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International Workshop on Recreational Fishing Surveys

R. Marks, C. Desfosses, A. Tate

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Enquiries:

WA Fisheries and Marine Research Laboratories,
PO Box 20,
North Beach, WA 6920

Tel: +61 8 9203 0111
Email: library@fish.wa.gov.au
Website: fish.wa.gov.au

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Department of Primary Industries and Regional Development
Gordon Stephenson House
140 William Street
PERTH WA 6000
Telephone: (08) 6551 4444
Website: dpird.wa.gov.au
ABN: 18 951 343 745

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Executive Summary

Recreational fishing surveys have been conducted by the Department of Primary Industries and Regional Development (DPIRD, formerly Department of Fisheries) since 1975 (Tate *et al.,* 2020). Within Western Australia, the first international workshop on recreational fishing surveys was held in January 2010 at the Western Australian Fisheries Marine Research Laboratories in Perth. The workshop aimed to audit existing survey methods and make recommendations for the design of integrated surveys to estimate recreational fishing harvest, catch and effort at statewide and bioregional scales (Wise & Fletcher 2013). The core element of this statewide survey was the introduction of the Recreational Boat Fishing Licence (RBFL), which could be used as a sampling frame for future recreational surveys. The outcomes of this workshop therefore provided the framework for four subsequent statewide recreational fishing surveys in Western Australia (Ryan *et al*., 2013; 2015; 2017; 2019).

The overall objective of the 2019 workshop was to bring together national and international experts to review and evaluate survey designs and statistical methods for monitoring recreational fishing in Western Australia that had occurred since the first workshop. Discussions focussed on considering the current approaches for monitoring participation, effort and catch in other jurisdictions; how these provide the evidence used for assessment and management; and how these approaches align with current best practice. Several themes were addressed, including the information required for monitoring and assessing recreational fisheries; current management and research in each jurisdiction; off-site survey designs (effort and catch); on-site survey designs (effort and catch); on-site survey designs (catch rates and average weight); innovative approaches for monitoring recreational fisheries (vessel monitoring and comparison of data collection methods) and social and economic considerations of recreational fishing. Each session comprised several presentations and a discussion around key issues and outcomes. The workshop concluded with discussions on the current and future challenges for survey designs to support sustainable recreational fisheries.

The workshop provided an opportunity to highlight the strengths and developments made in recreational fishing survey designs in recent years, as well as current issues, and how any limitations might be overcome to support future opportunities in this field. Key points raised included the need for increased fisher engagement, effective collaborations, the implementation of a general licence/registry, the use of multi-modal contact methods and long-term low-level monitoring. The workshop achieved all objectives and outputs and involved wide-ranging discussions, including the evaluation of survey designs and statistical methods, improving accuracy and precision in survey estimates and how best to incorporate survey outputs in reporting and assessments.

This report provides an overview of the presentations and discussions to inform scientific advice that will assist in planning the next decade of surveys to be implemented in Western Australia.

1.0 Session 1: Information required for monitoring and assessing recreational fisheries

Chaired by Karina Ryan, Senior Research Scientist, Department of Primary Industries and Regional Development, Western Australia

A Whadjuk Welcome to Country performed by Matthew McGuire opened the workshop. This was followed by a welcome address by Dr Dan Gaughan (Director of Aquatic Science and Assessment, DPIRD) and then a number of presentations highlighting the differing perspectives of recreational fishing research, including policy, stakeholder and research priorities.

Nathan Harrison (Director of Aquatic Resource Management, DPIRD) provided a perspective from recreational fishing policy and management in Western Australia. Key management needs, current issues, and future drivers for recreational fishing research were outlined, as well as the importance of having a collaborative approach between recreational fishing research and management.

Leyland Campbell (Operations Manager, Recfishwest) provided a recreational fishing stakeholder perspective. While understanding the difficulties in collecting the data needed, Recfishwest believe that recreational fishers have a sense of stewardship with aquatic resources, and are keen to adopt new management practices and participate in data collection. Further, he outlined that amenity and maximising the fishing experience should be priorities alongside maintaining the sustainability of a fishery.

Dr Brent Wise (Senior Principal Research Scientist, DPIRD) rounded out the session by discussing the research perspective, particularly the balancing act between meeting conflicting stakeholder requirements, resource limitations and the realities of recreational fishing surveys. The session was concluded by outlining the strategic direction and overall aims of the workshop.

The overarching aim of this workshop was to discuss survey designs and methods that represent contemporary approaches for monitoring fishing activity, including both broad-scale (statewide) and small-scale (local) surveys.

1.1 Policy perspective

Nathan Harrison (WA: DPIRD)

DPIRD undertakes a collaborative approach, such that management work closely with researchers, which is critical from a Western Australian perspective. Strong collaboration helps inform different monitoring undertaken by research, which then links back to management of target species. This presentation highlighted the importance of a licensing frame, which provides a sampling frame for probability-based surveys, as well as generating ~$8 million in licence revenue. Key management priorities include integrated fisheries management to generate allocations and harvest strategies which inform decision rules, comprehensive catch and effort information is thus required to evaluate the effectiveness of management change. Current issues include the spatial scale of resource sharing, gathering information on smaller scales,

and linking research to governance. Future drivers include sustainability, social and economic considerations, and digital data collection, with a suggestion that rock lobster would be a good place to trial initiatives for recreational fisheries in Western Australia. Overall, there needs to be collaboration not only between management and research but also with Recfishwest, to support management decisions.

1.2 Stakeholder perspective

Leyland Campbell (WA: Recfishwest)

This presentation outlined the key priority for the recreational lobby group, Recfishwest: Maximum Experiential Yield (MExY). This was demonstrated through restocking and artificial reefs, which provide positive experiences, i.e. more places to fish and more fish to catch and are overall sustainable, accessible and enjoyable. From Recfishwest's perspective, sustainability is the starting point of management, but there should be further goals to consistently provide the best possible fishing experience. Essentially, if the experience is right, then sustainability will take care of itself. Although it is important to understand what fishers want from a fishing experience, which often starts a long time before a fisher goes in the water, it has proven to be extremely difficult to define what a recreational fisher's MEY might be. The fish is not always the driver. For example, the key drivers in the marron fishery include, firstly, spending time with family and friends, secondly to get away, and thirdly catching marron. Similar reasoning was observed with abalone fishers. However, with rock lobster, catch is likely the most important driver as pulling pots is fun the first time, but not so much after that. Finally, Recfishwest agreed that the alignment of researchers, managers and fishers is important.

1.3 Research perspective

Brent Wise (WA: DPIRD)

This presentation highlighted the strategic directions of the workshop which included a review of current survey methods, as implemented from outcomes of the previous workshop, and a 10-year plan outlining future surveys. The complication of differing management priorities was raised, as well as the need for collaboration and partnership between research, policy and stakeholders. Other points included the realities of survey design, often influenced by the conflicting needs of managers, key stakeholders, recreational fishers, and other survey limitations (primarily funding, resourcing and logistical constraints).

2.0 Session 2: Current management and research in each jurisdiction

Chaired by Cameron Desfosses, Research Scientist, Department of Primary Industries and Regional Development, Western Australia

The proportion of the catch taken by recreational fishers is large for some species. Surveys are becoming increasingly important for determining and monitoring resource allocation between the recreational and commercial sectors, as total allowable recreational catches (TARC) are being incorporated into harvest strategies and recreational catch and effort estimates are often a requirement of third-party certification processes (e.g. Marine Stewardship Council: MSC). Biological data, catch, effort, catch rate (catch per unit effort: CPUE), participation and satisfaction estimates derived from the surveys are also used to incorporate recreational data into stock assessments and harvest strategies; develop and review control measures (bag/size limits), management plans and policy; determine fisher's awareness of fishery-related issues; provide demographic, attitudinal and avidity data; quantify the social and economic value of recreational fishing, and educate the public.

The aims for this session were to highlight:

- similarities and differences between policy and data needs in each Australian jurisdiction;
- similarities and differences between the survey methods applied in each Australian jurisdiction; and
- how the policy, data requirements and survey methods applied in Australia relate to those used internationally

Representatives from each State and Territory presented i) the methods currently employed to undertake recreational fishing surveys; ii) challenges and issues impacting on the ability to provide accurate and precise estimates; and iii) future directions for data collection, analysis, assessments and management in their respective jurisdictions (Figure 1; Table 1).

The importance of carrying out rigorous, probability-based recreational surveys was a feature of the session, as was the importance of designing surveys for broad spatial and temporal scales to provide a time-series of accurate, precise and representative data. Recreational survey designs varied across the jurisdictions, with a range of off-site (telephone, diary, smart-phone apps) and on-site (access point, remote camera, aerial) surveys being used either as stand-alone or as integrated surveys. Fishery-independent surveys, along with commercial and charter data, were also used by some states in the absence of recreational fishing surveys being implemented. Accounting for released fish and incorporating accurate post-release mortality into stock assessments was raised as an increasing priority for many jurisdictions.

A common thread across all jurisdictions was the need for alternative survey methods to replace traditional sampling frames that are becoming outdated and which are having issues with under-coverage and declining response rates. For example, a shift towards mobile phones and unlisted numbers is rapidly making sources such as the

“White Pages” obsolete as a representative sample of the population. Even so, telephone interviews are a key contact method in off-site surveys, and engaging external research groups with experience in computer-assisted data collection, telephone surveys and contact methods has proved a successful model for off-site surveys in several states and territories. However, several long-term data sets showed a decrease in survey participation and completion rates and an increase in non-contact or refusal rates, exacerbating the difficulties in collecting representative data across broad spatial and temporal scales. There were also concerns raised about the cost-effectiveness of commercial mobile phone databases and the potential inaccuracy and bias that could be introduced through the use of mobile phone and social media Apps.

All jurisdictions were investigating novel and innovative methods to collect recreational fishing data. Options being considered include compulsory reporting of recreational catch for priority species, harvest tags, mobile phone apps, internet surveys, social media data mining, and the use of remotely piloted aircraft (i.e. drones). Collaborations with external organisations with expertise in survey design, computer-assisted data collection, App development and social media engagement were also high priorities. The consensus was that a general fishing register is the most cost-effective and efficient source for obtaining a representative sample of the recreational fishing community. A national strategy was suggested to provide a collaborative approach for improving off-site recreational fishing surveys Australia-wide. Improved integration with on-site surveys should also be considered to reduce bias in survey data and build confidence in estimates derived from recreational fishing surveys.

The socio-economic aspects of recreational fishing are becoming increasingly important; however, defining these has been complex as behaviours and motivations differ markedly among recreational fishers. There is no one-size-fits-all for defining satisfaction or maximum experiential yield (MExY) and, as such, there is often no clear policy in relation to social, economic and ethical aspects of recreational fishing in most Australian jurisdictions. Obtaining a definition for MExY would be fundamental for ensuring managers, researchers and recreational fishers are working together when setting priorities.

Engagement with recreational fishing groups, managing competing socio-economic priorities and communicating survey results to the general public were identified as areas that need to be improved. Several recent examples were given where the results of recreational fishing surveys had been successfully presented using various media platforms. Overall, it is important to have clear objectives for what needs to be communicated and who the target audience is. On-site surveys were also identified as an important tool for engaging and communicating with recreational fishers, by informing them of the importance of their data and building trust in the accuracy and precision of estimates that are derived from survey data.

The presentations were closed with a keynote presentation from Dr Kieran Hyder from the United Kingdom’s Centre for Environment, Fisheries and Aquaculture Science (CEFAS). Dr Hyder provided insights into the current status of recreational fishing in Europe, including the complexities surrounding the collection of data and the uncertainties around data sources; incorporating multiple data sources into single assessments; differing rules and management objectives across the multi-national

scope that European legislation encompasses; quantifying the poorly-defined but high priority social aspects of recreational fishing; as well as the different behaviours, motivations and ethics in different European countries.

2.1 Overview of current recreational fishing management and research in WA

Karina Ryan, Stephen Taylor (WA: DPIRD)

Approximately $2.4 billion is spent on recreational fishing in WA each year (Lindner & McLeod, 2019). with an estimated 619,000 recreational fishers operating in the state (DPIRD, 2019). For sustainable fisheries, it is important to monitor participation, effort, catch and fisher satisfaction. Monitoring recreational fishing depends on several factors, including the overall management objectives, the spatial and temporal scale of the fishery, and the availability of a sampling frame. In 2019/20 there are were 13 recreational fishing surveys conducted in WA, contributing to elements of Ecosystem-Based Fisheries Management (EBFM), Marine Stewardship Council (MSC) certification and Integrated Fisheries Management (IFM), which includes resource allocation between sectors. Species of particular interest to recreational fishers in WA include the Blue Swimmer Crab (*Portunus armatus*), Western Rock Lobster (*Panulirus cygnus*), School Whiting (*Sillago* spp.), Australian Herring (*Arripis georgianus*), Pink Snapper (*Chrysophrys auratus*) and Squid (*Sepioteuthis australis*). It is important that ongoing monitoring is undertaken to provide estimates of recreational fishing effort and catch for these key species and to observe changes in these indices over time. Best practice off-site (i.e., mail, phone) and on-site (i.e. access point, roving, aerial) survey designs have been utilised to provide information on fishing effort and catch, as well as fishery and fisher characteristics to help support a range of management strategies for recreational fishing in Western Australia.

2.2 The state of South Australia's community-shared fisheries

Mike Steer (SA: PIRSA/SARDI)

The Minister's Recreational Fishing Advisory Council (MRFAC) is tasked with looking at the key issues for stakeholders. Key recreational species in South Australia include Snapper (*Chrysophrys auratus*), King George Whiting (*Sillaginodes punctatus*), Garfish (*Hyporhamphus melanochir*) and Southern Calamari (*Sepioteuthis australis*). Allocated resource shares are based on the 2007/08 survey; however, the 2013/14 survey changed the dynamic as some of the resource allocations changed based on results, leading to a bag and boat limit review and declines for King George Whiting, Garfish and Snapper. A statewide survey is due, including a need for increased precision of estimates that are embraced by all sectors. There is also a need to adopt new technology, such as real-time data collection or a smart phone App. This technology would improve data collection strategies, develop catch proxies in intervening years and be responsive and agile.

2.3 An overview of recreational fisheries in the NT

Kane Dysart, Shane Penny (NT: DPIR)

Recreational fishing surveys have been in place in the Northern Territory since the 1994-95 Fishcount survey of recreational fishing. Since the National Recreational and Indigenous Fishing Survey in 2000-01 (Henry & Lyle, 2003), there have been 6 more surveys. These surveys have occurred primarily in the Greater Darwin Area (annually from 2014-2017), with two larger-scale statewide surveys in 2009-10 (West *et al*., 2012) and 2018-19. The current survey design features a telephone-diary survey on NT non-Indigenous resident fishers (in collaboration with Kewagama Research), and on-site surveys at key recreational fishing areas. These collect visitor and local fisher information, including Indigenous, through Survey Solutions and NT Fisheries. The on-site data complement those collected through the phone-diary surveys and provide minimum estimates of recreational fishing effort (as there are restrictions in survey coverage, namely day-time fishing only, and limited spatial coverage). Key challenges in the Northern Territory include no licensing framework or register; logistical challenges due to widespread fishing effort; a large percentage of visiting fisher effort; difficulty in quantifying indigenous fishing effort; White Pages becoming obsolete; and a poor response rate from the mobile phone database.

2.4 Overview of the current statewide survey, the Net Free Zone satisfaction monitoring, the Boat Ramp Survey and the Keen Angler program in Qld

James Webley (Qld: DAF)

There are several surveys operating in Queensland which contribute to the monitoring of recreational fishing in this state. Surveys include a statewide survey, net free zone satisfaction, boat ramp survey, keen angler program and roving surveys. The statewide survey occurs over a 12-month period, providing information on fishing trips and expenditure, and is run by the Social Research Centre (SRC), Melbourne. The net free zone (NFZ) satisfaction survey was established in 2015 to monitor satisfaction and expectations within the net free zones and is repeated approximately every two years. The boat ramp survey has been in operation for 12 years across ~45 boat ramps throughout the state. The aim of this survey is to collect length data and monitor trends in indices of catch, effort and catch per unit effort (CPUE). Travel data are also collected which feed into travel cost analyses developed by CQU and have recently expanded into stocked impoundments. The keen angler program provides fish frames and length data for species that may be missed through commercial sampling, thus building a complementary database of age-length data. The roving surveys target tailor annually on Fraser Island and seasonally on the Gold Coast. Each of these surveys provides long-term data that feed into the stock assessment and management of key recreational fish species.

2.5 Monitoring and management of recreational fishing in NSW: current and future directions

Faith Ochwada-Doyle, Julian Hughes, Ashley Fowler, Jeff Murphy (NSW: DPI)

Recreational fishing participation rates in New South Wales have ranged from 12-17 %, with the highest number of recreational fishers throughout Australia (Henry & Lyle, 2003; West *et al*., 2015), generating ~$3.4 billion expenditure into the NSW economy each year (ANCORS, University of Wollongong). Documented recreational

fishing research in NSW dates back to the early 1980's and includes studies at both small and large spatial scales. Since 2000 there have been 19 recreational fishing projects in NSW, 11 of which focussed on small spatial scales that served a singular and immediate management objective. Most of the smaller studies utilize on-site survey methods, yet due to the associated costs, they are unable to contribute broad recreational fishery information to the stock assessment process in a cost-effective way. The studies that operate on larger spatial scales however, have a greater potential to contribute to overall stock assessments. There have been a series of statewide telephone and diary-based surveys that have monitored fishing across the whole state; the first being part of the National Recreational and Indigenous Fishing Survey in 2000-01 (Henry & Lyle, 2003); followed by a second statewide survey in 2013-14, and a third in 2017-18 which incorporated into the broader Recreational Fisheries Monitoring Program (RFMP) which is repeated on a biennial basis and also monitors the NSW charter-boat fishery. A fourth statewide survey is currently underway for the 2019/20 period and will also be incorporated into the RFMP. The RFMP provides a "comprehensive ongoing assessment of recreational fishing in NSW" and comprises two components; i) a survey of recreational fishing in NSW, and ii) a charter monitoring program. The charter monitoring program uses information from the charter fishery to address key knowledge gaps and support the management of recreational fisheries in NSW. The RFMP provides additional information to commercial or fishery-independent sources, including a time-series of catch and effort, size structure and angler satisfaction. NSW is now moving towards a harvest strategy approach which incorporates biological and social data sources to fully integrate the recreational sector into the overall management strategy.

2.6 An overview of Tasmanian recreational fisheries

Jeremy Lyle, Sean Tracey (Tas: IMAS)

There are two recreational management units in Tasmania; the sea fishery, managed by the Department of Primary Industries, Parks, Water & Environment which is regulated via fishery management plans; and the inland fishery which is managed by the Inland Fisheries Service. The sea fishery requires no general licence, but are species- and method-specific (e.g. rock lobster, abalone, set line, beach seine), whereas the inland fishery is regulated by recreational licences (including short-term and age exemptions) as well as gear restrictions, size and bag limits, temporal (spawning) and spatial closures. Information on recreational fishing is gathered through statewide assessments which use a stratified random sampling and multi-phase design. These surveys gather information on participation, catch and effort, expenditure and fisher awareness, attitudes and preferences which are used as input for stock assessment, social and economic indicators and in the development and review of management plans and policy. Survey limitations include under-coverage due to the sampling frame, non-response and data quality (i.e. biases associated with self-reporting). It is clear that in the absence of a comprehensive registry of fishers, there is a need to explore multi-frame and alternate contact methods. Technology (smart phones, internet, social media etc.) can play a key role in data collection, however, it is not a substitute for probability-based sampling.

2.7 Reflections from using an integrated approach to monitoring the status of recreationally important fish stocks using targeted creel, angler diary and fisheries independent surveys

Simon Conron, Justin Bell (Vic: VFA)

The aim of recreational fishery monitoring in Victoria is to monitor the condition of the stocks and fisheries, assess management interventions, and sustain and improve fisheries for over 500 water bodies throughout the state. Monitoring approaches are prioritised by value and popularity and provide multiple lines of evidence for stock assessments. There are three key aspects of monitoring: stock condition which monitors abundance, recruitment and fishing pressure; fishery performance which includes catch rates, harvest and visitation; and social perceptions which include satisfaction, preferences and 'quality' of fishing. There are a number of surveys in place in Victoria including creel surveys which measure stock/fishery performance; the angler diary program which measures angler catch rate, size composition and can provide an indication of recruitment; commercial fishing data which provides information on population health; fishery-independent surveys which can give an indication of recreational fishing pressure and measures population condition; and pre-recruit surveys which actively target juveniles to provide a reliable indicator of future year-class strength.

2.8 Keynote presentation: Recreational sea fishing in Europe in a global context – Participation rates, fishing effort, expenditure, and implications for monitoring and assessment

Kieran Hyder (United Kingdom: CEFAS)

Marine recreational fishing (MRF) is a high-participation activity with large economic value and social benefits globally, and it impacts on some fish stocks. Here, MRF in Europe will be described and key challenges identified, alongside future research requirements. The main policy drivers for MRF data collection include sustainable fisheries, environmental impact, and maritime spatial planning. Reporting MRF catches is a European Union legislative requirement, but estimates are only available for some countries. There are an estimated 8.7 million marine recreational fishers in Europe that fish for 77.6 million days. Direct expenditure on MRF is €5.9 billion annually, with a total economic impact of €10.3 billion that supports almost 100,000 jobs. Comparisons with other regions showed that European MRF participation rates and expenditure were in the mid-range, with higher participation in Oceania and the United States, and higher expenditure in the United States. Catches can also be significant with between 2 and 43% of the total removals for certain stocks, highlighting the importance of inclusion of MRF in stock assessments, ensuring sustainable management. Other benefits of MRF will be discussed including social, health, environmental improvement, and impacts in coastal communities. Future biological, physical, and social challenges associated with MRF and the need for novel approaches for co-management that integrate the commercial and recreational sectors will be demonstrated.

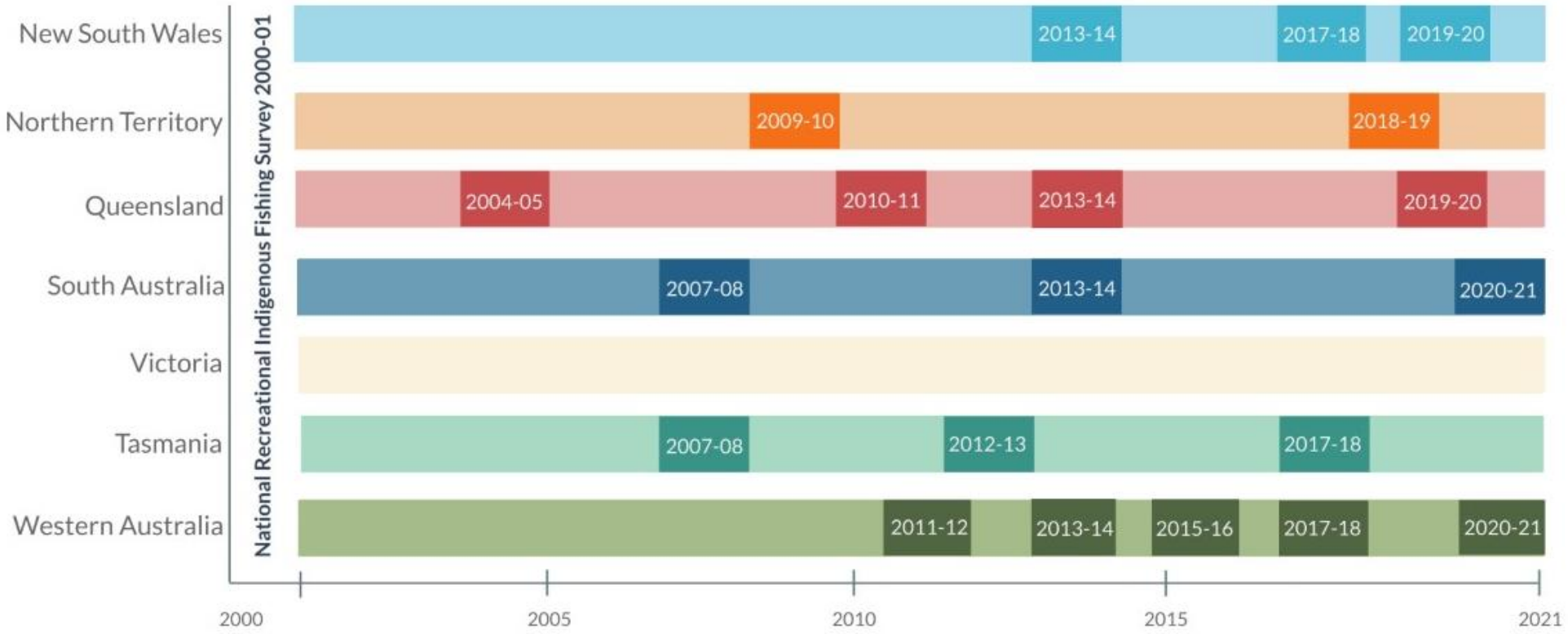

Figure 1. Timeline of statewide recreational fishing surveys in Australia since 2000/01.

Table 1. Summary of statewide recreational fishing surveys in Australia from 2000 to 2019. Key challenges were those outcomes raised as part of the group discussions.

Jurisdiction	Statewide surveys	Methodology	Information collected	Future plans	Key challenges	Source
New South Wales	2017-18 2013-14 2000-01	Based on NRIFS (2000-01) Since 2017-18 have incorporated the Recreational Fisheries Monitoring Program (RFMP) which comprises two components; i) a survey of recreational fishing in NSW, and ii) a charter monitoring program.	Catch (harvest and release) and effort Catch rates (line fishing) Fishing participation rates Fisher demographics	Fourth statewide survey currently underway (2019-20) will continue biennially Moving towards a harvest strategy approach which incorporates biological and social data sources	Limited recreational fishing data Integrating recreational fishing data into harvest strategies for multi sector fisheries	2017-18* 2013-14 2000-01
Northern Territory	2018-19 2009-10 2000-01	Based on NRIFS (2000-01)	Catch (harvest and release) and effort Fishing participation rates Fisher expenditure	Annual survey of recreational fishing in the greater Darwin area	No licensing framework or register Logistical challenges due to widespread fishing effort. Large percentage of visiting fisher effort Difficulty in quantifying indigenous fishing effort White Pages becoming obsolete and a poor response rate from the mobile phone database	2018-19* 2009-10 2000-01

Jurisdiction	Statewide surveys	Methodology	Information collected	Future plans	Key challenges	Source
Queensland	2013-14 2010-11 2004-05 2000-01	Based on NRIFS (2000-01)	Catch (harvest and release) and effort Fishing participation rates	Statewide survey currently underway (2019-20)	No licensing framework or register Communicating science and value of long term data to recreational fishers and maintaining support	2013-14 2010-11 2000-01
South Australia	2013-14 2007-08 2000-01	Based on NRIFS (2000-01)	Catch (harvest and release) and effort Fishing participation rates Fisher demographics Attitudes and motivations of recreational fishers	Statewide survey (2019-2020) Increase stakeholder engagement Commitment to undertake survey as part of core business	No licensing framework or register Outdated data frame (White Pages) = lack of confidence in estimates Need for increased precision of estimates that are embraced by all sectors Need to adopt new technology, such as real-time data collection or a SMART phone App	2013-14 2007-08 2000-01
Tasmania	2017-18 2012-13 2007-08 2000-01	Based on NRIFS (2000-01)	Catch (harvest and release) and effort Fishing participation rates Fisher demographics Fisher expenditure	With clear lack of comprehensive registry of fishers, there is a need to explore multi-frame and alternate contact methods	Lack of comprehensive registry of fishers Incorporating technology (smart phones, internet, social media etc.), in data collection, however, it should not be a substitute for probability-based sampling	2017-18 2012-13 2007-08 2000-01

Jurisdiction	Statewide surveys	Methodology	Information collected	Future plans	Key challenges	Source
Victoria	2000-01	No current statewide survey since NRFS Monitoring approaches prioritised by value and popularity of the 500 water bodies statewide	Stock and fishery performance (creel survey) Catch rate, size composition, and recruitment (angler diary programs) Population health (commercial fishing data) Population condition and recreational fishing pressure (fishery-independent surveys)	Angler diary App programs continue including: ▪ Rock Lobster App for tagging trial ▪ GoFishVic (angler diary app) Remote cameras at key boat ramps to collect effort data King George whiting tagging Value of seagrass to recreational fisheries	Stakeholder engagement	2000-01
Western Australia	2017-18 2015-16 2013-14 2011-12 2000-01	Statewide Recreational Boat Fishing Survey undertaken biennially since 2013. Integrates on and off-site survey methods to obtaining annual estimates of recreational catch by boat-based fishers and samples for recreational fishing from boat licence database	Catch (harvest and release) and effort Catch rates for key species Fishing participation rates Fisher demographics Fisher expenditure Harvest weights of key species	Moved to triennial survey (2020-21)	Lack of licence database for shore-based fisheries and key species such as Blue swimmer crab Incorporating technology (smart phones, internet, social media etc.), in data collection	2017-18 2015-16 2013-14 2011-12 2000-01

3.0 Session 3: Off-site survey designs (effort and catch)

Chaired by Eva Lai, Research Scientist, Department of Primary Industries and Regional Development, Western Australia

Off-site survey designs are used to estimate fishing effort and/or catch and attitudinal information from fishers self-reporting their data post fishing trip. Off-site designs typically involve survey staff contacting fishers via mail, telephone, or reporting data through angler diaries/logbooks or catch cards (Jones & Pollock, 2013). They also have the advantage of covering large temporal and spatial scopes compared to on-site survey designs (Pollock *et al*., 1994). However, as data is self-reported, it is more difficult to verify catches reported by fishers in off-site surveys.

The recreational fishing workshop held in 2010 identified several elements for an integrated statewide recreational fishing survey in Western Australia, which has been conducted biennially since 2011/12 (Ryan *et al*., 2013; 2015; 2017; 2019) One component of this survey was a 12-month phone survey to provide harvest, catch and effort for important species, using the RBFL as a sampling frame (Wise & Fletcher, 2013).

The focus of this session was to discuss off-site survey designs with particular focus on catch and effort estimates of recreational fishing. Dr Bruce Hartill opened the session with a keynote presentation on the relevance of NZ fishing surveys to the Western Australian paradigm, providing insights into the similarities and differences between the two jurisdictions. The specific aims of this session were to:

- identify where and how off-site survey designs (to estimate effort and catch) are conducted in other jurisdictions in Australia and internationally;
- identify whether off-site survey designs applied in WA are consistent with those applied elsewhere;
- identify strengths and limitations for the current statewide off-site survey designs used in WA;
- determine whether off-site survey designs are still appropriate for estimating effort and catch at statewide and bioregion scales in WA.

Presentations within this session focussed on the current challenges faced by each jurisdiction and comparing approaches to the statewide survey in Western Australia. Increasing issues with under-coverage and declining response rates were common to all representatives, especially with the changing demographic and social landscape. Solutions to increase response rates included trialling different methods of response via email, online or SMS text messaging, as well as the importance of ongoing engagement to improve the accuracy of information.

The group discussion revealed a strong consensus that a national register of recreational fishers would greatly improve the ability to conduct off-site surveys, and that there is an immediate need to collectively voice this opinion at a federal level in Australia. The benefits of a national register will need to be clearly outlined to other government and stakeholder groups as their support is essential.

3.1 Keynote presentation: Insights from recent recreational fishery surveys in New Zealand and their relevance to Western Australia survey methods

Bruce Hartill (New Zealand: NIWA)

Fishing is one of New Zealand's most popular recreational activities and there are several similarities between recreational fishing survey methods in New Zealand and Western Australia. Every five to six years, three surveys are conducted to estimate recreational harvest, which are: an offsite national panel survey, a national mean weight creel survey and the regional aerial-access survey. To provide annual relative indices, camera/creel monitoring and rock lobster monitoring surveys are also conducted alongside an ongoing gamefish tagging program and a charter boat reporting regime. An additional kahawai catch-at-age creel survey is also conducted over two consecutive years every five years, to inform an age-based stock assessment for this species, which is New Zealand's second most important recreational species (after snapper).

Comparisons of data and estimates provided by concurrent onsite and offsite surveys provide insights into the relative strengths and limitations of each survey approach, and potential sources of survey bias. For example, trends at indicator sites may not represent the wider fishery. Cameras have been used to monitor trends recreational boating effort at high traffic boat ramps since 2005, but there has been a growing emphasis towards ongoing creel survey monitoring in recent years. Recent analyses suggest that changes in catch rates may be more influential than changes in levels of fishing effort. Creel survey interview data can be used to track changes in both catch rates and effort, and there has therefore been a reallocation of resources away from camera monitoring, with its high associated maintenance and image interpretation costs, towards creel survey monitoring at a greater number of sites.

3.2 Implementing statewide surveys of recreational fishing in Western Australia

Vicki Graham, Karina Ryan (WA: ECU)

A formal Research Agreement between Edith Cowan University (ECU) and DPIRD was established in 2010 to support statewide surveys of recreational fishing. DPIRD provide the background knowledge, co-supervise students, undertake analyses of catch and effort data and provide expert feedback. ECU provides recruitment, progression management and supervision of postgraduate students, and research expertise in survey design and reporting. The Social Research Centre (SRC) provides experience in survey implementation, with regular reports to DPIRD on call outcomes and agreed data extractions. ECU SRC has been in operation for over 10 years and is highly regarded by clients and peers for high-quality data collection. The strategic policy is to 'create positive outcomes in our communities through mutually beneficial engagement'. To address this policy, ECU strives to conduct surveys that benefit the community; advocate for the importance of ethics approval; work with clients to ensure that Ethics approval is achieved; and have access to all University resources, with the certainty of organisational sustainability necessary for long-term projects.

3.3 Estimating effort and catch from statewide surveys at state and bioregional scales

Karina Ryan, Norm Hall, Eva Lai, Claire Smallwood, Alissa Tate, Stephen Taylor, Brent Wise (WA: DPIRD)

Recreational fisheries data are required for government reporting, sustainability, management and social amenity; thus, regular surveys are required to provide estimates with known precision that are comparable with other sectors. Recreational fishing is a popular activity in Western Australia, providing important social and economic benefits to the State's population, 80% of which is located in, or close to the Perth metropolitan region. Obtaining suitable recreational data in Western Australia is challenging because of the State's large coastline (20,781 km) and ongoing regional development, which is changing the distribution and intensity of recreational fishing activity. The aim of the statewide survey is to estimate annual effort and catch from boat-based recreational fishing at statewide and bioregional levels, by numbers and weight. Since the previous recreational workshop in 2010, there have been four statewide recreational fishing surveys conducted in WA; 2011/12, 2013/14, 2015/16 and 2017/18, which utilise the Recreational Boat Fishing Licence (RBFL) database, providing a suitable sampling frame for a comprehensive statewide survey (both spatially and temporally). The statewide surveys comprise three components; i) off-site Phone Surveys using the RBFL sampling frame; ii) on-site Boat Ramp Surveys to provide biological information; iii) a Remote Camera Survey to monitor 24/7 launches and retrievals at key boat ramps. The percentage catch and effort from boat-based recreational fishers is consistently higher in the metro zone of the west coast bioregion, but sampling concurrently in other bioregions provides comparable reporting across multiple aquatic resources. The data collected through the statewide survey are used to inform stock assessments, resource allocation between fishing sectors, and the development, implementation and review of management plans. Effective management of fish resources requires accurate estimates of the catch taken by all sectors; therefore, a high priority has been placed on the collection of data for key recreational fisheries in Western Australia.

3.4 Disaggregating statewide surveys to estimate effort and catch at small spatial scales

Claire Smallwood, Karina Ryan (WA: DPIRD)

Many fisheries resources are managed and monitored at spatial scales defined by stock boundaries, which may vary in size from large, bioregional areas (i.e. territorial waters) to small, localised areas (i.e. estuaries). Understanding the total catch and proportion taken by all sectors within these areas is required for resource allocation and stock assessment. Commercial fisheries generally complete mandatory catch and effort reporting which provides a census of fishing activity, whereas recreational catch data are predominantly based on survey data which are collected periodically, have uncertainty and may not be designed to produce data at the same scales as commercial management units. Four statewide Phone Diary Surveys of recreational fishing have been completed since 2011/12 which provide a mechanism for exploring whether broad-scale survey data can be disaggregated to inform small scale fisheries management. The Peel-Harvey Estuary blue swimmer crab fishery and the multi-species recreational fishery within the Abrolhos Islands Fish Habitat Protection Area were used as case studies. Acceptable sample sizes

(>30 diarists) and levels of uncertainty (<40 % RSE) were achieved for estimates of fishing effort and total catch for both fisheries in some survey years, using several analyses. The success of these approaches will vary between areas of interest based on location (i.e. nearshore/offshore, adjacent to large population centres), the level of fishing activity occurring and the number of survey samples obtained.

3.5 Approach to 2019-2020 QLD Statewide Recreational Fishing Survey

Eugene Siow, Sebastian Mission (VIC: The Social Research Centre)

Understanding the catch, effort and participation rate of recreational fishers is an important part of sustainably managing Queensland's fisheries. The statewide recreational fishing survey, conducted by the Social Research Centre (SRC), is part of Fisheries Queensland's monitoring program collecting recreational fishing data. The SRC departed from the methodology employed in earlier surveys, mainly in relation to the inclusion of mobile frames to expand coverage of the QLD population in the initial contact phase, and the inclusion of self-complete mobile and PC collection of fishing diary activity from fishers during the diary phase.

The justification for the inclusion of mobile frames in the population frame was briefly discussed. With respect to the diary phase, a number of considerations in designing an online diary were presented including examples of the look and feel of the diary. Comparisons between online and telephone diarists were made, including suggestions that online diarists generally reported their fishing in a more timeline manner.

The revised weighting methodology employed to produce estimates was also presented.

4.0 Session 4: On-site survey designs (effort and catch)

Chaired by Alissa Tate, Research Scientist, Department of Primary Industries and Regional Development, Western Australia

On-site surveys are often used to estimate fishing effort and/or catch. They involve survey staff collecting data while the fishers are in the process of fishing, or immediately afterwards as they return from the fishing trip (Pollock *et al.*, 1994). Examples include access, roving, and aerial surveys (Jones & Pollock, 2013). While they generally have a narrower spatial and temporal scope than off-site surveys, on-site surveys have the advantages of taking place during or immediately after the fishing event has occurred, where trained survey staff can verify the catch. This minimises the biases that can be associated with self-reported data, such as recall bias, prestige bias, misidentification of species and measurement errors (Pollock *et al.*, 1994).

This was a brief session, focussed on on-site surveys for effort and catch in Western Australia. Several highly customised studies were presented to outline how recreational surveys differ according to varying spatial and temporal scopes.

The aims were to:

- determine where and how on-site surveys, designed to estimate effort and catch, are conducted in jurisdictions in Australia and internationally;
- determine whether on-site survey designs in WA are consistent with those applied elsewhere;
- assess the strengths and limitations for on-site survey designs within WA;
- evaluate whether on-site survey designs are still appropriate for estimating effort and catch for small-scale fisheries in WA.

Identifying the gold standard for each survey design is key, but often difficult to do. In many cases, data are often being applied to management questions that the survey was not designed to answer, which is neither feasible nor statistically-robust. Considerations include developing robust survey designs before the survey commences, honouring the primary sample unit (PSU) and stratification when carrying out analyses, aggregation or disaggregation data where required, the importance of corroborating and validating derived estimates and the uncertainty associated with them, and applying model-based inference rather than design-based inference.

Defining the objectives at both the spatial and temporal scope, as well as determining the level of precision, were identified as important priorities in survey design. Simulation studies will assist in statistically determining the required sample size, and associated costs, to detect significant shifts in the coefficients of variation. The ability to implement these studies, however, will ultimately depend upon the value of the fishery and the overall program objectives. Ultimately, the consensus was that there is a need to routinely fund on-site surveys for data collection at smaller spatial scales.

4.1 Corroborating effort and catch data from an integrated survey of boat-based recreational fishing in the Perth metropolitan area

Eva Lai, Karina Ryan, Ute Mueller, Glenn Hyndes (WA: ECU, DPIRD)

Probability-based survey methods are often used to estimate effort and catch for recreational fisheries which have no mandatory reporting scheme. Survey designs are usually subject to management objectives, financial constraints and logistical practicalities of conducting the survey. Inferences drawn from survey data and used in management decisions need to be reliable and accepted by stakeholders. It is desirable, but very rare, to have multiple surveys implemented at the same time which can be used for validating results provided by different survey methods. In Western Australia, an integrated survey implemented in 2011/12 has provided a unique opportunity for corroborating estimates of catch and effort for a boat-based recreational fishery, including an off-site phone-diary survey cover a large coastline (20,781 km); a bus-route access point survey at six key public boat ramps in the Perth metropolitan area; and remote camera monitoring to provide a census of effort at those key boat ramps over a 12-month period. Corroborating estimates from an off-site survey used for routine monitoring of a boat-based recreational fishery with an on-site survey can improve confidence in estimates of catch and effort, as well as subsequent sustainability and management decisions for the recreational sector. It is useful to assess biases incurred in surveys for developing cost-effective recreational fishery survey methods for long-term use.

4.2 Integrated surveys of boat-based recreational fishing in inner Shark Bay

Stephen Taylor, Claire Smallwood, Cameron Desfosses, Karina Ryan, Stuart Blight, Gary Jackson (WA: DPIRD)

Monitoring the temporal and spatial variability in recreational fishing provides necessary information for assessing resource sustainability, monitoring resource allocation and informing fisheries management. This is particularly important in inner Shark Bay because recreational fishing occurs in a World Heritage Area and Marine Park. The majority of boat-based recreational fishers in inner Shark Bay target Pink Snapper (*Chrysophrys auratus*), and three genetically distinct stocks of this species occur in the Denham Sound, Eastern Gulf and Freycinet Estuary Management Zones. These stocks are particularly vulnerable to exploitation because Pink Snapper aggregate in predictable locations to spawn each winter when recreational fishing effort is typically greatest. The primary objectives of this study were to generate annual estimates of the recreational catch (both kept and released) by boat-based fishers at the three boats ramps in inner Shark Bay (Denham, Monkey Mia and Nanga), and to provide annual estimates of the recreational catch of Pink Snapper by boat-based recreational fishers in Freycinet Estuary. The boat-based fishery was assessed using the traditional access point method which provided estimates of annual effort and recreational catch for the three boat ramps. A supplemented access point method was used which involved the installation of remotely-operated cameras at the three ramps to provide information on powerboat retrievals. The boat ramp surveys enabled the number of powerboat retrievals to be adjusted for non-fishing activity and provide harvest rate and catch rate data. Additional aerial surveys were conducted in the Freycinet Estuary, which, when combined with catch and effort information from the boat ramp surveys, provided an estimate of Pink Snapper catch in

this region. To ensure that fishing activities in Shark Bay continue to be managed at sustainable levels, ongoing monitoring of recreational catches are required. This will provide more accurate information on the recreational harvest to assist in assessing whether or not contemporary harvest levels in the Freycinet Estuary Management Zone are exceeding the TARC. Where possible it is recommended that future onsite surveys in Shark Bay are aligned to coincide with the statewide surveys of boat-based fishing to assist in the corroboration of survey results.

4.3 Quantifying the footprint of recreational scoop-net fishing at Peel-Harvey Estuary

Cameron Desfosses, Stuart Blight, Stephen Taylor (WA: DPIRD)

Obtaining fine-scale data on the spatio-temporal distribution of recreational fisheries can be difficult, particularly in the absence of a user-specific sampling frame or where there is substantial nocturnal fishing activity.

The RAMSAR-listed Peel-Harvey Estuary supports the largest recreational fishery for blue-swimmer crab (*Portunus armatus*) in Western Australia. The shore-based recreational fishery is unlicensed and a large proportion of the fishing activity occurs at twilight or night. As a result of the world-first Marine Stewardship Council (MSC) accreditation of the recreational fishery in 2016, evidence was collected to determine the spatio-temporal distribution of shore-based recreational fishing within the estuary.

A modified roving on-site survey was used to geo-reference wading activity for an environmental risk assessment, as well as providing data to generate an annual estimate of fishing effort. Over 60 days in a 12-month period, a laser range-finder was combined with a custom-designed mobile App to geo-reference wading activity based on the distance and bearing of people from fixed survey locations around the estuary, and a mobile thermographic camera was also used to help observe the nocturnal activity. Kernel density estimation was used to identify areas of high scooping activity within each stratum (season [high, medium, low, closed]; day type [weekday, weekend/public holiday]), while the progressive count method was used to estimate annual scoop-net fishing effort.

For scoop-net fishing, high activity sites were identified; however, these varied substantially by season, day type and time of day. The annual estimate for the scoop-net fishing effort was 100,815 fisher hours (se = 12,521).

The results of the kernel density estimates have helped to locate new fixed-location thermographic cameras to provide ongoing low-level monitoring of high-use sites within the estuary, which will be integral to providing a proxy for fishing effort in the mid- to long-term. These data will be combined with data from habitat and bird surveys to develop an environmental risk assessment to improve understanding of the interaction between shore-based recreational fishers, threatened waterbirds, and their habitat.

4.4 From sustainability to safety: a new-age recreational abalone fishery

Lachlan Strain, Jamin Brown, Anthony Hart (WA: DPIRD)

The Perth Metropolitan Roe's abalone (*Haliotis roei*) recreational fishery is a unique fishery as the highly prized abalone is located on the doorstep of a major metropolitan city. The ease of access and high density of the nearshore sessile invertebrate makes it

susceptible to overfishing and has resulted in this fishery being one of the most restrictive recreational fisheries in the world. The recreational fishery is monitored through an access point survey design that uses total effort coverage, CPUE and weight data to calculate total season catch. The sustainability of this fishery was further challenged by the 2011 marine heatwave and subsequent years of above average sea surface temperatures, which resulted in the decline of large animals and spawning biomass, growth stunting and recruitment impairment. As a consequence, management was tightened and the fishery is now open for only 4 hours per year! Unfortunately, the restrictive season has resulted in 5 fatalities since 2012 and given the season length, the fishery has a mortality rate of 1 death per 6.6 fishing hours, making it the most dangerous recreational fishery in Australia. The politically sensitive nature of public safety while recreationally fishing prompted the Government to initiate a Safety Review, which facilitated a restructure of the fishing season. The relationship between fisher safety, weather conditions and catch was used to alter season timing and facilitate the opening or closing of a fishing session based on predicted weather conditions. An in-season catch prediction model was developed to provide real time recreational fishing estimates to manage the season on a session (1 hour) basis. The prediction model utilises a subset of the data collected through the access point survey (fisher effort, weather parameters and individual animal weight) to predict each fishing session's catch, allowing the season length to be adjusted in order to maintain the catch with the allocated TARC for that season. This presentation chronicles these challenges, the management responses over time and how the recreational fishing survey has adapted to facilitate the changes.

5.0 Session 5: On-site survey designs (catch rates and average weight)

Chaired by Dr Stephen Taylor, Senior Research Scientist, Department of Primary Industries and Regional Development, Western Australia

On-site surveys can also be used to collect biological data and interview fishers for attitudinal surveys. The collection of biological information, such as length, weight or age data, is important to convert estimates of catch by numbers to catch by weight for stock assessments and to monitor resource allocations (Jones & Pollock, 2013; Ryan *et al*., 2016). Catch rates (i.e. catch per unit effort: CPUE) are important to provide a time series of data to estimate biomass, and inform management decisions and resource allocations (e.g. Tate *et al.,* 2019).

This session focussed on on-site survey designs for catch rates and average weight across several Australian states and was opened with a keynote presentation from Dr Aldo Steffe (Director, Fishing Survey Solutions) on the importance of survey design and analysing data at the appropriate level. The aims were to:

- determine where and how on-site survey designs, designed to estimate effort and catch, are conducted in jurisdictions in Australia and internationally;
- identify the considerations for survey designs that aim to estimate catch rate and average weight;
- identify the considerations for estimation of catch rates and average weight;
- evaluate the trade-offs in resources, quality and quantity that allow appropriate spatial-temporal coverage and frequency of surveys.

From a management perspective, estimating catch allocations or evaluating stock assessments require animal/fish weights for biomass estimations, and so the conversion of numbers to weights is essential. It was highlighted that in the next one to two decades there will likely be an increase in recreational fisheries across all jurisdictions, and it is therefore essential that the experimental design to collect recreational catch rates is robust to provide estimates that may be used in future stock assessments. It was acknowledged that on-site creel surveys and angler diary programs have been successful in recording weight estimates, yet there are still issues regarding estimates of release and post-release mortality. Post-release mortality is not currently addressed in Australia, and with reductions in possession limits, high-grading is becoming more prevalent leading to an increased number of releases, and thus unquantified mortality.

5.1 Keynote presentation: Sample units, data elements and design-based inference in surveys

Aldo Steffe (NSW: Fishing Survey Solutions)

Sampling theory provides a logical framework and guidance for resolving issues associated with survey design, sampling, and analysis. Common survey-related issues include determining the best method to provide unbiased estimators & correctly assign measures of precision, which may be more problematic given multiple (conflicting) objectives of a survey. Design-based inferences are derived from the probability

distribution of an estimated variable that is induced by the sample weights and survey design. Population values that are being estimated are often regarded as fixed and model, or distribution free.

Prior to commencing any sampling, the survey design must be articulated (i.e. stratification, samples size etc.) and a random process is used to select the sample which is assigned a known probability of selection i.e. probability-based sampling. The sample units form the basis for multi-stage sampling and should be used to derive point estimates and measures of precision for important variables, such as means, stratum totals etc. A sample unit is thus a frame of non-overlapping units with a known selection probability and statistical independence. Data elements, however, are metrics that are nested within sample units and should not be used to derive point estimates and measures of precision for important variables. Data elements are often highly correlated and should be treated as frequency distributions nested within a primary sampling unit (PSU). Failure to use the structure of a probability-based survey design causes pseudoreplication issues which may occur in the estimation of effort and catch, spatial analyses and visualisations. It may also contribute to underestimation of variances, and true sample sizes obtained through power analyses, incorrect weighting of data elements, and issues with length, weight and catch rate frequency distributions.

It is therefore important to use survey weights and survey design in all analyses, summaries and visualisations, and there is a need to correctly identify not only the primary sampling unit but also the data elements. The primary sampling unit provides point estimates for variables (estimators) and frequency distributions of data elements nested within primary sampling units. When more than one option is available there is a need to consider the survey objectives, logistics, cost and respondent burden.

5.2 Time series of catch rates for shore-based fishing in the Perth Metropolitan area

Alissa Tate (WA: DPIRD)

Shore-based recreational fishing in the Perth metropolitan area of Western Australia is a popular lifestyle activity (Smallwood *et al.*, 2011). An estimated 619,000 Western Australian residents participate in recreational fishing (DPIRD, 2019), and approximately 50 % of the recreational harvest is taken from the shore (Henry & Lyle, 2003). This fishery extends along the coastline adjacent to the majority of the state population, and routine assessment of total harvest is difficult to obtain due to the lack of a licence frame for shore-based fishing, large geographical scope and often remote fishing locations (Fletcher & Santoro 2014). However, based on previous research (Henry & Lyle, 2003), the recreational harvest is known to exceed that of the commercial harvest for some species. Estimates of shore-based recreational harvest rates for these species can be compared over time and included in management strategies and monitoring plans, to facilitate sustainable allocation of the stocks between recreational and commercial stakeholders.

This study evaluates potential indices of harvest rate for nearshore teleost species by applying GLMs to data from four shore-based recreational fishing surveys conducted between 2010 and 2016. The study has focussed on key target species, particularly the Australian herring (*Arripis georgianus*) and School whiting (*Sillago* spp.). The main

objectives were to: identify the variables that contribute to temporal changes in harvest rates; identify the most appropriate error distribution model(s) for estimating and standardising harvest rates; and compare raw and standardised harvest rates.

Five candidate error distributions (lognormal, Gamma, Zero-Altered Gamma, Tweedie and delta-lognormal) and seven independent variables (year, month, target species, fishing platform, fishers' avidity, time of day and day type) were examined for each species. Zero-Altered Gamma and Tweedie models performed best overall, although model performance and explanatory variables varied between species. Standardised harvest rates for Australian herring (*Arripis georgianus)* declined from 1.88 ± 0.17 (mean ± SE) fish per fishing party per day in 2010 to 0.86 ± 0.07 in 2016, while harvest rates for School whiting (*Sillago* spp) increased from 0.44 ± 0.21 in 2010 to 0.94 ± 0.34 in 2016. The standardised harvest rates for both species generally showed less fluctuation among years and consistently had smaller errors than the raw harvest rates. Overall, the results suggest that the choice of error distribution, as well as explanatory variables, is species-dependent when assessing shore-based fisheries. The approach used could easily be adapted to other recreational fisheries to establish reliable species-specific harvest rates that can detect variability against thresholds set in harvest strategies.

5.3 The challenges of improving the analysis of recreational time series catch rate data for stock status assessments

Justin Bell, Simon Conron, Khageswor Giri, Karina Ryan (Vic: VFA)

Most commercial fisheries have been bought out in Victoria but the remainder are monitored and managed using standard approaches. As a result, many fisheries in Victoria have a larger proportion of the catch taken by recreational fishers than commercial. Most monitoring of the recreational sector is conducted via creel surveys, which are targeted at obtaining the most data possible for the lowest cost as opposed to measuring the total catch. Sampling is focussed around weekends, public holidays, the warmer summer months, or when the most targeting of key species occurs, meaning it is a biased sampling regime. Catch rates are standardised in the same way as commercial data, to account for other external factors that are unrelated to biomass. Model selection takes into account zero-inflation and a range of factors, including angler avidity, fishing location, season, target species, and maintains year and environmental variables as fixed effects. A Generalised Linear Mixed Model (GLMM) is implemented in R using the 'glmmTMB' package, assuming a negative binomial distribution which accounts for zero-inflation, but requires count data as opposed to CPUE. An offset of angler hours is incorporated to account for this.

The western snapper stock is the most important fishery in the state and recreational catches far outweigh the commercial component. There is no closed season and spawning aggregations are extensively fished. Catch rates obtained from creel surveys in October-December are used as a proxy for adult biomass. Catch rates are standardised taking into account area, avidity and the interaction between year and area. Area explained 25 % of the variation in snapper catch rates, whereas avidity was a less important factor and explained 10 % of the variance. Recreational catch rates of western snapper provide a validation tool for comparison against 0-age abundance indices

derived from fishery-independent surveys. These can be used as a forecasting tool and provide an early warning system in the case of poor recruitment.

Standardisation can minimise filtering thereby maximising the amount of data, and confidence in the results. Following a standardisation process, targeted creel surveys can provide a reliable proxy for biomass. Targeted creel survey results can be used as a benchmark for assessment purposes and can be combined with recruitment information to forecast future catch rates to make timely management decisions.

5.4 An update on how catch rates are being used to monitor effects of Net Free Zones and other potential uses

Daniella Teixeira (Qld: DAF)

Three net free zones (NFZ) were implemented in 2015 to improve recreational fishing in Cairns, Mackay and Rockhampton. The main objectives of these NFZs were to provide more fish, bigger fish, and greater angler satisfaction. Boat ramp surveys began in November 2015 at each NFZ with additional reference sites at Hinchinbrook, Townsville and Hervey Bay. These surveys record fish length, number caught, kept and released, distance travelled and the number of trailers at each ramp. Monitoring data collected through these boat ramp surveys may provide information on catch and abundance. If catch rates are a true reflection of abundance, then higher catch rates would be expected in southern Queensland and also during the winter at all locations. Since the NFZ began, there has been an increase in effort (i.e. number of trailers at the boat ramps) and in Rockhampton catch rates are higher than the reference site. In contrast, catch rates at Cairns and Mackay are similar to, or lower than those at the reference sites, suggesting that other factors may be impacting catchability in these areas. Boat ramp surveys may provide a tool to disentangle causes behind these observed catch rates and determine whether they are a representative indicator of fish abundance.

5.5 Benefits of a restricted spatial and temporal survey design for determining average weight of recreational catches

Claire Smallwood (WA: DPIRD)

Surveys of recreational fishing are conducted in many jurisdictions to provide catch estimates, usually measured as the number of individual fish kept. Converting catch estimates (numbers of fish) to weight is necessary for comparability with catch data from other sectors to support resource allocation and other management strategies. Weight data are rarely obtained during these surveys to minimise respondent burden and accommodate the logistical and resource constraints on survey designs. On-site Boat Ramp Surveys of recreational fishers for this purpose were implemented across four marine bioregions in Western Australia in 2011/12 using a randomised design (12-months) and in 2013/14 using a randomised design restricted to peak periods of fishing activity (4-months). Both surveys achieved high response rates (> 97 %) with 6,018 measurements in 2011/12 and 10,795 in 2013/14. Measurements were collected from 280 species (or family groupings), of which > 30 % had more than 10 samples. Average weights were calculated for 30 key species aligned with fisheries management priorities, of which 75 % of nearshore and 30 % of demersal species had significant differences between fishing seasons and survey periods. Implementing recreational fishing surveys

with the specific aim of obtaining data on average weight for this sector is rare. Average weights calculated from both designs can be used to provide estimates of catch (by weight) for comparison with other sectors, thereby reducing reliance on secondary data sources. However, the restricted survey design was more cost-effective and obtained higher samples from a broader suite of species. This design is recommended for the future collection of weight data, especially in locations that are remote from major population centres and have highly seasonal peaks in fishing activity.

5.6 Estimating average weight of western rock lobster from boat ramp surveys with a restricted spatio-temporal sampling frame

Cameron Desfosses (WA: DPIRD)

Recognition of the importance of recreational fisheries to inform fisheries management requires an appropriate survey design to collect data that is representative of the catch. This study describes a probability-based, access-point survey to collect biological data from catches of western rock lobster (*Panulirus cygnus*) retained by boat-based recreational fishers in Western Australia involving substantial spatiotemporal differences across the distribution of the species and recreational fishery. Carapace length and body weight were recorded for retained lobsters at fifteen latitudinally-separated boat ramps across four fishing seasons (2015/16-2018/19). The spatial and temporal scope of the survey differed between years to determine a long-term cost-effective design to evaluate the mean body weight of retained lobsters. Current funding provides for six (3 weekday/weekend) to eight (4 weekday/weekend) shifts per site per month. Confidence intervals (95 %) for bootstrapped mean body weight did not overlap an historic mean weight of 500 g that has historically been used to estimate total recreational catch, indicating that the mean weight of recreationally-caught *P. cygnus* is greater than historic catches. There was also no difference in the 95 % confidence intervals for mean weight between months, though there were large differences between the northern, southern and metropolitan areas within the West Coast Bioregion. The results, in conjunction with data obtained from statewide integrated surveys, provided strong evidence for future monitoring of the mean body weight of *P. cygnus* retained by boat-based recreational fishers in WA coinciding with sites and months with greatest fishing activity. This facilitated a cost-effective annual survey, with a recommendation to conduct occasional, comprehensive, probability-based surveys to detect longer-term biological changes. This approach could also be applied in other low-participation recreational fisheries.

5.7 A comparison of average length & weight from boat ramp surveys, charter logbooks & SUYS

Brett Crisafulli (WA: DPIRD, ECU)

Quantifying recreational fishing harvest by weight is vital for stock assessments and fisheries management. However, estimating recreational harvest is complex. It is impractical to obtain weights of all fish caught in recreational fisheries. Therefore, harvest is often calculated from estimated numbers landed multiplied by an estimate of average weight. The average weight of a species in the catch may be derived from measured weights, as well as imputed weights from measured lengths using established length-weight relationships. Here, we evaluated the impact of uncertainty in lengths and weights from three independent data sources to determine average weights and estimated

recreational harvest of four demersal species in Western Australia. Data sources included (i) measured lengths and weights from on-site surveys of boat-based fishers, (ii) self-reported lengths in logbooks of charter-boat fishers and (iii) lengths from fishery-dependent biological samples donated by recreational fishers. For the latter two data sources, weights were imputed from length measurements. Generalised linear models were used to obtain standardised average weight estimates and standard errors across data sources, years and spatial zones where possible to capture known variability among these strata. For each species, 95% confidence intervals for harvest were derived from standardised average weights (from aforementioned surveys) and estimated catch in numbers (from off-site surveys). Statistical modelling resulted in harvest estimates that generally had greater precision than raw statistical means used in current surveys. The three data sources contain uncertainty and biases, such as measurement uncertainty from self-reporting, representativeness of lengths and weights, and small sample sizes. Increased application of representative length weight relationships and data sources to impute and model standardised weight can increase confidence in recreational harvest estimates and reduce sampling requirements.

6.0 Session 6: Innovative approaches for monitoring recreational fisheries

Chaired by Karina Ryan, Senior Research Scientist, Department of Primary Industries and Regional Development, Western Australia

There have been countless technological advances in the decade since the last recreational fishing workshop in Western Australia. However, the implementation of many of these technologies in recreational fishing surveys has lagged due to the lack of research into the impacts they may have on the precision and accuracy of the recreational fishing estimates derived as a result of incorporating them into the survey design.

A precise estimate has a small standard error, which is improved by increasing the sample size included in the survey, while an accurate estimate has a small mean squared error as a result of limited bias and a small standard error (Pollock *et al*., 1994). A simple, yet intuitive, representation of these concepts is illustrated in Figure 3.1 (p. 25) of Pollock *et al*., (1994). Biased or imprecise estimates of recreational catch and/or effort are an issue when expanding survey estimates up to the population; therefore, understanding the biases associated with incorporating new technologies into survey designs is essential for obtaining representative estimates of catch and effort.

The aims of this session were to:

- identify where and how innovative approaches are being used for recreational fishing surveys in Australia and internationally;
- assess the best way to adopt innovative approaches for recreational fishing surveys;
- determine how compatibility between proven/traditional approaches and new methods can be supported; and
- ascertain the trade-offs for resources, quality and quantity, in order to reduce bias while providing representative data.

Presentations in this session provided examples of innovative techniques currently used in Western Australian recreational fishing research and compared the estimates derived from those techniques to traditional methods for recreational fishing surveys. Discussions revealed a diverse array of views on the likely use of apps, citizen science, in-built sensors and machine learning in future recreational fishing surveys across jurisdictions.

Common themes that arose throughout the session included: managing expectations among researchers, managers and stakeholders regarding the use of technology and innovative survey methods into the future; defining effective sampling frames with untried methods; incorporating the expertise of external groups to maximise the utility of new technologies; and concerns about the ability to maintain the quality of the data and statistical rigour from self-reported or citizen science datasets. It was noted that apps, social media and other platforms that could be used to collect recreational fishing data could also be used to engage with fishers on the importance of their survey data and address issues in relevant fisheries, helping to negate some of the misinformation being spread through various external channels. Once again, the implementation of a universal

fishing registry/licence was identified as a necessity to maximise the success of any survey design that required compulsory reporting from recreational fishers.

6.1 Insights from monitoring recreational fisheries using remote cameras

Stuart Blight (WA: DPIRD)

Western Australia has an expansive coastline, and recreational fishing takes place across the length and breadth of the state. Obtaining reliable, accurate and precise estimates of fishing effort is prohibitive for remote areas, and so remote cameras have been used to complement traditional on- and off-site surveys in Western Australia since 2005. In addition, they have been used to support Marine Stewardship Council accreditation of fisheries, plan compliance patrols in remote areas, provide usage statistics for other state departments' planning purposes, and provide evidence to support prosecution in criminal cases. While data from these cameras have been reliably incorporated into successive statewide surveys over the last decade, there are several considerations to take into account, and improvements that could be made, to make the data obtained from remote cameras more cost-effective. This presentation outlines the evolution of the department's remote camera network over the last 15 years, explains some of the considerations and limitations in the network, and highlights innovations that could be made to make the data collection more cost-effective and relevant to changing research objectives.

6.2 When less is more: cost-precision trade-off for remote camera surveys

Ebenezer Afrifa-Yamoah (WA: ECU)

Digital camera monitoring is increasingly being used to monitor boating activity for the subsequent estimation of recreational fishing effort. In a posteriori analysis, we investigated the trade-offs between the cost of manually interpreting camera data and the accuracy of estimates obtained at various sampling proportions, illustrated using camera data from a 'moderate use' boat ramp in the Perth metropolitan region. With days of the year as our primary sampling unit, the simple random sampling, systematic sampling and stratified sampling with proportional and optimal allocation designs were evaluated to assess their trade-offs in terms of bias, accuracy, precision, coverage and cost in estimating the annual total number of powerboat retrievals in 10,000 jack-knife resampling draws. The 95 % predicted margin of error of the total number of powerboat retrievals declined asymptotically after 50 % sampled proportion. The preliminary results suggest that interpreting 50 % of the days of camera footage in a year could be deemed as an adequate level of sampling effort to obtain unbiased and accurate estimates. The outcomes of this study will assist survey practitioners in developing sampling strategies for digital camera monitoring.

6.3 Spatial and temporal patterns in vessel characteristics from a large scale boat-based recreational fishery

Shannon Burchert (WA: ECU)

Integrating characteristics of the recreational fishing fleet – in terms of vessel numbers, size, propulsion type and technology – with the fishery itself is important for sustainable management. With the increase in fishing vessel efficiency and technological advancements, known as "technology creep", recreational fishers have a greater

opportunity to locate and catch their target species, essentially increasing their fishing power. As vessel requirements for recreational fishing activities vary depending on target species, environmental conditions, fisher knowledge and distance to fishing grounds, there is potential to integrate these into spatio-temporal analyses to help explain catch, effort and catch rate estimates. Hampered by the lack of understanding of spatial and temporal patterns in vessel characteristics, this presentation aimed to capture any variation in vessel characteristics across Western Australia using data from the 2011/12, 2013/14, 2015/16 and 2017/18 wash-up surveys. These data improve our understanding of fleet characteristics in WA and also inform management decisions with regards to infrastructure planning and development. There were few differences in vessel characteristics between survey years; however, more notable differences were present across regions in WA. These spatial differences may have an impact on the type of fishing and fishing behaviours observed across the state and should, therefore, be considered in further analysis.

6.4 Comparison of data collection methods – using new technologies to develop efficiencies in randomised, representative surveys of recreational fisheries in Western Australia

6.4.1 *Licence and White Pages® sampling frames*

Stephen Taylor (WA: DPIRD)

There are currently six species and fishery licence categories in WA which provide sampling frames for ongoing recreational fishing surveys. However, there is no licence type for shore-based recreational fishing which leaves a high proportion of the recreational fishing population under-represented and thus broad-scale estimates of shore-based fishing are limited. This study compared two concurrent cross-sectional telephone surveys conducted in 2016 and 2017 to assist in developing future statewide surveys which include both boat- and shore-based recreational fishing. The sampling frames used include the Recreational Boat Fishing Licence (RBFL), and the resident population of WA from the White Pages (WP). The aim of this study was to compare response rates from each survey, compare demographic and behavioural characteristics of the boat- and shore-based fishers, and compare the number of licence holders estimated from WP surveys with actual licence numbers. Response rates from the RBFL surveys were more than double those from the WP surveys, with 35 % of the WP surveys identifying a “telephone number disconnected” error. Once households were contacted in WP surveys, survey participation rates were high. Demographic characteristics were broadly consistent for boat-based fishers sampled from the WP and RBFL surveys, yet while significant differences were encountered between surveys due to large sample sizes and a high power to detect changes, in most instances there were very little differences in past and intended fishing activities. Overall however, there were several issues associated with WP sampling, including sample loss, non-contacts, and increased costs associated with achieving a target sample of intending fishers for subsequent longitudinal surveys. Dual frame surveys in WA would provide a viable means to estimate shore-based and boat-based catches, using the RBFL as the primary sampling frame and including a secondary sampling frame of either the WP, or an ‘enhanced directory’.

Comparison of offsite designs that use general or specific list-based sampling frames has broad applications.

6.4.2 *Comparison of phone and online data collection: Western Rock Lobster recreational fishery*

Claire Smallwood (WA: DPIRD)

The commercial and recreational fishery for Western Rock Lobster (*Panulirus cygnus*) is one of the highest value fisheries in Australia. Recreational fishers require a Rock Lobster licence to participate in this fishery, and there are currently ~50,000 issued annually. In 2009, this resource was the first to go through the Integrated Fisheries Management process with 95 % of the catch allocated to the commercial sector and 5 % to the recreational sector. Since the 1980s, the licence database has been used as the basis for ongoing monitoring of catches from the recreational sector to assist with sustainable management and catch allocation. Recent changes in management arrangements enabled the recreational rock lobster fishery to be open all year. The alignment of seasons between the commercial and recreational sectors has provided an opportunity to test new technologies for the collection of data. In 2018/19, concurrent phone and online recall surveys were implemented with the aim of providing annual and monthly estimates of fishing effort and catch (by numbers) statewide and by region while also allowing the efficacy of survey modes to be compared. Response rates were higher for the phone survey (98 %) than the online survey (25 %). However, the preliminary analysis found similarities in fisher profiles and behaviour did exist between survey modes. Further comparison and exploration of data obtained from each survey mode is required to decide on the sampling for future fishing seasons and is currently underway.

6.4.3 *Incorporating drones into recreational fishing surveys*

Cameron Desfosses (WA: DPIRD)

A key part of designing recreational fishing surveys involves the selection of the most suitable survey design and data collection tool to match the desired management objective and collect representative and accurate data. The rapid increase in the use of remotely piloted aircraft systems (RPAS), colloquially known as drones, has afforded researchers a potentially innovative tool for collecting recreational fishing data. This study trialled the use of multi-rotor RPAS as a data collection tool in the inner Shark Bay recreational fishery (Freycinet Estuary) and the Peel-Harvey Estuary blue swimmer crab fishery. The former fishery has a broad geographic scale in a remote location, while the latter fishery has a smaller geographic scale close to major metropolitan centres, but has a substantial nocturnal component. In each fishery, RPAS were used to assess the spatial extent of recreational fishing activity and were operated concurrently with conventional recreational fishing surveys, thereby enabling comparisons of the strengths and limitations between the methods. The use of these multi-rotor RPAS had benefits and limitations that were common to both fisheries. Benefits included: access to otherwise out-of-scope areas, high quality recorded footage, the ability to use waypoints to fly reproducible routes, and the potential to use the in-built GPS to geo-reference fishing activity. Limitations were primarily: the requirement to maintain a visual line of sight (VLOS), battery life, and weather-related constraints.

Based on the outcomes of the present study, RPAS is not currently a viable data collection tool that can be cost-effectively incorporated into DPIRD recreational fishing surveys that utilise probability-based survey designs. The use of smaller fixed-wing or hybrid RPAS with vertical take-off and landing capability would potentially be suitable for; i) recording fishing effort under some small-scale applications (e.g. counts of abalone/shore-based fishers at distinct beaches); or ii) under scenarios where probability-based designs are less of a priority. There would certainly be uses in other areas of fisheries research, monitoring and compliance, in addition to current applications in primary industries.

6.4.4 *Phone and App data collection*

Fabian Trinnie (WA: DPIRD)

The use of smartphone Apps as tools to collect recreational data has become increasingly popular, particularly amongst citizen science projects. However, the ease and appeal of using Apps has largely ignored the continued need to use probability-based sampling techniques to provide a representative sample of the target population and understand the potential biases associated with these data collection methods. The aim of the present study was to compare the fisher demographics and fishing behaviour between a concurrent cross-sectional phone-recall survey and a longitudinal smartphone App survey of respondents that were randomly selected from a database of freshwater angling licence holders. A screening survey of licence holders was undertaken to recruit respondents into the App survey. The study found that respondents that were eligible and subsequently invited into the App survey (i.e. likely to fish next season and owned a smartphone) were younger and more avid (days fished in the previous season) than ineligible respondents. All eligible fishers that accepted the invitation to participate in the App survey (n=1136) were sent a text message with a link to the App, with 64 respondents recording at least 1 fishing event during the 12-month trial period. In comparison to the phone-recall survey conducted post the 12-month season trailed by the App, App users were younger and more avid. The percentages of the kept and released catches for redfin perch and rainbow trout were similar between surveys. The highest percentage of the kept catch was for redfin, while the highest percentage of the released catch was for rainbow trout in both surveys. Differences occurred between surveys when species were encountered in low numbers, the App survey did not report any kept catch of silver cobbler or brown trout, but were reported in low numbers in the phone-recall survey. The App survey catch and effort could not be extrapolated to the population estimates with any confidence due to a low number of App users overall. This study demonstrates observable differences between a phone-recall survey and an App survey in fisher demographics and fishing behaviour, and the difficulties of obtaining and retaining App users under a probability-based sampling regime.

6.4.5 *Paper and iPad data collection*

Alissa Tate (WA: DPIRD)

On-site surveys involving face-to-face interviews are implemented around the world across a number of scientific disciplines. Incorporating new technologies into such surveys by using electronic devices is becoming more common and is widely viewed to be more cost-effective and accurate. However, comparisons between paper-based data capture (PDC) and electronic data capture (EDC) to quantify the accuracy and cost-

effectiveness of these methods are rarely completed. A roving creel survey of shore-based recreational fishers in Western Australia from February to June 2019 was conducted using PDC and EDC concurrently to provide a direct comparison between the two methods. Randomisation strategies were employed to minimise bias between the various survey staff using each technique. A total of 1,068 interviews with recreational fishers were undertaken during this time period and of these, less than 10 % had errors. Of these errors, 65 % occurred through paper-based data capture; 50 % through interviewer recording error and 15 % in the subsequent data entry process. The electronic data capture contributed 35 % of all errors, confirming our hypothesis that EDC has the capacity to reduce errors whilst minimising both the time and costs of a survey. Electronic data capture is often implemented into a survey design without a full evaluation of the implications. This study demonstrates the benefits and limitations of electronic data capture in on-site recreational fishing surveys, which can be implemented without compromising the survey design. Such findings can be widely applied beyond the field of recreational fishing surveys to any study which includes face-to-face interviews.

7.0 Session 7: Social and Economic

Chaired by Dr Claire Smallwood, Research Scientist, Department of Primary Industries and Regional Development, Western Australia

Social and economic considerations are increasingly becoming as important to manage in recreational fisheries as sustainability. However, while the economic contribution of recreational fishing has been quantified for many years across Australia and the world, the social dynamic is much harder to quantify.

The main difficulties in measuring social objectives across the whole recreational fishing community are i) they are poorly defined by groups representing recreational fishers; and ii) those motivations and priorities that are defined differ among individual fishers. For example, where one fisher may value spending time with family and friends, another fishes to get away for some time alone. Likewise, where one fisher will spend significant resources targeting a trophy fish, another is primarily fishing to catch an economical family meal. These contrasting priorities make it very difficult for fishery agencies to manage fisheries to all recreational fishers' social objectives.

Presentations for this session outlined the contribution of recreational fishers to the national and various state economies, as well as social objectives and drivers of recreational fishers. Dr John Henstridge opened the session with a keynote presentation on the benefits and limitations of using traditional sampling frames for various surveys, which are most often used to collect economic and social data from recreational fishers.

The aims of this session were to:

- identify the social and economic objectives that are used to inform policy for recreational fisheries in Australia and internationally;
- identify the strengths and limitations for the current concepts or metrics used for these objectives;
- determine how fit-for-purpose survey designs need to be to meet these objectives;
- ascertain the trade-offs for resources, quality and quantity, to allow appropriate spatial-temporal coverage and frequency of surveys.

In this session, participants discussed current approaches to collecting social and economic data and the strengths and limitations of the metrics used to measure these objectives. Currently, all jurisdictions examine satisfaction indicators which are time- and context-based. The contribution recreational fishers make to the Australian economy is significant, and thus there is a need to understand social objectives and drivers for recreational fishers, and incorporate these into policy decisions.

7.1 Keynote presentation: Surveys - fishing for data?

John Henstridge (WA: Data Analysis Australia)

Fisheries research uses survey methods for a number of purposes, including surveys of people who are or might be recreational fishers. Conducting such surveys is always a challenge from the sampling, questionnaire and analysis viewpoints. In recent years the sampling challenges have grown as traditional methods of sampling have become less effective and alternatives have been proposed. The recent failure of political polls in

Australia and elsewhere have highlighted that old methods do not necessarily continue to work.

7.2 Developing a national social and economic survey of recreational fishers: do we need to choose between being robust and cost-effective?

Andy Moore, Jacki Schirmer, Kate Stark (ACT: ABARES)

There is an ongoing need to conduct regular national recreational fishing surveys, which are statistically robust, trusted by stakeholders, repeatable, comparable and cost-effective. The last National Recreational and Indigenous Fishing Survey was conducted in 2000/01 (Henry & Lyle, 2003), encompassing 3.36 million fishers, 23.2 million fishing events and harvesting 163 million aquatic animals. The associated spend was approximately $1.8 billion. National surveys are costly ($6.8 million) and complex as there is a need for alignment between jurisdictions. Stakeholders want a national social, economic and wellbeing survey, which involves participation, social, motivational and wellbeing questions, 12-month expenditure, trip-based data (distance, expenditure etc.) and biosecurity. The main challenge is the value of a long-term trend vs a single intensive survey while addressing a drive to be innovative and test new approaches. There is currently no adequate sampling frame as very few accessible licence frames are available. For example, the White Pages are no longer a representative sample, and random digit dialling provides no geographic information, thus there is an increase in refusal rates. Future options include a national fishing licence, yet there appears to be little political will to implement, and has to be driven by both the recreational sector and scientists.

A National Social and Economic Survey of Recreational Fishing is currently underway and results are expected to be released post 2020. This survey is targeted at presenting the different social and economic benefits of recreational fishing as well as the direct and indirect contribution of recreational fishing to the national economy. To address recruitment biases associated with online surveys, this survey incorporates probability based mail out, open call, river sampling, panel sampling and probability based phone survey. To assist in addressing recall bias, a 12-month online diary survey which collects trip-based information, complements the online survey.

7.3 Economic dimensions of recreational fishing in Western Australia

Paul McLeod (WA: Economic Research Associates)

The primary component of economic value in recreational fisheries has historically been based on survey data of major categories of expenditure incurred by recreational fishers. This presentation details expenditure data collected via questions added to DPIRD's Electronic White Pages (EWP) survey. This economic-based survey was conducted in the latter part of 2016 using a comprehensive sampling frame from the EWP which covered shore-based and boat-based recreational fishers. Anyone in a WA household who could be contacted by any phone was interviewed, however, there may be some bias to the extent that some households cannot be contacted by either a landline phone or a mobile phone. Data were collected on household size, structure, and location; age & gender for each household member; fishing activity for each fisher; fishing platform &

bioregion. Data were also obtained on annual economic expenditure for the main fisher in each household, but unlike questions on fishing activity, expenditure questions were 12-month recall questions. Benefit transfer was employed to derive a separate estimate of consumer surplus from recreational fishing that could be added to estimated expenditure to estimate a comprehensive measure of the economic value, or gross willingness to pay for the recreational fishing experience. The 789 recreational fishers in the EWP survey made 9,796 fishing trips during the survey period, and scaling up to the WA population yields an estimate of consumer surplus of $908.1 million. Expenditure on recreational fishing underestimates the economic value of the benefits from recreational fishing because the willingness to pay (WTP) will be greater than or equal to expenditure voluntarily incurred to go fishing. WTP for recreational fishing incorporates market and non-market values, including catch as a source of food, the sporting value of landing the catch, and the experiential value of outdoor leisure activity. Consumer surplus equals WTP for the item less the cost that needs to be incurred to acquire it.

7.4 Random Utility Modelling of recreational fisher site choice for management strategy evaluation in recreational fisheries

Matthew Navarro (WA: UWA)

Recreational fisheries management primarily seeks to alter fisher behaviour to ensure resource sustainability and to maximise the long-term social benefits for recreational fishers. However, the tools used to design recreational fisheries policies often fail these objectives on two counts; i) fisher behaviour is not formally modelled; and ii) the social impacts of policies on recreational fishers are rarely quantified. Economic modelling techniques known as random utility models address both shortcomings, but disciplinary barriers have meant that these models have not been well integrated into recreational fisheries sciences or management. Here we present a random utility model of a recreational fishing site and target species choice along 2,000 km of coastline in the south-west of Western Australia. Our model repurposes existing data collected on recreational catch and effort. The model is used to estimate the impacts of changes in demersal bag limits, demersal seasonal closures and spatial closures on recreational fishing experiences, and to identify behaviours that emerge from these interventions. We find that all management interventions have unintended effects, redirecting effort spatially or across target species. We also find that modelled modifications to bag limits reduced catch of demersal fish at the lowest cost to recreational fishing experiences.

7.5 Economic and social assessment of Tasmanian-fisheries

Jeremy Lyle (Tas: IMAS)

The social and economic objectives used to inform policy in Tasmania are to maintain or provide reasonable access to fish stocks for recreational fishers and to mitigate any adverse interactions that result from competition between different fishing methods or sectors for access to shared fish stocks and/or fishing grounds. However, there is no operational, defined objective for managing recreational fisheries; it is not clear who is meant to have access, and it is not clear on what basis/principles to mitigate any adverse interactions. What is provided is very broad, especially for the quality or experience aspects and benefits of recreational fisheries. There has been no evidence of intent to manage directly to increase the value of the recreational experience in recent policy or

management decisions (i.e. the focus is on providing access and minimising interactions with other sectors). The social and economic indicators that are assessed as part of the 2016/17 recreational fishing surveys included access (using participation as a proxy), and the quality of interaction (using fisher satisfaction as a proxy). An additional survey is proposed for 2018/19 which aims to describe the sectors accessing each fishery and to assess the performance against stated and inferred management objectives. The inclusion of indicators for the purposes of describing each sector has enabled more information to be reported that could be informative in reviewing policy or in allocation decisions. This is therefore reliant on correctly inferring policy and management objectives and information needs. Descriptive indicators include access/resource sharing, recreational fishing participation, recreational fishing motivation and charter tourism activity. The performance assessment indicators include recreational utility, recreational participation amenity and recreational consumptive amenity. It is difficult to assess the effects of management changes using selected indicators due to limitations of scale and frequency of surveys; however, the individual fishery survey reports do this for high-value target spp. (e.g. rock lobster, abalone). The inclusion of multiple sectors for multiple fisheries allows for broad comparison. The development of a Recreational Fishing Strategy will likely identify multiple objectives and their relative weighting, and indicators

8.0 Session 8: Current and future challenges for survey designs to support sustainable recreational fisheries

Chaired by Dr Stephen Taylor (Senior Research Scientist) & Dr Brent Wise (Principal Research Scientist), Department of Primary Industries and Regional Development, Western Australia

This session was primarily a discussion session to identify and acknowledge the challenges facing recreational fishing surveys. This was particularly with respect to developing long-term research plans to minimise reactive research, incorporating recreational data into stock assessments and the provision of advice to managers, annual reporting requirements for recreational data, defining data standards for recreational fishers, and how best to deal with calls for mandatory reporting and real-time management for recreational fisheries. At the 2010 workshop, similar discussions were integral in developing a standard for the statewide survey in Western Australia, as well as identifying where work was needed to improve consistency and compatibility between each jurisdiction's research.

Discussions revealed that having a long-term research plan and formalised standards for data quality are essential in guiding research and negating legal disputes relating to changes in the management of fisheries. While short-term priorities may arise, the long-term plan facilitates the prioritisation and allocation of increasingly stretched survey resources. Being able to have either a time-series of data, or the ability to reconstruct catches throughout the history of the fishery were also identified as important for quantitative assessments and to track changes in the fishery over time.

Finally, the issue of conflicting stakeholder expectations was raised, as commercial stakeholders in some high-value fisheries want the recreational sector to be subject to the same harvest strategy requirements as the commercial sector if they exceed their TARC. It was recognised that many of the alternatives are politically unpalatable and need the compliance support to ensure they succeed; however, formalised priorities with respect to the social, economic and sustainability aspects of the fishery would help to manage competing stakeholder expectations in the absence of political decisions being made.

9.0 Workshop Summary

The workshop invited Australian and international representatives to explore current management and research methods and the challenges and issues affecting recreational catch and effort estimates. Recreational fishing surveys are an essential component in providing estimates of recreational catch and effort that contribute to quantitative stock assessments and third party accreditations to ensure the sustainability of fish stocks. Stakeholders and peak bodies, including the recreational, commercial and indigenous sectors, have an important role in driving research.

Off-site recreational fishing surveys were compared to identify strengths and limitations of current survey designs. Increasing issues with under-coverage and declining response rates were common themes and proposed solutions including alternate modes of data collection for recreational fishers via apps, email, online or through SMS. Globally, several countries have a national register for recreational fishing which is linked to each citizen's social security number. It is clear that a national register of recreational fishers in Australia, involving all jurisdictions, would provide a more collaborative approach and would greatly improve the ability to conduct off-site recreational fishing surveys Australia-wide. Within Western Australia, the ability to sample from a national register of fishers would provide a means to estimate shore-based catches in a cost-effective manner.

There is also a need for routine on-site surveys for data collection at smaller spatial scales. On-site survey designs for catch rates and average weight are essential to provide estimates of recreational harvest (by weight), which is critical for determining catch allocations and evaluating stock assessments. Data are often being applied to management questions that the survey was not designed to answer, which may not be feasible nor statistically-robust. Objectives must be defined at both the spatial and temporal scope required, as well as determining the level of precision required. Considerations should include the survey design, aggregation or disaggregation of data, applying the survey stratification to data analyses, and validating data estimates. Simulation studies will assist in determining the sample size required, and thus associated resource requirements, to detect significant shifts in the coefficients of variation. However, the ability to implement these will ultimately depend upon the value of the fishery and the overall objectives.

The issue of estimating the number of fish released was also covered during this workshop. It was acknowledged that on-site creel surveys and angler diary programs have been successful in recording this information; however, there are still issues with regards to understanding post-release mortality and converting that information into estimates of release harvest. A behavioural change is occurring and catch and release fishing is seen as both ethical and responsible. There is a need to better understand the changing behaviour of recreational fishers and what the implications are for post-release and fishing mortality. In addition, the impacts of depredation are an increasing issue in both the commercial and recreational sectors.

The technological advances witnessed in the past decade have revolutionised data collection and maintenance; however, the implementation of many of these

technologies in recreational fishing surveys has lagged due to the lack of research into the impacts they may have on the accuracy and precision of derived estimates and how these data collection tools can best be incorporated into survey design. Survey objectives and data requirements are essential in deciding what technique to use, thus it is important to understand the potential biases that can be introduced through implementing new technologies compared to traditional technologies. There is an ongoing need to develop innovative methods to obtain a cost-effective, representative sample, and so, multi-modal methods may provide an opportunity to combine 'optimal' aspects from multiple technologies. Issues raised included: effective sampling frames; changing data collection methods and subsequent impacts on time-series data; collaborating with external groups to maximise the utility of new technologies; challenges in communicating new technologies with stakeholders; and maintaining statistical rigour and data quality. The use of a well-designed smartphone 'App' may allow more than just data collection, through use of increased engagement and collaboration with recreational fishers. Engaging with recreational fishers on social media or other platforms may also raise awareness of the importance of recreational fishing surveys and any issues surrounding them.

Economics is an increasing priority after a recent study in Western Australia (McLeod & Lindner, 2018) and leading into the next National Recreational Fishing Survey. Likewise, the social aspects of recreational fishing are becoming a critical focus for the sector, and so, are increasingly important to quantify; however, defining these is complex and has not occurred to date, as behaviours and motivations differ markedly among recreational fishers. The contribution recreational fishers make to the Australian economy is significant, so there is a need to understand the social objectives of recreational fishers, and incorporate them into policy decisions alongside biological indicators. There is no "one-size-fits-all" for defining satisfaction or maximum experiential yield, and as such, there is often no clear policy in relation to social, economic and ethical aspects of recreational fishing in most Australian jurisdictions.

Managing recreational fisheries is becoming more about balancing competing demands as opposed to focussing on biological maximum sustainable yield; yet in multi-sector fisheries where recreational fishing dominates the catch, there is usually no difference in the overall management objectives. There is a clear need for communication and stakeholder engagement within the recreational sector; however, there is greater success in jurisdictions where there is a centralised peak body, particularly where positive collaboration occurs between peak bodies and management agencies. Overall, it is important to have clear objectives for what needs to be communicated and who will be the target audience, which may be facilitated by a structured decision-making process.

Finally, developing a long-term research plan and formalised standards for data collection and quality are integral in guiding research and mitigating disputes relating to changes in the management of fisheries. While short-term priorities may arise, the long-term plan facilitates the prioritisation and allocation of increasingly stretched survey resources. Having either a time-series of data or the ability to reconstruct catches throughout the history of the fishery were also identified as important for quantitative assessments and to track changes in the fishery over time.

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11.0 Appendix 1: Workshop Participants and Attendees

Department of Primary Industries and Regional Development, Western Australia

- Ainslie Denham (Senior Research Scientist)
- Alex Hesp (Senior Research Scientist)
- Alissa Tate (Research Scientist)
- Anthony Hart (Principal Research Scientist)
- Arani Chandrapavan (Research Scientist)
- Brent Wise (Senior Principal Research Scientist)
- Brett Crisafulli (Senior Technical Officer)
- Cameron Desfosses (Research Scientist)
- Claire Smallwood (Research Scientist)
- Daniel Yeoh (Technical Officer)
- Danielle Johnston (Senior Research Scientist)
- David Harris (Research Scientist)
- David Oberstein (Research Survey Officer)
- Eva Lai (Research Scientist)
- Fabian Trinnie (Research Scientist)
- Gary Jackson (Principal Research Scientist)
- Graeme Baudains (Principal Fisheries Management Officer)
- Griffin Grounds (Fisheries Management Officer)
- Joshua Brown (Coordinator Community Education and Volunteers)
- Karen Williams (Project Support Officer)
- Karina Ryan (Senior Research Scientist)
- Kim Smith (Senior Research Scientist)
- Lachlan Strain (Research Scientist)
- Marcus Newman (Technical Officer)
- Mark Goninon (Research Data Coordinator)
- Matias Braccini (Senior Research Scientist)
- Nathan Harrison (Director Aquatic Resource Management)
- Nick Caputi (Senior Principal Research Scientist)
- Norm Hall (Principal Senior Research Scientist)
- Paul Fildes (Research Data Coordinator)
- Paul Lewis (Research Scientist)
- Rachel Marks (Research Scientist)
- Shane Walters (Senior Fisheries Management Officer)
- Stephen Newman (Principal Research Scientist)
- Stephen Taylor (Senior Research Scientist)

- Stuart Blight (Senior Fisheries Research Officer)
- Susan Martin (Research Survey Officer)
- Tim Nicholas (Manager Aquatic Resource Management)
- Vangie Gerginis (Validation Data Entry Officer)
- Veronique Vanderklift (Research Data Manager)

Western Australia

- Brooke Shields – Department of Biodiversity, Conservation and Attractions
- Clara Obregon – Murdoch University
- Ebenezer Afrifa-Yamoah – Edith Cowan University
- Glenn Hyndes – Edith Cowan University
- Johanna Zimmerhackel – University of Western Australia
- John Henstridge – Data Analysis Australia
- Johnny Lo – Edith Cowan University
- Jordan Goetze – Department of Biodiversity, Conservation and Attractions
- Leyland Campbell – Recfishwest
- Matt Navarro – University of Western Australia
- Matt Pember – Western Australian Fishing Industry Council
- Michael Hughes – Murdoch University
- Michael Tuffin – Department of Biodiversity, Conservation and Attractions
- Paul McLeod – Economic Research Associates
- Shannon Burchert – Edith Cowan University
- Sonia Prokojes – Edith Cowan University
- Vicki Graham – Edith Cowan University

Australian Capital Territory

- Andy Moore – Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES)

New South Wales

- Aldo Steffe – Fishing Survey Solutions
- Ashley Fowler – NSW Department of Primary Industries
- Faith Ochwada-Doyle – NSW Department of Primary Industries
- Julian Hughes – NSW Department of Primary Industries

Northern Territory

- Kane Dysart – NT Fisheries
- Shane Penny – NT Fisheries

Queensland

- Daniella Teixeira – Qld Department of Agriculture and Fisheries

- James Webley – Qld Department of Agriculture and Fisheries

South Australia

- Mike Steer – South Australian Research and Development Institute (SARDI)

Tasmania

- Carlie Devine – Commonwealth Scientific and Industrial Research Organisation (CSIRO)
- Jeremy Lyle – University of Tasmania/Institute of Marine and Antarctic Studies
- Kate Stark - University of Tasmania/Institute of Marine and Antarctic Studies
- Sean Tracey - University of Tasmania/Institute of Marine and Antarctic Studies

Victoria

- Eugene Siow – Social Research Centre
- Justin Bell - Victoria Fisheries Authority
- Sebastian Mission – Social Research Centre
- Simon Conron – Victoria Fisheries Authority

New Zealand

- Bruce Hartill – National Institute of Water and Atmospheric Research (NIWA)

Europe

- Kieran Hyder – Centre for Environment, Fisheries and Aquaculture Science (CEFAS), UK

12.0 Appendix 2: Workshop Agenda

International Workshop on Recreational Fishing Surveys

Western Australia Fisheries and Marine Research Laboratories (WAFMRL), Hillarys Perth

28-31 October 2019

Monday 28 October	
8:30-9:00	Meet and Greet
9:00-9:20	Welcome to Country: Matthew McGuire Welcoming remarks: Dan Gaughan Chair: Brent Wise

Information required for monitoring and assessing recreational fisheries

9:20-9:40	**Nathan Harrison, WA** *Policy perspective*
9:40-10:00	**Andrew Rowland, RecFishWest** *Stakeholder perspective*
10:00-10:20	**Brent Wise, WA** *Research perspective*

Current management and research in each jurisdiction

10:20-10:40	**Karina Ryan & Steve Taylor, WA** *Overview of current recreational fishing management and research in WA*
10:40-11:00	Morning tea
11:00-11:20	**Ashley Fowler, Faith Doyle & Julian Hughes NSW** *Monitoring and management of recreational fishing in NSW: current and future directions*
11:20-11:40	**Shane Penny & Kane Dysart, NT** *An overview of recreational fisheries in the NT*
11:40-12:00	**James Webley, QLD** *Overview of the current statewide survey, the Net Free Zone satisfaction monitoring, the Boat Ramp Survey and the Keen Angler program in QLD*

12:00-12:20	**Mike Steer, SA** *The state of South Australia's community-shared fisheries*
12:20-12:40	**Jeremy Lyle & Sean Tracey, Tas** *An overview of Tasmanian recreational fisheries*
12:40-13:00	**Simon Conron & Justin Bell, VIC** *Reflections from using an integrated approach to monitoring the status of recreationally important fish stocks using targeted creel, angler diary and fisheries independent surveys*
13:00-14:00	Lunch break
14:00-14:30	**Keynote speaker: Kieran Hyder, UK** *Recreational sea fishing in Europe in a global context— Participation rates, fishing effort, expenditure, and implications for monitoring and assessment*
14:30-15:30	Outcomes of session - group discussion
15:30-15:45	Afternoon tea
15:45-17:00	Outcomes of session - group discussion cont.
17:00	**Chair to close**

Tuesday 29 October

9:00-9:30	**Keynote speaker: Bruce Hartill, NZ** *Insights from recent recreational fishery surveys in New Zealand and their relevance to Western Australia survey methods*

Off-site survey designs (effort and catch)

9:30-9:50	**Vicki Graham, WA** *Implementing statewide surveys of recreational fishing in Western Australia*
9:50-10:10	**Karina Ryan, WA** *Estimating effort and catch from statewide surveys at state and bioregional scales*
10:10-10:30	**Claire Smallwood, WA** *Disaggregating statewide surveys to estimate effort and catch at small spatial scales*

10:30-11:00	Morning tea
11:00-11:20	**Eugene Siow & Sebastian Mission, QLD** *Approach to 2019-2020 QLD Statewide Recreational Fishing Survey*
11:20-13:00	Outcomes of session – group discussion
13:00-14:00	Lunch break

On-site survey designs (effort and catch)

14:00-14:20	**Eva Lai, WA** *Corroborating effort and catch data from an integrated survey of boat-based recreational fishing in the Perth metropolitan area*
14:20-14:40	**Steve Taylor, WA** *Integrated surveys of boat-based recreational fishing in inner Shark Bay*
14:40-15:00	**Cameron Desfosses, WA** *Quantifying the footprint of recreational scoop-net fishing at Peel-Harvey Estuary*
15:00-15:20	**Lachlan Strain, WA** *From sustainability to safety: a New Age recreational abalone fishery*
15:20-15:45	Afternoon tea
15:45-17:00	Outcomes of session – group discussion
17:00	**Chair to close**

Wednesday 30 October

9:00-9:30	**Keynote speaker: Aldo Steffe, NSW** *Sample units, data elements and design-based inference in surveys*

On-site survey designs (catch rates and average weight)

Catch rates

9:30-9:50	**Alissa Tate, WA** *Time series of catch rates for shore-based fishing in the Perth Metropolitan area*

9:50-10:10	**Justin Bell, VIC** *The challenges of improving the analysis of recreational time series catch rate data for stock status assessments*
10:10-10:30	**Daniella Teixeira, QLD** *An update on how catch rates are being used to monitor effects of Net Free Zones and other potential uses*
10:30-11:00	Morning tea

Average weight

11:00-11:20	**Claire Smallwood, WA** *Benefits of a restricted spatial and temporal survey design for determining average weight of recreational catches*
11:20-11:40	**Cameron Desfosses, WA** *Estimating average weight of western rock lobster from boat ramp surveys with a restricted spatio-temporal sampling frame*
11:40-12:00	**Brett Crisafulli, WA** *A comparison of average length & weight from boat ramp surveys, charter logbooks & SUYS*
12:00-13:00	Outcomes of session – group discussion
13:00-13:45	Lunch break

Innovative approaches for monitoring recreational fisheries

Vessel Monitoring

13:45-14:05	**Stuart Blight, WA** *Insights from monitoring recreational fisheries using remote cameras*
14:05-14:25	**Ebenezer Afrifa-Yamoah, WA** *When less is more: cost-precision trade-off for remote camera surveys*
14:25-14:45	**Shannon Burchert, WA** *Spatial and temporal patterns in vessel characteristics from a large scale boat-based recreational fishery*
14:45-15:00	Afternoon tea

Comparison of data collection methods

15:00-16:00	*Using new technologies to develop efficiencies in randomised, representative surveys of recreational fisheries in Western Australia* **Steve Taylor** - licence and White Pages® sampling frames **Claire Smallwood** - phone and online data collection **Fabian Trinnie** - phone and App data collection **Alissa Tate** - paper and iPad data collection **Cameron Desfosses** - Incorporating drones into recreational fishing surveys
16:00-17:00	Outcomes of session – group discussion
17:00	**Chair to close**

Thursday 31 October

9:00-9:30	**Keynote speaker: John Henstridge, WA** *Surveys - fishing for data?*

Social and Economic

9:30-9:50	**Andy Moore, ACT** *Developing a national social and economic survey of recreational fishers: do we have to choose between being robust and cost effective?*
9:50-10:10	**Paul McLeod, WA** *Economic dimensions of recreational fishing in Western Australia*
10:10-10:30	**Matthew Navarro, WA** *Random Utility Modelling of recreational fisher site choice for management strategy evaluation in recreational fisheries*
10:30-11:00	Morning tea
11:00-11:20	**Jeremy Lyle, Tas** *Economic and social assessment of Tasmanian-fisheries*
11:20-13:00	Outcomes of session – group discussion
13:00-14:00	Lunch break

Current and future challenges for survey designs to support sustainable recreational fisheries

14:00-14:20	**Brent Wise, WA** *Incorporating survey outputs into reporting* *Providing management advice* *Challenges and opportunities*
15:00-16:00	Outcomes for WA statewide survey – group discussion
16:00	**Brent Wise, WA** *Closing remarks*