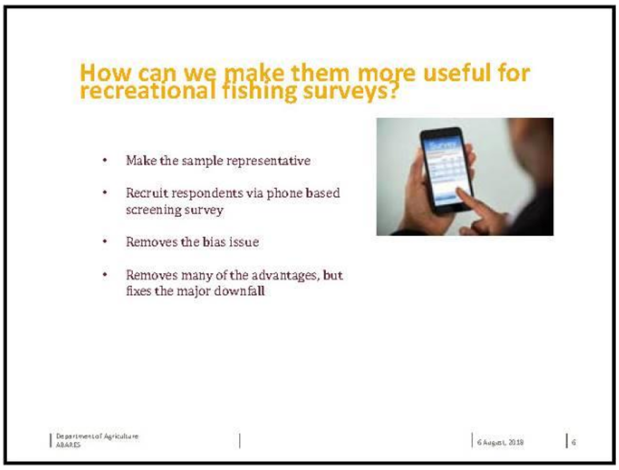












How can we test it?

- Victoria = opportunity
- Benchmark/validation study
- Recruit respondents via probability based sampling
- Same sample size in phone and internet based survey
- Run a standard internet survey for comparison
- Door knock

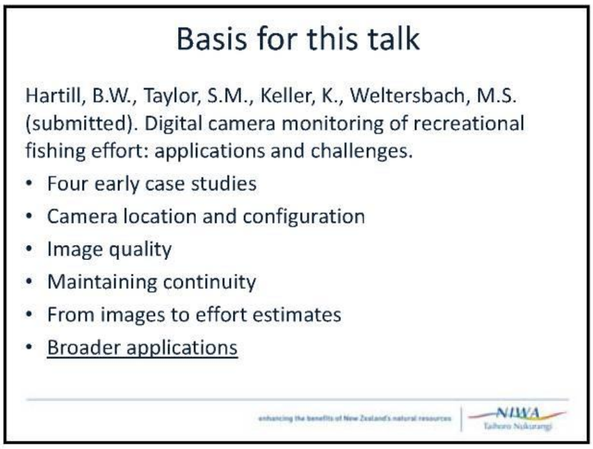
Department of Agriculture
ABARES

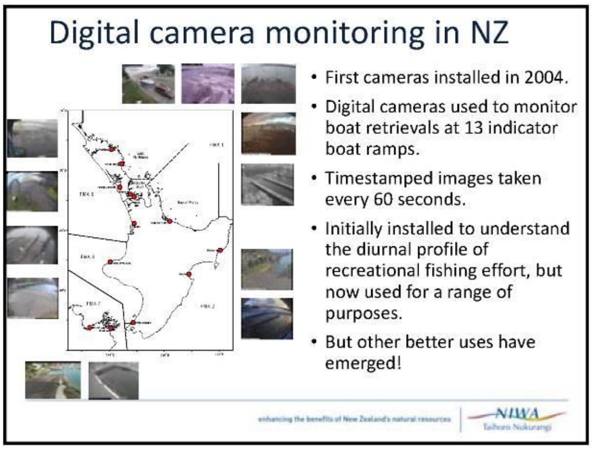
6 August, 2016

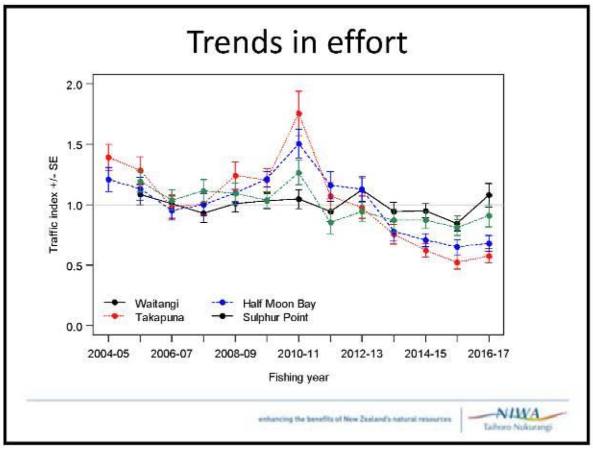
7

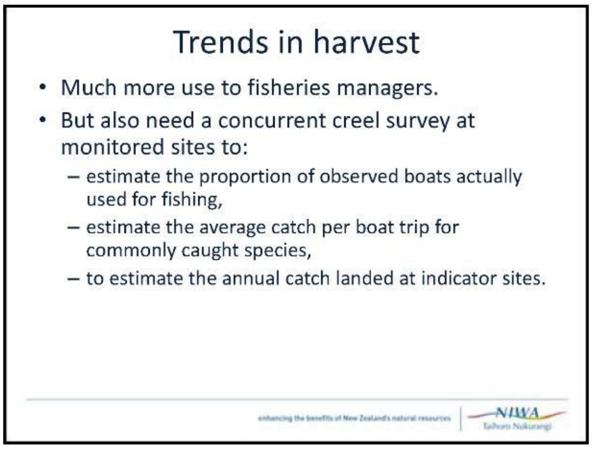
Appendix 7: What role can digital camera monitoring of boat retrievals play in informing fisheries management

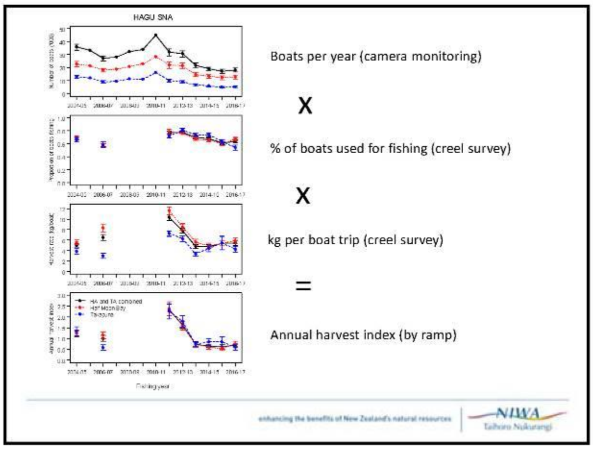
Bruce Hartill- NIWA





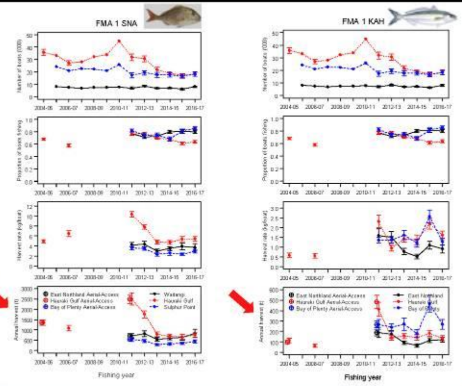






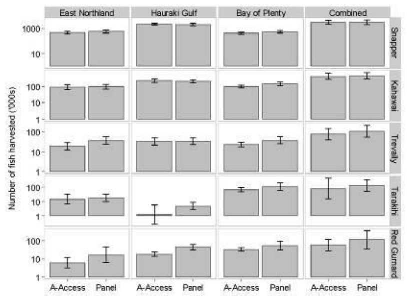
Harvest trends

- Much more use to fisheries managers.
- But also need a concurrent creel survey at monitored sites to:
  - estimate the proportion of observed boats actually used for fishing,
  - estimate the average catch per boat trip for commonly caught species,
  - to estimate the annual catch landed at indicator sites.
- Can use occasional fishery wide harvest estimates to scale up ramp specific harvest indices.



Hartill et al. (2016)

Measuring temporal bias in onsite surveys

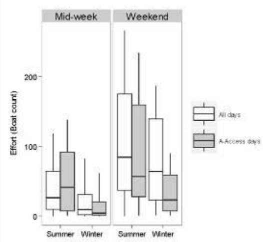


Aerial-access survey estimates mostly lower

BRT analysis suggested that temporal variables explained most of the differences between estimates

Hartill & Edwards (2015)

Temporal bias in onsite survey estimates

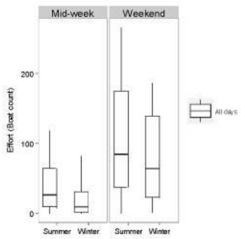


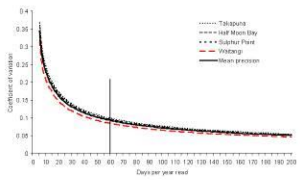
Looked at camera based daily traffic count data for all 365 days falling within the surveyed year.

Aerial-access survey days quieter than average in three out of four temporal strata.

Hartill & Edwards (2015)
Steffe et al. (2008) & Taylor et al. (2018) – post correction of effort estimates

Optimising temporal survey designs





Each subsequent day allocated to the temporal stratum that reduces the overall variance the most.

How many days?

Smallwood et al. (2012) – defining strata and allocating sampling effort
Hartill et al. (2016) – above
Edwards and Schindler (2017) – optimizing spatial allocation of effort (lakes)

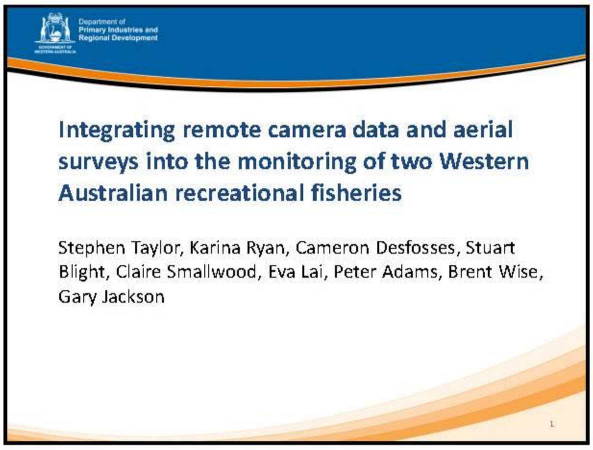
Other applications

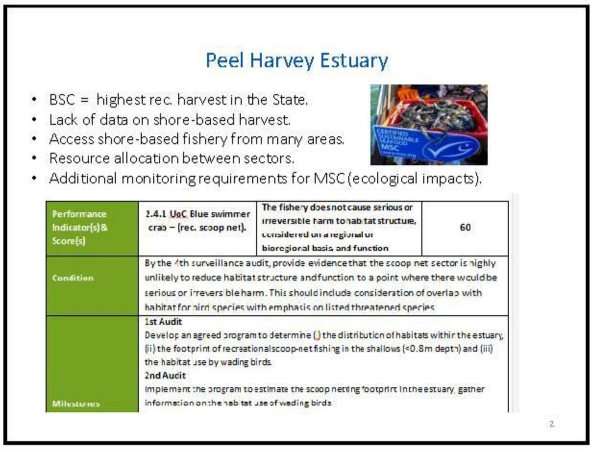
- Monitoring night time fishing effort (Smallwood et al. 2012, Taylor et al. 2018).
- Monitoring fishing effort in areas where marine reserves are proposed (Lancaster et al. 2017).
- Assessing the effectiveness of a closed season (Powers and Anson 2016).
- Assessing use of artificial reef structures (Keller et al. 2016, Wood et al. 2016).

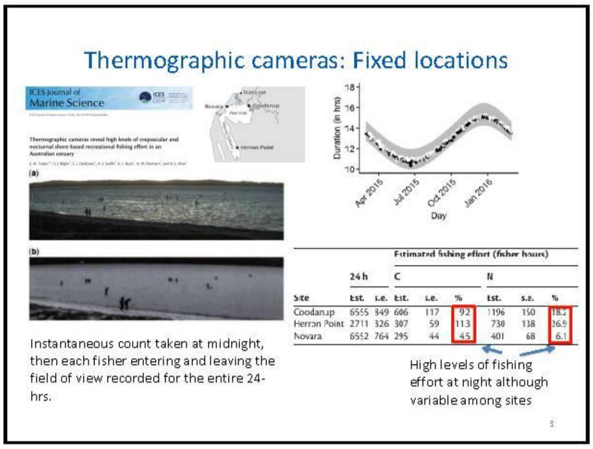
Thank you
enhancing the benefits of New Zealand's natural resources
NIWA
Taihoro Nukurangi

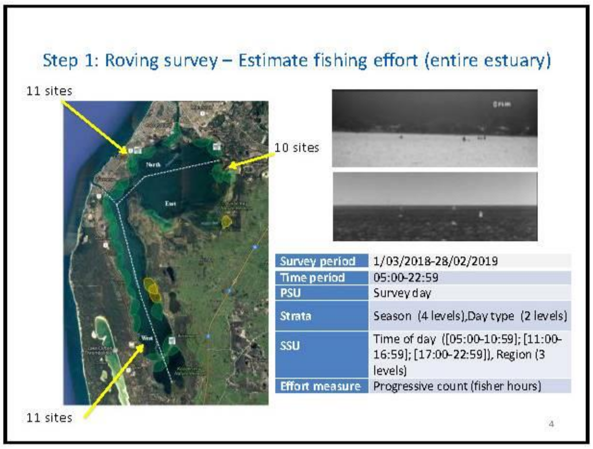
Appendix 8: Integrating remote camera data and aerial surveys into the monitoring of two WA recreational fisheries

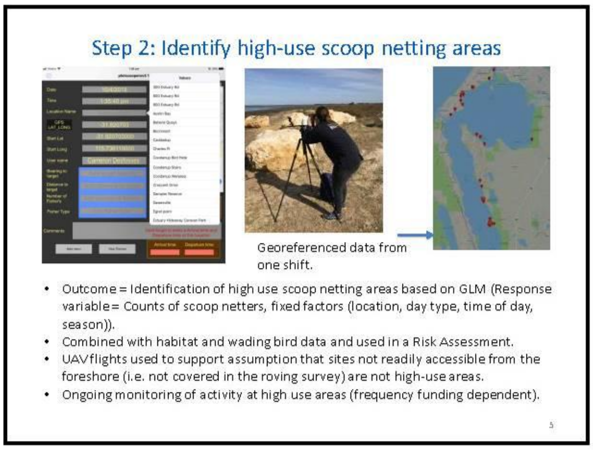
Steve Taylor- DPIRD, Western Australia











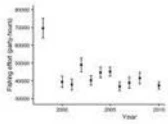
Inner Shark Bay

- Essentially a 'rec only' fishery.
- Pink Snapper stocks managed to notional TACs:
- Eastern Gulf (11.25 t recreational (~3,500 fish); 3.75 t commercial).
- Denham Sound (11.25 t recreational (~3,500 fish); 3.75 t commercial).
- Freycinet Estuary (3.75 t recreational (~1,000 fish); 1.25 t commercial).

7

Historical monitoring of recreational fishing: Boat ramp surveys and harvest tags (Freycinet Estuary)


Long-term monitoring of boat-based recreational fishing in Shark Bay, Western Australia: providing scientific advice for sustainable management in a World Heritage Area




ICES Journal of Marine Science

Original Article

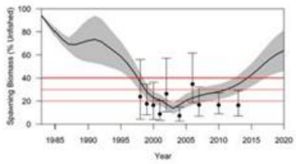
Assessing the effectiveness of harvest tags in the management of a small-scale, iconic marine recreational fishery in Western Australia

Hard limit to constrain the harvest

8

Sustainability Status for Pink Snapper

- Stocks recovered (Jackson and Moran, 2012).
- Latest assessment (2015): Freycinet Estuary stock rebuilt to target level (40% unfished level; see graph below).



- Jan 2016: Removal of Harvest Tags in Freycinet Estuary

9

2016 onwards (after management changes)

- Need to monitor Pink Snapper harvest in inner Shark Bay (finer-scale).
- Challenging to get robust estimates for each stock.
- Ongoing Departmental surveys focussed on broader-scale estimates.

Statewide | Gascoyne Bioregion | Carnarvon and Shark Bay Zone | Inner-Shark Bay | Individual stocks | Boat ramps

Offsite surveys → Onsite surveys

10

Corroborating survey estimates = More confidence in finer-scale catch estimates

Survey	Method	Timeframe	In scope
iSurvey	Phone-diary	2011/12, 2013/14, 2015/16, 2017/18	All boat-based (incl. multi-day trips, boats not retrieving at Denham, Monkey Mia and Nanga, 24-hr fishing activity)
Supplementary Access Point Survey (SAP)*	Remote cameras, boat ramp survey	2016/17 2018/19 (6-month overlap with iSurvey)	Denham, Monkey Mia and Nanga (24-hr boat launches, daytime catch info)
Aerial*	Fixed wing plane,	2018 (6 months)	All Freycinet Estuary (daytime effort)
	Unmanned Aerial Vehicles	Trials in May and July	Tamala and Carrarang (daytime effort)

* Funded through the Recreational Fishing Initiatives Fund.

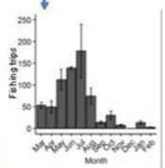
11

SAP: From camera to ramp-based estimates of harvest

Results from Taylor et al. 2018b

	Estimated total number of powerboat retrievals (se)		
Location	Full days (24-hours)	Nautical dawn to dusk	Percent during daylight hours
Nanga	781 (15)	765 (16)	98

Adjust for recreational fishing activity



Multiply by harvest rate

Number of Pink Snapper

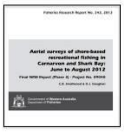
Location	Kept	se	Rel	se	Total	se
Nanga	709	549	2,012	1,073	2,721	1,582

Weight (t)

Location	Kept	No. fish measured	Av TL (mm)	Av wt (kg)	Total kept (t)	se	95% CI
Nanga	709	67	669	3.8	2.7	1.6	0.7–5.8

12

Other fishing activity in Freycinet- Aerial Survey

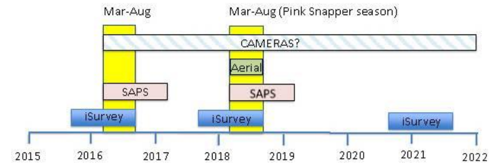


- Daily estimates of fishing effort (boat hours) for 28 flights between March and August 2018 (SRS).
- Randomised start location and direction of travel.
- Total effort estimates obtained for 6-month period. Provide a means to scale up the catch from Nanga (with assumptions).

13

Recommendations for ongoing monitoring

- Compare estimates on an 'apples with apples' basis.



- One option: Use iSurvey estimate for inner Shark Bay (i.e. all three stocks combined), then proportion the harvest based on 2018/19 onsite surveys.
- Other options: Use remote cameras to monitor changes in fishing effort between iSurveys. Use onsite surveys to estimate harvest rates between iSurveys or to estimate the harvest.

14

Summary – Remote cameras

October 12, 2017
Fisheries research report No. 286
Framework for Integration of Data from Remotely Operated Cameras into Recreational Fishery Assessments in Western Australia

Monitoring objective	Recommended sampling strategy
✓ 1. Initial assessment of the relative magnitude of fishing effort in a data-poor fishery	Small probability-based sample (5-10% coverage of full PSU's)
2. Index of fishing effort	Medium probability-based sample (10-75% coverage of full PSU's)
✓ 3. Estimate fishing effort	Medium probability-based sample (10-75% coverage of full PSU's)
4. Describe patterns of fishing effort that occur at different temporal scales	Small to medium probability-based sample (5-75% coverage of full PSU's)
✓ 5. Supplement an existing on-site survey design by increasing coverage for fishing effort of the temporal frame	Census preferred but large probability-based sample (75-100% coverage of full PSU's) can be used
✓ 6. Expand an existing survey design by including an additional monitoring component that provides coverage of night-time fishing effort	Medium probability-based sample (10-75% coverage of full PSU's)
✓ 7. Corroborate estimates of fishing effort from another independent survey	Census preferred but large probability-based sample (75-100% coverage of full PSU's) can be used
8. Validate estimates of fishing effort from another independent survey	Census (100% coverage of full PSU's)

15

Acknowledgements

- All the recreational fishers who participated in the research
- Recreational Fishing Initiatives Fund
- Aldo Steffe (Fishing Survey Solutions)
- Recfishwest: Andrew Rowland, Matt Gillett, Vanessa Abbott
- Camera readers: Current = Blaine Hodgson, Dan Yeoh, Jason Harney, Sue Martin
- Admin support: Karen Williams, Tamara Mowday
- Data entry: Vangie Gerginis
- Shark Bay field staff: Mark Halse, Dean Whitehead, Jess Herriot, Marigula Muriopulos, Tiffany Taggart, Joe McLoughlin
- Peel Harvey field staff: Hayden Munday, Jason Harney, Kade Parmenter, Sarah Poulton, Teagan Young
- Nanga Bay Resort and the RAC Monkey Mia Dolphin Resort
- Shark Bay Aviation
- City of Mandurah, Shire of Murray
- Emily Fisher
- Byron Francis, Dean Clarke

References

Jackson, G., and Moran, M. 2012. Recovery of inner Shark Bay snapper (Pagrus auratus) stocks: relevant research and adaptive recreational fisheries management in a World Heritage Property. Marine and Freshwater Research, 63. 1180–1190.

Jackson, G., Ryan, K. L., Green, T. J., Pollock, K. H., and Lyle, J. M. 2016. Assessing the effectiveness of harvest tags in the management of a small-scale, iconic marine recreational fishery in Western Australia. ICES Journal of Marine Science, 73. 2666–2676.

Smallwood, C. B., and Gaughan, D. J. 2013. Aerial surveys of shore-based recreational fishing in Carnarvon and Shark Bay, June to August 2012. Final NRM Report (Phase 3) - Project No 09040. 40 pp.

Taylor, S. M., Blight, S. J., Desfosses, C. J., Steffe, A. S., Denham, A. M., Ryan, K. L., and Wise, B. S. 2018a. Thermographic cameras reveal highly variable levels of shore-based recreational fishing in an Australian estuary. Accessed 8/5/2019. ICES Journal of Marine Science.

Taylor, S. M., Steffe, A. S., Lai, E. K., Ryan, K. L., and Jackson, G. 2018b. A survey of boat-based fishing in inner Shark Bay 2016/17. Government of Western Australia. Department of Primary Industries and Regional Development. Fisheries Research Report 86 pp.

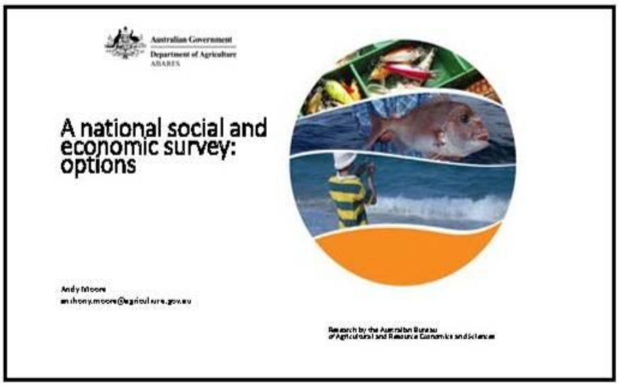
Colefax, A. P., Butcher, P. A., Kelaher, B. P. 2018. Potential for unmanned aerial vehicles (UAVs) to conduct marine fauna surveys in place of manned aircraft. ICES Journal of Marine Science 75. (1). 1-8.

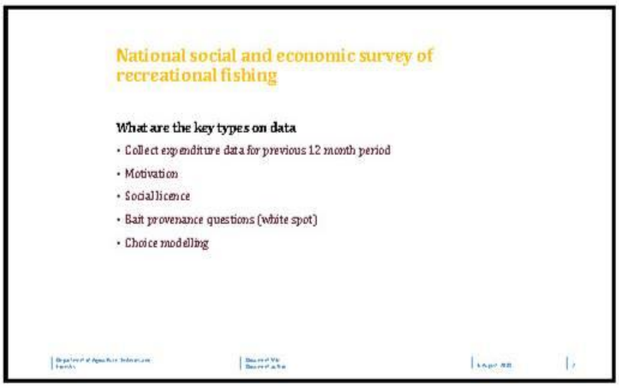
Wise, B. S., Telfer, C. F., Lai, E. K. M., Hall, N. G., and Jackson, G. 2012. Long-term monitoring of boat-based recreational fishing in Shark Bay, Western Australia. Providing scientific advice for sustainable management in a World Heritage Area. Marine and Freshwater Research, 63. 1129–1141.

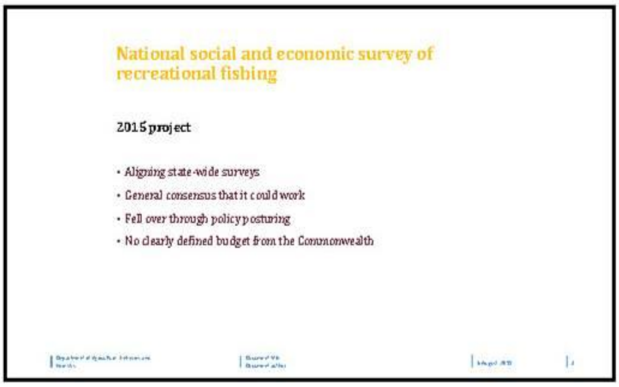
16

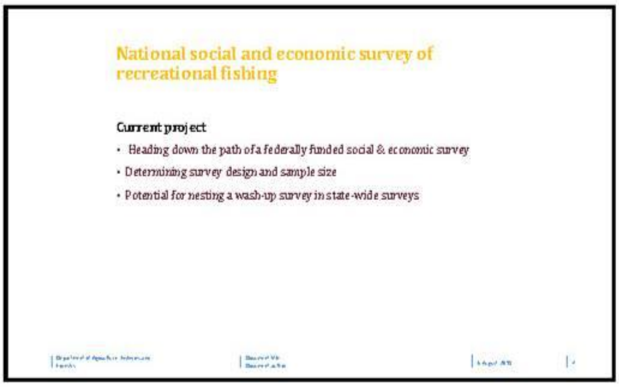
Appendix 9: A national social and economic survey: options

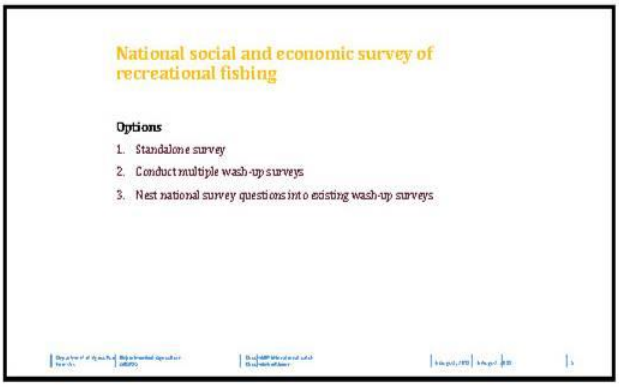
Andy Moore- ABARES, Canberra

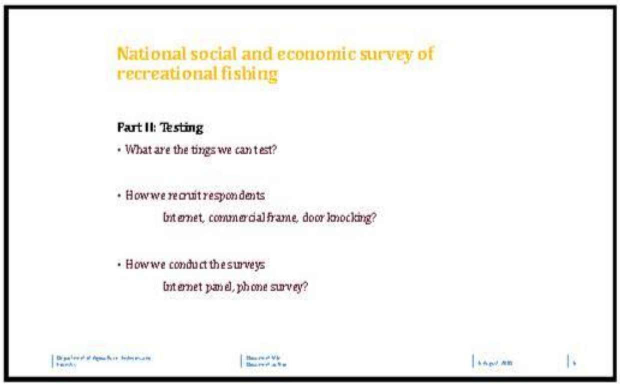












National social and economic survey of recreational fishing

Previous survey

- Surveyed 44,000 households
- Based on getting good RSEs of commonly caught species
- However, we need good RSEs on economic and social data, not catch and effort
- How many households per state do we need to call?
- Based on some earlier work to repeat the 2000/2001 survey would cost $6.8 million

National social and economic survey of recreational fishing

Previous national survey

- Data rich survey that included expenditure and social data for each state
- Random removal of respondents to reduce sample size
- What effect does this have on annual total expenditure estimates and RSEs?