A framework for regular national recreational fishing surveys

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Summary

Context and need

Australia's recreational, commercial and Indigenous customary fisheries sectors are characterised by diverse stakeholders, utilise and share a large number of species and exhibit complex spatial and temporal patterns. Understanding the biological, social and economic impacts of recreational fishing requires high quality data over a range of spatial and temporal scales. This information assists in assessing and managing fisheries resources, promoting sustainable recreational fishing and developing and supporting the sector. Because many fish stocks cross jurisdictional boundaries, as do the stakeholders who utilise them, broad-scale data provide a fundamental tool for assessing and managing these resources. These data are also critical for informing policy and related programs.

Compulsory data collection systems are in place for Australia's commercial fisheries, but detailed information on the biological, social and economic impacts of recreational fishing is lacking—particularly at cross-jurisdictional and national scales. The last (and only) national recreational fishing survey in Australia was undertaken in 2000–01 (Henry and Lyle 2003). Since then, Australia's states and territories have undertaken recreational fishing surveys at a range of spatial and temporal scales. With the exception of Western Australia, which has a legislated requirement to collect recreational fishing data every two years, states and territories do not have current plans or legislated requirements to undertake regular statewide surveys.

A recent project (Griffiths et al. 2014) found that because existing recreational fishing datasets were too fragmentary in space and time, it is not possible to aggregate them in a statistically defensible way to produce reliable national estimates in any given year. Consequently, Griffiths et al. (2014) recommended that in order to improve recreational fishing data at the national level, another national survey should be undertaken, or coordination between jurisdictions be improved.

An objective of the Australian Government's *Policy for a More Competitive and Sustainable Fisheries Sector* (August 2013) is to conduct national recreational fishing surveys every five years. This report presents a cost-effective, repeatable framework using 'best-practice' methods for implementing these surveys.

Key stakeholders, which include fishery managers, scientists and the recreational fishing sector, have wide-ranging information needs over different spatial and temporal scales. The accuracy and precision of data required for specific purposes is highly variable. This influences the cost and complexity of collecting recreational fishing data and may influence the adoption of survey objectives, approaches and methods.

National survey objectives

The objectives for regular national recreational fishing surveys that were agreed to by stakeholders involved in this project are to:

- determine the participation rate in recreational fishing nationally, by states and territories and regionally, and profile the demographic characteristics of recreational fishers
- identify key species and quantify catch and effort of the recreational fishing sector nationally, by states and territories and, where appropriate, regionally

- assess economic activity by the recreational fishing sector nationally and, where appropriate, regionally
- assess the social contribution of recreational fishing, and fishers' attitudes to and awareness of issues relevant to fishing.

Survey approaches

To achieve these objectives, three main approaches were investigated through this project:

1) Regular temporal alignment of recreational fishing surveys conducted by Australia's states and territories (the preferred approach)

2) A centrally coordinated national survey undertaken independently from, or in place of, statewide surveys

3) A national survey of the social and economic contribution of recreational fishing undertaken independently from statewide surveys. This approach would only partially address the objectives.

Most stakeholders involved in this project supported an approach that involves the regular temporal alignment of recreational fishing surveys conducted by Australia's states and territories to deliver national scale information (approach 1). While it would be possible to undertake a national survey independently of these state and territory surveys (approach 2), such an approach may be impractical because of reduced buy-in, and may not assist in building a long-term legacy of cooperation and coordination.

Approaches 1 and 2 would collect catch and fishing effort, social (including demographic, participation, and attitudinal) and economic (expenditure) data that could be aggregated to provide both a jurisdictional and a national picture of recreational fishing. This would also allow data to be compared with data collected through the 2000–01 National Recreational and Indigenous Fishing Survey (NRIFS; Henry and Lyle 2003) and state- and territory-wide surveys undertaken since then. If collected regularly, these data will become an invaluable tool for measuring changes in recreational fishing over time.

This project sought to develop a framework that could be applied to approaches 1 and 2. Consequently, the core survey methods proposed are applicable to either approach. Estimated costs are only applicable to an approach that involves a centrally coordinated national survey (approach 2).

Survey methods

The off-site telephone–diary survey method proposed for approaches 1 and 2 is similar to that used for the NRIFS. However, it has required additional development to account for changes and improvements since the last national survey, and to incorporate improvements identified through this project. These improvements include more efficient ways to collect data (for example, using text messaging and computer assisted telephone interview technology) and better data analysis packages. Changes in the use of fixed-line telephones and the incorporation of a wider range of sampling frames to contact fishers (the 'hybrid' method, which uses the White Pages® telephone directory as the primary sampling frame, supplemented by other available sampling frames, including recreational fishing licence databases) have also been considered. It is also proposed that an on-site survey is undertaken to validate estimates provided by the telephone–diary survey method.

This choice of survey approach and methods is an acknowledgement by most stakeholders involved in the project that it is the most cost-effective way to collect the high-quality information required by stakeholders. Benchmarking the proposed methods against international recreational fishing surveys highlighted that the methods are highly appropriate for undertaking national recreational fishing surveys in Australia.

These methods will collect information that is of comparable quality—and will be able to be used for similar purposes—as current state- and territory-wide surveys. The project investigated alternative contact methods, such as the use of smartphone applications and mail or online surveys, but found that the information collected using these techniques is often biased because of the characteristics of those who respond. Some technologies, such as using text reporting to determine if fishers have fished and require a follow-up telephone interview, can augment the preferred approach and have been used successfully in Western Australia and New Zealand surveys. However, many of these novel methods do not currently provide a panacea for the necessarily complex and more costly process of collecting high-quality, representative information at broad spatial and temporal scales that will be trusted by stakeholders and is able to be used effectively for fisheries assessment and management. Other approaches, such as face to face surveys, were also investigated but were found to be impractical for national surveys in Australia because of the high costs and because the last national survey and subsequent statewide surveys have used (and continue to use) a telephone–diary methodology.

It is recommended that development of a national survey based around the preferred approach is continued with a view toward jurisdictional alignment of recreational fishing surveys in 2017–18. This timeline is suggested as it aligns with the Western Australian survey timelines and is a sufficient period of time from the 2013–14 statewide surveys undertaken in New South Wales and Queensland. It would provide sufficient lead-in time for coordination and implementation of a national survey. If other jurisdictions are committed to state- or territory-wide surveys, they would align the timing of their surveys. Operationalising the survey would also require agreement on standard survey components, such as ensuring that fishing activity outside the respondent's home state is captured and that information collected on key species shared between jurisdictions is adequate. The survey output specifications outlined in this report provide the framework for consistent data collection across Australia.

Estimated cost of a centrally coordinated national survey

The estimated cost of a coordinated national survey (approach 2) in 2017–18 based on the methods presented is $6.8 million. This should be viewed as an estimation of what a national survey might cost if it were undertaken independently from (or in place of) current state and territory survey processes. The estimate assumes levels of precision and sample sizes that are generally agreed to provide information that is able to be used effectively at broad spatial and temporal scales, as well as assuming other potentially variable costs such as labour. This estimate includes additional work that would need to be undertaken before implementation of any national survey, including further investigation of the 'hybrid' survey method and development of a data management strategy.

Because each jurisdiction currently funds its own survey based on its required level of precision and hence sample sizes, the $6.8 million cost estimate needs to be viewed with caution because it does not consider the resourcing and timing of planned statewide data collection processes (legislated or otherwise). In the context of the preferred approach to temporally align jurisdictional surveys (approach 1), which it is hoped would provide a lasting legacy of cooperation and coordination, then the additional resources required may be significantly lower than this estimate. The cost of the approach to align jurisdictional surveys could not be

estimated as the resourcing of current or planned jurisdictional surveys was unknown. State- and territory-wide surveys undertaken previously may provide a useful indication of the likely costs of a national survey if the cost was to be borne solely by these jurisdictions.

A commitment by jurisdictions to undertake regular statewide surveys would assist with the implementation of a regular national survey. However, resourcing and other constraints may mean this is impractical at this time and consequently, it is likely that additional funding will be required to align surveys in 2017–18 and, in the absence of any commitment to regular surveys by the states and territories, periodically thereafter.

The preferred approach to align jurisdictional surveys may provide efficiencies by achieving consistency between current state and territory survey processes that can produce spatially and temporally disparate information. Taking a coordinated approach to recreational fishing surveys will allow for a more comprehensive picture of Australia's recreational fisheries—an important consideration in Australia where recreational fishers freely cross jurisdictional boundaries, as do the species they catch. With sufficient commitment and adequate resources, the preferred approach to align jurisdictional surveys is feasible and would meet the needs of many stakeholders.

Alternative approach

Recognising that the resources to implement the preferred approach may not be available, a reduced national survey that only focuses on components of the objectives may be considered. A national survey of the social and economic contribution of recreational fishing (approach 3) could be undertaken independently from current state and territory survey processes. This approach would meet the social and economic objectives of national recreational fishing surveys and would provide useful information for guiding investment in, and development of, the recreational fishing sector. This approach may also provide information for managers, scientists and the recreational fishing sector involved in fisheries management and policy development and implementation. However, this approach would not provide a national picture of recreational fishing catch and effort, address information gaps on the impact of recreational fishing on stocks that span jurisdictional boundaries, or quantify catch levels and fishing effort of non-resident fishers in each jurisdiction.

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Background

Recreational fishing is an important component of Australia's broader fisheries sector and has substantial biological, social and economic impacts. The 2000–01 National Recreational and Indigenous Fishing Survey (NRIFS; Henry and Lyle 2003) estimated that 20 per cent of Australians, or about 3.36 million people, undertook 23 million fishing trips and caught 136 million aquatic animals, including 71 million finfish, during the survey period. A number of studies, including the NRIFS, have indicated that recreational catches of some species can approach or exceed commercial catch levels (Murray-Jones and Steffe 2000; Henry and Lyle 2003; Leigh and O'Neill 2004; Ford and Gilmour 2013). Recreational catches need to be considered when assessing the sustainability of stocks, particularly those shared between recreational, commercial, Indigenous customary and other sectors. This information is particularly important for fisheries management, as the ability to balance the needs of multiple stakeholder groups strongly depends on an adequate understanding of the nature and extent of each group's activities.

Data are also required to understand the social and economic contribution of recreational fishing to the Australian public and for guiding ongoing research in, and development of, the sector. When asked in the NRIFS about reasons for fishing, primary motivations for recreational fishers included 'to relax and unwind', 'to spend time with family', 'fishing for sport' and 'to be outdoors'. The NRIFS estimated that fishers spent $1.8 billion on services and items linked to recreational fishing (Campbell and Murphy 2005). A report to the Fisheries Research and Development Corporation (FRDC) by the Recreational Fishing Economic Valuation Committee (RFEVC 2014) estimated that, in 2013, the economic contribution of the sector was $2.56 billion. Other recent estimates by the recreational fishing industry suggest that recreational fishing generates around $10 billion in economic worth to the Australian economy every year (ARFF 2013). While these estimates exist and can be used for certain applications, there is no consistent or regular approach to collecting information on the social or economic contribution of recreational fishing in Australia.

Recreational fishing in Australia is managed by the states and territories, with relevant jurisdictional legislation extending to the management of recreational fisheries in adjacent Commonwealth waters. State and territory recreational fishing surveys have historically focused on estimating fishing effort and catch of key species, and generally meet their main objective to provide information at a scale relevant to the assessment and management of fish stocks for that jurisdiction. However, data collected as part of these surveys can be of limited use for understanding stocks that straddle jurisdictional boundaries and, like other data, can become outdated quickly. Additionally, these surveys have historically focused on resident fishers and so have not usually collected data on fishing effort and expenditure of non-resident fishers. Up until recently, the NRIFS was the only survey that sought to collect this important information.

Limited data is a major constraint to understanding, managing and developing recreational fisheries. Currently in Australia, there are few reliable methods for collecting recreational fishing data at a national scale. An objective of the Australian Government's *Policy for a More Competitive and Sustainable Fisheries Sector* (2013) is to undertake national recreational fishing surveys every five years, which include the collection of catch, fishing effort, social and economic data. As part of this commitment, the Australian Bureau of Agricultural and Resource Economics

and Sciences (ABARES) has designed a framework and associated methods for conducting regular national recreational fishing surveys.

To achieve the high-level objectives to collect high quality catch, fishing effort, social and economic information, a survey approach needs to be cost-effective, provide reliable data and defensible conclusions, and be supported and trusted by data users. Consequently, there is a trade-off between the accuracy and precision of data required for various applications and the cost of an appropriate survey method. The preferred approach and methods presented in this report reflects an acknowledgement by most stakeholders involved in this project that they are appropriate for meeting these objectives and associated requirements, and will ultimately provide a basis for improved decision making in the future.

Related policy, surveys and data collection

National-scale

The 1994 National Recreational Fishing Policy endorsed the principle that 'fisheries management decisions should be based on sound information, including fish biology, fishing activity, catches and the economic and social values of recreational fishing'. It also recognised the need to obtain accurate national information on recreational fishing, and that information available at the time was inadequate to assist fisheries management over various spatial and temporal scales. The policy recommended a national survey of expenditure, participation rates, demographics and the attitudes of recreational fishers.

After a number of years of consultation with stakeholders, the Australian Government played a coordination role and contributed significant funding to the development and implementation of the NRIFS. This survey provided the first and only comprehensive assessment of recreational fishing in Australia and collected important benchmarking information, including:

- the participation rate in recreational fishing nationally, by state or territory and regionally, and a profile of the demographic characteristics of recreational fishers

- catch and effort of the recreational fishing sector nationally, by state or territory and, where appropriate, regionally

- data on expenditure by the recreational fishing sector nationally and regionally

- the attitudes and awareness of recreational fishers to management issues of relevance to their fishery

- fishing activity by Indigenous fishing communities in northern Australia

- fishing activity by overseas visiting fishers.

The NRIFS comprised three independent surveys: the National Recreational Fishing Survey (NRFS), the Indigenous Fishing Survey of Northern Australia and the Overseas Visitor Fishing Survey. Different methodological and analytical approaches were required for each of these surveys, reflecting the substantially different socioeconomic and demographic characteristics of the target populations for each survey. The national survey was implemented as a series of temporally aligned statewide surveys using a common methodology, which had the advantage of providing comparable information Australia-wide as well as the activity of non-resident fishers.

The NRIFS was developed over several years by a team of scientists specialising in the fields of recreational fishing surveys, survey design and statistical analysis. International experts in

recreational survey design were also consulted prior to and during the development of the methodology. The method was pilot tested at several locations in Australia during 1999. Table 1 shows the timelines for development and implementation of the NRIFS.

A full set of survey documentation, including reviewer manuals, questionnaires, data collection forms, diaries, fish identification booklets and survey maps were produced and are available. Training programs for survey staff were developed. The NRIFS established a database that is held by ABARES. Each jurisdiction also holds its own data.

Table 1 Timelines for development and implementation of the National Recreational and Indigenous Fishing Survey

Development of methodology for feasibility study (adopted May 1998)	3 years (1995–98)
Development phase –survey refinement, including pilots	July 1998–99
Implementation phase	Survey commenced in May 2000, completed in August 2001
Analysis and report writing	Report released in July 2003
	Economics report 2005

Source: SDWG 2000

By conducting the 2000–01 survey nationally, directly comparable information was collected across all jurisdictions. This allowed the data to contribute to assessments on a variety of scales. Such analyses were relevant for stocks and fisheries that have wide distributions or that cross jurisdictional boundaries. There were also benefits in assessing the levels of effort and economic activity of non-resident anglers that fished interstate.

The $4.5 million cost of the NRIFS included a scoping study ($1.2 million) and implementation ($3.3 million – funded through the Natural Heritage Trust [$1.6 million], the Fisheries Research and Development Corporation [FRDC; $0.8 million] and state and territory governments [$0.9 million including in-kind contributions]). This cost equates to around $6.7 million in 2014 dollars.

In October 2008, the then Minister for Agriculture initiated the first review of the 1994 National Recreational Fishing Policy and the development of a National Recreational Fishing Industry Development Strategy (RFIDS). This strategy retained some of the features of the 1994 policy but focused more on coordinating the efforts and resources of recreational fishers, industry and governments on actions and outcomes to improve recreational fishing and promote a thriving industry (RFAC 2011). At this time, fishers, industry and governments continued to rely on the NRIFS for national recreational fishing data. Governments had moved away from agreement to co-fund regular national surveys and attempts at alternative approaches to national surveys were unsuccessful.

A primary goal of the RFIDS was to provide an information base at national, state and regional levels on recreational fishing to meet the needs of government and the community. The strategy noted that the slow progress in the area of national recreational fishing statistics during the 2000s reflected the 'unresolved complexity and costs involved in meeting disparate information needs of different sectors at different scales and for different purposes' (RFAC 2011).

A project funded through the RFIDS, *A coordinated national data collection for recreational fishing in Australia* (Griffiths et al. 2014), sought to:

- provide an understanding of the current state of knowledge, and identify information gaps, across the recreational fishing sector at a national scale

- explore approaches to filling key information gaps and begin development of system(s) and protocols that will allow data to be stored, aggregated and analysed to answer questions related to recreational fishing in a timely and responsive way

- assess the feasibility of aggregating available recreational fishing datasets to provide reliable regional and national information on catch, effort, participation, and social and economic aspects in the recreational fishing sector.

The research indicated that because existing datasets were too fragmentary in space and time, it was not possible to aggregate them in a statistically defensible way to produce reliable national estimates in any given year. Consequently, the project recommended that in order to improve recreational fishing data at the national level, another national survey should be undertaken, or coordination between jurisdictions be improved.

State and territory scale

Since the NRIFS, several states and the Northern Territory have conducted regional or statewide surveys to meet their information needs and obligations under their legislation and policy (Table 2). These vary between regular surveys conducted every two years (for example, Western Australia in 2011–12 and 2013–14), to a single or no statewide survey since the NRIFS. Statewide surveys conducted during this time tended to focus on catch and fishing effort, but also sought to capture some of the social and economic aspects of recreational fishing. All statewide surveys were based on the methods used for the NRIFS.

These statewide surveys have generally been used for the operational management of fisheries for key species targeted by both recreational and commercial fishers. Harvest estimates for species that are caught infrequently are generally less precise when aggregated than data for more commonly caught species. Catch and fishing effort data can generally be used to inform stock assessment and other fisheries management issues for a number of years after a survey. However, information can quickly become outdated, particularly for species with large temporal variations in abundance. Additionally, most stock assessments require a time series of catch, and so single estimates are of limited value (Griffiths et al. 2014).

A number of targeted surveys have also been used to improve the understanding of the economic and social contribution of recreational fishing at statewide, regional and local scales (see, for example, Frijlink & Lyle 2010; Ward et al. 2012; Pascoe et al. 2014a).

Table 2 Summary of jurisdictional off-site recreational fishing surveys since 2000–01

Jurisdiction	Most recent statewide survey	Methodology	Information collected	Cost	Future statewide survey plans	Source
New South Wales (incl. Australian Capital Territory)	2013–14	Based on NRIFS methodology (phone–diary survey)	• Fishing participation rates among various subgroups (e.g. age, gender, area of residence) • Catch (harvest and release), effort (days and hours fished) and catch rates for key species • Other recreational fishing-related data (e.g. boat ownership, fishing club membership)	Approx. $1.5 m	Unknown	West et al. (2015)
	2013 survey on economic contribution of recreational fishing in NSW	Telephone household screening survey and sampling supplemented by recreational fishing licence database	• Awareness and opinions on various fisheries-related issues • Expenditure	Unknown		
Victoria	2000–01	No statewide survey has been undertaken since the NRIFS. However: • 2009 web-based survey of recreational fishing licence holders • 2012 web-based (email) Inland Fishing Survey: 4500 recreational fishing licence holders surveyed about importance of inland fishing locations • An angler diary program has been running since the mid 1990s, providing valuable time series information about catch trends, spawning success, survival and growth rates for key fish species	The 2009 survey gathered views on: • education • protection and restoration of fish habitat • increasing fish numbers • access • fishing rules.	2014 survey (currently in planning) costed at approx. $1m	A statewide survey was planned for 2014; still in development	2009 survey: DPI Fisheries Victoria (2010) 2012 survey: DPIE Victoria (2012)
Queensland	2013–14 2010–11 2004–05 4 VRFISH phone–diary surveys between 1996–	Based on NRIFS methodology (phone–diary survey)	2013–14 survey: • Key species caught, fishing locations and techniques • Attitudes and awareness of recreational fishing opportunities and management arrangements	Approx. $1m	Unknown	In prep. 2010 statewide survey: Taylor et al. (2012)

Jurisdiction	Most recent statewide survey	Methodology	Information collected	Cost	Future statewide survey plans	Source
	2005		• Demographics of fishers.			
South Australia	2007–08	Based on NRIFS methodology (phone–diary survey)	• Statewide and regional participation levels and demographics of SA residents • Effort and catches (retained and released) for 12 key species • Attitudes and motivations of recreational fishers • Produced the SA Recreational Fishing Atlas, an online portal for fishers, students, community groups, other government departments and the general public	Not reported; current survey (in planning) approx. $0.45 m	Survey planned but not yet finalised	2007–08 survey: Jones (2009)
Western Australia	2013–14 2011–12	Statewide Recreational Boat Fishing Survey was undertaken in 2013–14 (and 2011–12), based on NRIFS methodology – but integrated several survey methods to provide a more robust approach for obtaining annual estimates of recreational catch by boat-based fishers at both statewide and bioregional levels, including sampling from the Recreational Fishing from Boat licence database	• Estimates of the total recreational catch (both retained and released) and effort by boat-based recreational fishers at statewide and bioregion levels • Participation and fishing effort • Statewide recreational catch and harvest weights of key species • Bioregional fisheries (overview of species composition)	Reported to be $3.2 m for 2011–12 survey, but included compliance activities 2013–14 survey unknown	Unknown; likely to be 2015–16	2011–12 survey: Ryan et al. (2013) 2013–14 survey: Ryan et al. (2015)
Tasmania	2012–13 2007–08	2012–13 and 2007–08 statewide surveys based on the NRIFS methodology (phone–diary survey) Other surveys include: • Surveys of Tasmanian recreational rock lobster and abalone fisheries • Offshore fishing activities were surveyed between November 2011–September 2012 to gain an understanding of the offshore and game fisheries in Tasmania, particularly in relation to the catch of tunas, pelagic sharks, striped trumpeter and blue-eye trevalla	2012–13 survey: • Determine the participation rate and profile the demographic characteristics of recreational fishers • Catch and fishing effort by method, region and key species • Estimated harvest weights • Compare to previous recreational fisheries surveys • Report on fisher attitudes, motivations and awareness	2012–13 statewide survey cost approx. $0.5 m	Unknown	Lyle et al. (2014)

Jurisdiction	Most recent statewide survey	Methodology	Information collected	Cost	Future statewide survey plans	Source
			• Estimate annual expenditure on recreational fishing by recreational fishers			
Northern Territory	2009–10	Based on NRIFS methodology (phone–diary survey)	• Determine the participation rate and profile the demographic characteristics of recreational fishers	Approx. $0.5 m	Unknown	West et al. (2012)
			• Catch and fishing effort by region, method and key species			
			• Fishing activities and related expenditure			
			• Attitudinal survey including boat ownership and fisher opinions and attitudes to various fishing-related matters			

Need for broad-scale data

Fisheries resources are generally regarded as 'common property assets', with stocks sometimes spanning jurisdictional boundaries and often being shared between the commercial, recreational, Indigenous customary fishing and other resource users (Flood et al. 2012; 2014). An important role of governments is to ensure the long-term sustainable use of these assets for the prosperity and wellbeing of the Australian community (SDWG 1998).

A number of studies, including the NRIFS, have indicated that the recreational catch of some species can approach or exceed commercial catch (Murray-Jones and Steffe 2000; Henry and Lyle 2003; Leigh and O'Neill 2004; Ford and Gilmour 2013). Recreational catches and the distribution and intensity of fishing activity need to be considered when managing resource access and allocation, and for assessing the sustainability of species harvested by recreational, commercial and other sectors (Griffiths and Pepperell 2006; Griffiths et al. 2014).

Governments and other stakeholders also require information on the social and economic contribution of fishing to the broader Australian community. This information is needed for numerous applications, including:

- industry development and investment

- developing and implementing policy and related programs, and measuring progress towards the objectives of these initiatives

- promoting effective communication and building trust between fishery managers, scientists, industry groups and fishers

- understanding and promoting the health and wellbeing benefits of fishing

- establishing, maintaining and improving the level of acceptance and approval granted to recreational fishers and fishing by the broader community (that is, the 'social licence to operate')

- resource access and allocation, frameworks for which are increasingly being proposed for inclusion in, or formalised into, fisheries management strategies (see, for example, Borthwick 2012; Western Australian Department of Fisheries 2012; MRAG Asia Pacific 2014).

As highlighted in the *Status of key Australian fish stocks reports* (Flood et al. 2012; 2014) and in Griffiths et al. (2014), there is currently a lack of up-to-date, consistent and accurate recreational fisheries data that can be used in decision-making processes at the national scale, and, to varying degrees, state and territory, regional and local scales. Furthermore, as outlined in the recent *National Agricultural Statistics Review* (ABS & ABARES 2015), more can be done to institute a culture of 'open data' across the system of statistics for Australia's primary industries. Regular national recreational fishing surveys would help to institute this culture.

The lack of progress in collecting national recreational fishing data since the NRIFS reflects the complexity and costs involved in meeting disparate information needs of different sectors, at different scales and for differing purposes (RFAC 2011). Stakeholders have highlighted that biological, social and economic information is critical for understanding, managing and developing recreational fisheries, and that a more coordinated, effective and efficient approach to the collection of these data is required.

2   Project objectives and scope

The Australian Government's *Policy for a More Competitive and Sustainable Fisheries Sector* (August 2013) included the objective to conduct recreational fishing surveys every five years:

> *'In conjunction with the Fisheries Research and Development Corporation and Recfish, the Coalition will collect data on the social and economic impact of recreational fishing as well as obtain catch data to help assess stock levels. This information will be made available to both policy makers and recreational fishing clubs and representative organisations'.*

As part of the Government's commitment, ABARES received funding during 2014–15 to:

- develop a cost-effective, robust and repeatable framework and associated methods that will support future national recreational fishing surveys

- consider the requirement to collect social, economic, catch and fishing effort data, and the different ways in which this may be done

- engage with stakeholders, including jurisdictions, the Australian Recreational Fishing Foundation (ARFF) and Recfishing Research.

Out of scope were the development of an operational workplan for implementation of a national recreational fishing survey and the development of a data management strategy, which will be necessary should further development and implementation proceed. Several other tasks involving development and possible trialling of novel survey components would need to occur before or during implementation, and are discussed in this report.

Developing methods that specifically target the fishing activities of the Indigenous community[2], including customary use, was also out of scope of this project. However, data collected from Indigenous people participating in surveys as a part of the proposed approach would be included in outcomes and results.

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[2] Because of the continued socioeconomic and demographic disparity between Indigenous and non-Indigenous Australians, different survey methods are often required to adequately collect data from the Indigenous community.

3   Project methods

The project commenced in August 2014 and was developed in consultation with a project steering committee, state and Northern Territory recreational fisheries managers and scientists, recreational fishing industry representatives, the Australian Government Department of Agriculture and Water Resources, FRDC (including Recfishing Research and the Indigenous Reference Group), Australian Bureau of Statistics (ABS) and experts in survey design and methods, social sciences, economics, statistics and database management. The steering committee comprised representatives of the Department of Agriculture and Water Resources, ABARES, FRDC, Recfishing Research, the University of Tasmania, ARFF and the Australian Fisheries Management Forum.

Two national technical workshops were coordinated by ABARES (November 2014 and May 2015), which included key stakeholders and experts in the recreational fishing sector and recreational fisheries management. The objectives of the first technical workshop were to:

- canvas views on objectives for national recreational fishing surveys

- identify common objectives for future national recreational fishing surveys

- identify constraints and preliminary options for implementing those surveys

- identify key elements of the process to design and cost the framework.

Prior to the workshop, key stakeholders were formally approached for their views on the objectives for regular national recreational fishing surveys and the types of information that should be collected as part of these surveys. Stakeholders then presented these perspectives at the workshop, which are summarised at Appendix A.

A second national technical workshop was held in May 2015, with the following objectives:

- review social and economic data needs (including recommendations of the social and economics expert forums)

- review preliminary results of the subprojects on survey methods, output specifications and costs

- review preliminary conclusions of the project on international initiatives to 'future-proof' recreational fishing surveys

- identify crucial attributes of the survey framework

- consider key requirements for finalising the framework and to implement regular national recreational fishing surveys

- consider the next steps, including an ongoing communication strategy, consultation and engagement.

Two subprojects were undertaken within ABARES. One of these subprojects investigated how to measure the economic contribution of recreational fishing, and undertook an exercise to apply a non-market valuation technique (the travel cost method) to an existing recreational fishing survey expenditure dataset. The outcomes of this work are included in Chapter 4 and a theoretical concept for assessing resource allocation issues and an analysis of the application of the travel cost method are included at Appendix B.

The second ABARES subproject analysed the social and attitudinal objectives and information needs of various stakeholders. Key components of this work are included in Chapter 4 and Appendix C.

These subprojects were supported by targeted expert forums to explore the economic and social objectives and information needs in more detail. These forums engaged technical experts and informed the concurrent development of national output specifications and associated approaches, methods and costs for implementing regular national recreational fishing surveys.

Three external subprojects were completed during the project. These were for the development of the scope, methods and costs of the (1) off-site and (2) on-site survey components (Chapter 7 and Appendix D), and (3) a literature review of international experience with recreational fishing surveys and how overseas jurisdictions are seeking to ensure repeatable methods for future recreational fishing surveys (Chapter 8 and Appendix E).

The outcomes of these technical workshops, forums and subprojects are embodied in the preferred survey approach and methods presented herein.

Review of this report was undertaken by the steering committee, state and Northern Territory recreational fishing survey managers, FRDC (including Recfishing Research and the Indigenous Reference Group), ARFF and key experts in survey design and methods. An internationally recognised recreational fishing survey expert—Mr Bruce Hartill from New Zealand's National Institute of Water and Atmospheric Research—undertook independent peer-review of the final report.

Communication strategy

ABARES developed a communication strategy and engaged a wide range of stakeholders during the project. Communication was targeted at various stakeholder groups, including recreational fishing industry representatives, the fishery managers who are largely responsible for jurisdictional survey design and implementation, policy and technical staff within the Department of Agriculture and Water Resources and the Australian Fisheries Management Forum. Social sciences, economics, statistics and database management experts from Australia and recreational fishing survey managers from New Zealand were also involved.

The communication strategy for the project included:

- regular project updates to the recreational fishing sector through ARFF, Recfishing Research and the Australian Fishing Trade Association

- regular updates to the Australian Fisheries Management Authority's recreational fishing forum

- promulgation of progress and results via state and territory fishery managers and researchers

- updates to meetings of the Australian Fisheries Management Forum and the December 2014 meeting of fisheries ministers.

In continuing the process of developing and implementing a national recreational fishing survey, the communication strategy will need to be continued and enhanced to ensure contact with relevant stakeholders before, during and after any national survey. This will engender ownership and acceptance by fishers and other stakeholders and will need to occur at relevant

jurisdictional and regional levels. A comprehensive communication strategy is essential for the success of any survey.

4   Survey objectives

High-level objectives

Stakeholders involved in the project, who included recreational fishery managers, scientists, technical experts and recreational fishing representatives, identified the following high-level aspirational objectives for regular national recreational fishing surveys:

- determine the participation rate in recreational fishing nationally, by states and territories and regionally, and profile the demographic characteristics of recreational fishers

- identify key species and quantify catch and effort of the recreational fishing sector nationally, by states and territories and, where appropriate, regionally

- assess economic activity by the recreational fishing sector nationally and, where appropriate, regionally

- assess the social contribution of recreational fishing, and fishers' attitudes to and awareness of issues relevant to fishing.

This information can be separated into three key areas: biological, economic and social (including demographic). The specific data needs and rationale for collecting this information is included below.

Biological objectives

Biological objectives and data needs for recreational fishing surveys, and the rationale for collecting this information, are well established (see, for example, Pollock et al. 1994; SDWG 1998; Griffiths et al. 2014). In brief, biological data are critical for informing day-to-day management of fisheries, for assessing and managing stock levels and for understanding catch composition and levels to inform resource access and allocation issues. Specific biological metrics to be collected as part of the preferred national survey approach are included in the survey output specifications (Chapter 7). Stakeholders consulted through this project agreed that biological data should include:

- species and numbers caught-and-retained and caught-and-released

  - finfish
  - non-finfish

- identification of targeted and 'iconic' species[3]

- identification of spatial and temporal patterns in catch and fishing effort

- size structure

- harvest weights.

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[3] 'These are species that are most highly valued by the recreational fishing sector, and may not necessarily be those species that are caught in the highest numbers.

Because of the complexity in collecting detailed size structure information for use in providing accurate harvest weight estimates, the method proposed for the preferred approach does not provide a cost for collecting this information. Consequently, it is anticipated that size structure and harvest weights would not be reported for most, if not all, species at the national scale. Because of differences in the availability of existing size structure data, geographical variation in species biology and different key species in different areas, the states and territories would be responsible for developing methods and costs for this component of any future national survey.

All other information should be collected at the national, state or territory, and where possible, regional scale. Robust information will be provided for species at broad scales but as data become limited for less common species, or fine scale precision decreases, then estimates will become less reliable.

Economic objectives

Economic data on recreational fishing can help measure the economic value of the sector and evaluate its contribution to the broader economy[4]. Economic data may also assist managers consider resource access and allocation between recreational and commercial fishers (and other resource users) and to assist in the management of, and investment in, recreational fishing by governments and other stakeholders. This is a complex area of public policy and a framework for considering economic information to inform such decisions is presented in Appendix B.

There is currently a lack of consistent and regularly collected economic data on Australia's recreational fishing sector. While some expenditure data exists at the jurisdictional level, a nationally consistent expenditure dataset has not been compiled for Australia's recreational fishing sector since the NRIFS. Attempts have been made to establish methods to value the sector (see, for example, Colquhoun 2013), although to date, these methods have not been widely adopted.

The economics experts' forum held by ABARES in February 2015 recognised that collecting expenditure data was the most feasible and cost-effective economic measure of recreational fishing for a national recreational fishing survey. Like commercial sector gross value of production (GVP), recreational fishery expenditure captures the sum of all the value added and all of the intermediate inputs used to produce the recreational fishing experience (that is, the economic output of the sector). Economic output is, however, not a measure of the economic contribution that a sector makes to the overall economy, measured in terms of contribution to gross domestic product (GDP). Here, only the value-added component of expenditure is relevant.

Expenditure data can be used for a range of purposes, including as an input to economic models to measure the regional or national contribution of recreational fisheries to income, employment, and the economy more broadly. A contribution analysis provides information on the relative economic size of a sector and the resulting flow of economic activity through the economy (Watson et al. 2007). Expenditure data are also an essential input to travel cost

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[4] The 'value' of the sector is a measure of social welfare and is measured using net economic value. The term 'contribution' refers to the gross change in the economy that can be attributed to a particular sector.

analyses, which is an economic valuation technique that is suited to measuring the use value of recreational fishing locations to users of those locations.

Expenditure data alone provide little information that could be used for determining efficient resource access and allocation arrangements between users, including recreational and commercial fishers. In the case of a resource sharing issue between two or more sectors, the net benefit of each sector in a particular area should be considered and evaluated to ensure that resources are allocated to their optimal use.

Estimating total economic value that the recreational fishing sector makes to a region's economy is complicated by the multi-faceted nature of the output that the sector produces. Commercial fishers produce goods that are traded on the market, where the market determines the food value of the fish produced. Conversely, recreational fisheries typically produce a recreational service where the value a fisher derives from participating in a fishing activity is a composite of a range of values, including the enjoyment of the outdoors, the satisfaction of catching your own fish, the food value of the fish caught, and so on. These values are non-market in nature and are difficult to measure in dollar terms. Importantly, fisheries resource users other than recreational fishers also share many of these non-market values.

The non-market nature of goods produced by fishing—particularly recreational fishing—makes it difficult to compare the economic value associated with recreational fisheries with the economic value of other sectors, including commercial fisheries. Making such comparisons between sectors requires an application of a non-market valuation methodology. A number of methods have been developed, as outlined in Table 3. Application of all methods outlined in Table 3 requires targeted economic research to tailor the method to a specific application.

Table 3 Non-market valuation techniques

Approach	Description	Advantages	Disadvantages
Revealed preference methods:	Estimate people's willingness to pay through observing their behaviours in markets of closely related goods	Relatively inexpensive to apply	Cannot measure non-use values Can only be applied if quantifiable relationship between non-market and market goods is observed.
Travel cost method	Uses information on travel costs to access the recreational value of a specific site	Based on actual market behaviour	Requires large sample size (e.g. 500–1000) Problems arise with accounting for multi-purpose trips, calculation of distance costs, holiday makers versus residents, substitute site, multi-destination trips
Hedonic price method	Based on the relationship between environmental attributes and property values	Uses individuals' actual choices	Cannot be used for all environmental goods Prone to biases

Approach	Description	Advantages	Disadvantages
Stated preference methods:	Survey based non-market valuation methods that involve asking people to state their preferences for different alternative outcomes of management or policy options	Can estimate both use and non-use values	Time consuming, costly

Requires large sample size (e.g. 300 but less than travel cost method) |
| Contingent valuation (CV) | In the CV questionnaire people are asked how much they would be willing to pay for a change in the quality or quantity of a resource | Can value both use and non-use values | Can value only a single alternative of policy or management change

Criticised for a number of biases such as: 'yea saying', strategic bias, and scope issues |
| Choice modelling (CM) | CM is form of conjoint analysis. In CM questionnaires, respondents are presented with a number of alternative resource allocations and asked to choose the preferred option. CM values the shift from the *status quo* to alternative management scenario. | Can value a number of alternative policy management options and a number of environmental and social attributes in one exercise

Overcomes all the biases issues of the CV method

Can take into account scope, scale and location differences

Respondents are not directly asked to state their values | Requires complicated survey design and modelling. |
| Other methods: | | | |
| Benefit transfer (BT) | BT is not a non-market valuation method; an approach that uses the estimated willingness to pay from one study and applies it to another study with similar characteristics | Does not require surveys

It is relatively inexpensive and can be easily applied | There must be close similarities between studies

Prone to generalisation error, publication bias

There are not many non-market valuation studies in Australia available to obtain the values |

Source: Mazur and Bennet 2008

One widely applied method to determine the economic value of recreational fishing is the travel cost method. However, the travel cost method underestimates the total net economic value as it only measures the use values. Despite this disadvantage, this method is relatively inexpensive and provides a good indication of potential non-market benefits of the recreational sector. The economics experts' forum discussed the possibility of cost-effectively augmenting expenditure

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datasets with the collection of additional travel cost information. With an adequate sample size, this could provide a basis for researchers to apply the travel cost method, potentially saving on costs of running a specifically tailored survey.

The values obtained from the travel cost method estimations may provide some information on the net benefits of recreational fishing in a particular location and could be used by researchers for non-market analyses of recreational fishing localities. In some instances, additional travel information collected may not be sufficient to carry out travel cost method estimations. Therefore, targeted non-market valuation studies may be required in specific regions to help with specific resource access and allocation issues. Nonetheless, the existence of a national expenditure dataset with adequate travel cost information would provide a baseline dataset to contribute to these additional studies.

Application of the travel cost method to the 2009–10 Northern Territory recreational fishing survey expenditure dataset

The investigation of economic objectives and data included a proof of concept exercise to apply the travel cost method to expenditure data from the 2009–10 Northern Territory recreational fishing survey (West et al. 2012) with the view to testing the feasibility of expanding the analysis options available from expenditure data to encompass economic valuation of the sector (Appendix B). The aim of the exercise was to test how the expenditure data collected by future surveys could be modified to enable application of a standard travel cost analysis. The exercise showed that at a relatively low cost, a slight modification of some questions and a few additional questions would assist with applying a standard travel cost analysis. One limitation identified was that for many locations, the number of responses collected as part of a national survey may be too low to allow application of the method.

Social objectives

Social objectives and associated indicators and data needs for recreational (and commercial) fisheries have historically been difficult to define (Pascoe et al. 2014b). Nonetheless, significant progress is being made in this area to allow social performance to be assessed alongside biological and economic objectives and to complement existing efforts towards ecologically sustainable development of Australian fisheries (see, for example, Pascoe et al. 2014b; Triantafillos et al. 2014; Brooks et al. 2015). These initiatives will increase the demand for data to inform social objectives and associated indicators.

Because demographic data collected through recreational fishing surveys are frequently used to stratify the Australian recreational fisher population to understand trends in participation, attitudes and awareness of issues related to fishing, these demographic data needs are better defined than those for other themes related to the social contribution of recreational fishing. However, the social objectives subproject recommended several additional demographic questions for inclusion in any national survey (Appendix C).

Six key themes related to the social contribution of recreational fishing were identified, and included:

- fisheries management and policy

- environmental attitudes and awareness

- the benefits of recreational fishing to individuals and families

- participation of recreational fishers

- demographics of recreational fishers and characteristics of fishing activities

- the contribution of recreational fishing to local communities.

To prioritise data collection, it needs to be clear why the data are being collected and how they will be used. Identifying the priorities for social data collection is challenging because there are multiple jurisdictions involved in fisheries management in Australia, and numerous recreational fishing sector bodies, all of whom have varying information needs at different scales of interest. Appendix C contains the rationale for collecting these data.

The criteria applied to these themes and sub-themes to prioritise social objectives and information needs included:

- addressing the information needs of a range of users, indicated by:

    - meeting data requirements of state and territory fishery managers, Commonwealth agencies and recreational fishing bodies

    - reflecting the November 2014 technical workshop's agreed objectives for a national survey ('social contribution—attitudes and awareness of fishers')

- producing a nationally relevant statistic, indicated by:

    - statistics that can be used at multiple scales (regional, state/territory, national)

- that information collected is comparable and consistent over time, indicated by:

    - standardised questions that are applicable across regions and state/territory boundaries with flexibility to adapt wording for specific issues to the jurisdiction

- that collection of this information is within methodological limits, indicated by:

    - the suitability for the data collection approach

    - the respondent group is recreational fisher households and fishers can answer the questions

    - the length of the survey not creating undue burden on survey respondents

    - other information sources are not already being available to fill the data gap (which could include, for example, licensing databases, compliance statistics, boat registration databases etc.)

    - data outputs being descriptive and appropriate to survey methods—rather than in-depth, analytical or experimental hypothesis testing, which would require qualitative or targeted research methods

    - availability of valid indicators to measure the concept.

Figure 1 summarises the results of the application of these criteria to the themes and sub-themes and highlights priorities. It is important to note that the process was undertaken to stimulate discussion, and priorities are likely to be refined in response to ongoing discussion with stakeholders before any national survey is implemented.

Figure 1 Proposed social data themes for national survey framework
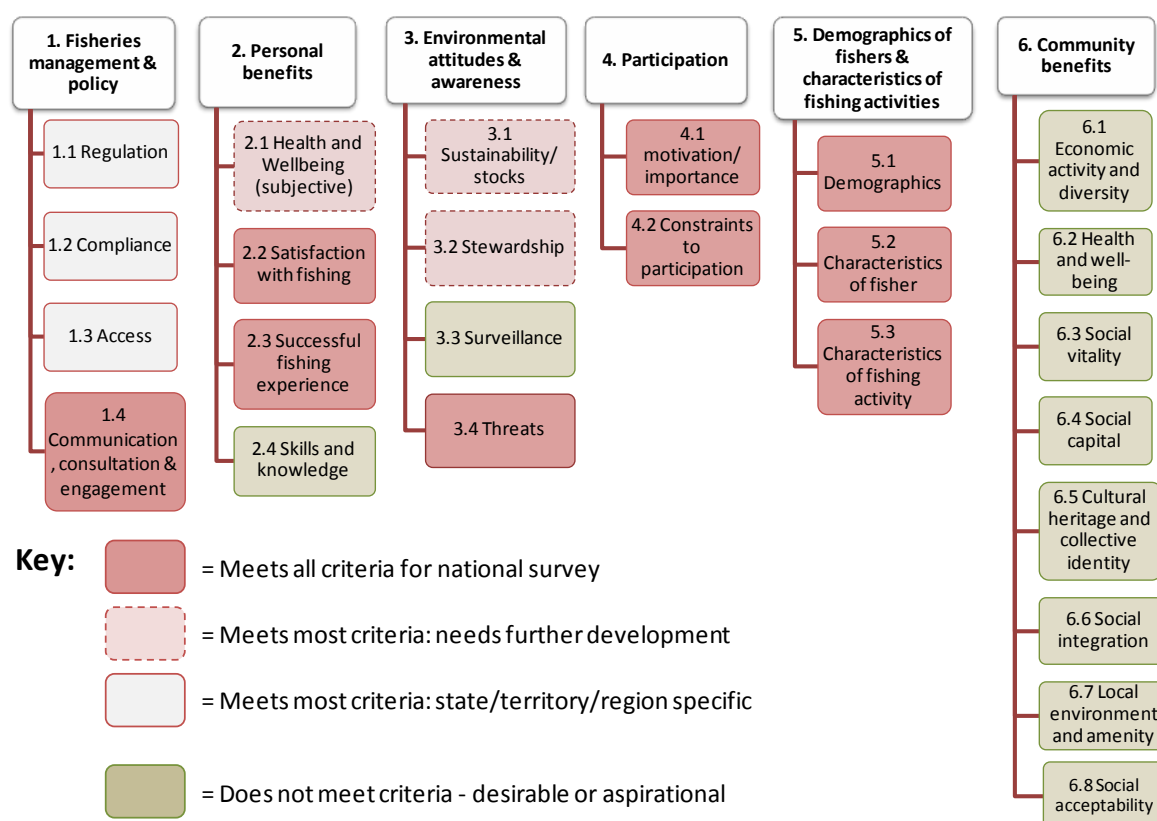
The subproject highlighted that the information collected by the methods proposed in this report would be limited by mainly collecting information on the social dimensions of recreational fishing from fishers themselves. Thus, as an example, the attitudes of the broader community towards fishers, fishing and fisheries management would not be captured as part of the proposed approach and associated methods. These types of information are classified under the 'Community benefits' theme; collecting information under these elements would require different methods and approaches that would explicitly seek to survey the broader community. Nonetheless, it was recognised that there could be some scope in certain components of the survey (for example, the initial White Pages® screening survey), in which respondents from the general public could potentially be asked questions to inform this theme and associated sub-themes.

As part of the identification of these elements, a series of questions was formulated that would be most relevant and useful at the national level. The 12 attitudinal and awareness questions most relevant at the national level are related to:

1) why people go fishing (motivations)
2) how important is fishing ('centrality to life'); and what activities could substitute for fishing
3) constraints to participation (i.e. what prevents people fishing)
4) fishing experience and ability
5) fisher risk-taking behaviour
6) what makes a successful fishing experience
7) preferred or trusted information sources about fishing
8) satisfaction with fishing
9) household seafood consumption (nutrition and food security)

10) subjective health and wellbeing outcomes: general life satisfaction; and the contribution of fishing participation to physical, mental and social wellbeing of fishers
11) learning skills and knowledge about fishing
12) threats to fishing.

Appendix C contains the complete series of attitudinal and awareness questions recommended for national recreational fishing surveys, including why the data would be useful and the source of the survey question or where it has been used before. These 12 questions were selected from a much larger set of possible questions covering the social dimensions of recreational fishing, based on the feedback and consultations received from stakeholders and on the objectives of the national survey.

It is assumed that social data items specific to state and territory information needs, which would mainly relate to day to day fisheries management, will be identified by the jurisdictional fisheries managers themselves and are therefore not included in the list of 12 national questions.

A detailed discussion of the rationale for, and prioritisation of, the themes and sub-themes outlined above is included in Appendix C.

5   Introduction to survey methods

The choice of recreational fishing survey method depends on various factors, including the survey purpose, the scale of the fishery, the available sampling frame or frames, the distribution or intensity of fishing effort and the types of fishing methods used by fishers (Hartill et al. 2014). A clearly defined sampling frame is particularly important because this is the population from which the sample is drawn. Examples of existing sample frames in Australia include the White Pages® directory, the New South Wales, Victorian and Tasmanian fishing licence databases or the Western Australian Recreational Fishing from Boat Licence database.

Inferences made from surveys that use these frames are only valid for that sampling frame (that is, the population) sampled. For example, without any auxiliary (supplementary) sampling, the results of a survey of White Pages® fishers are only valid for the population of fishers who are listed in the White Pages® and who responded to the survey. This is because other populations (for example, mobile phone-only users) may have quite different attributes. An ideal sample frame provides a complete list of those within a population who can be contacted and sampled, but full coverage of a population, such as might be achieved using face to face methods, is usually cost-prohibitive and impractical in most survey contexts. Discussion on the limitations of existing sampling frames is included in Chapters 8 and 9.

As well as the availability of sampling frames, the spatial extent of a fishery is an important determinant of the methods that can be used to assess it (Pollock et al. 1994; Hartill et al. 2014). Smaller-scale fisheries are most effectively assessed using on-site methods, whereas off-site methods are more viable at the state or national scale (Pollock et al. 1994). Sometimes combinations of off-site and on-site methods are used to validate results or to provide additional information, and to make surveys more cost-effective. Cost and complexity increase from mail surveys to telephone surveys to direct contact with fishers (Pollock et al. 1994). In addition to varying degrees of cost and complexity, each of these methods has benefits and drawbacks relating to the types of information that can be collected, the different levels of engagement with respondents, different response rates and the potential for different biases.

Off-site survey methods

Off-site surveys are usually conducted via mailing, diary or phone methods (or a combination of these methods) based on a sampling frame of fishers. The main advantages of off-site survey methods are that they can be used to survey a large number of fishers over large spatial and temporal scales. Generally, response rates to face-to-face and telephone surveys are higher than for mail survey methods because interviewers are able to build rapport with respondents. Accuracy may also be improved via direct contact with fishers.

One of the disadvantages of off-site surveys is that they often rely on public listings of telephone numbers. These databases are becoming increasingly incomplete as the proportion of households with landline telephones decreases (ACMA 2014; Hartill et al. 2014). This can be addressed in various ways, including by:

• assuming that there are no differences between fishers listed in these directories and those who are not

• adopting a licensing regime or register so that all fishers can be counted

• using a different method, for example face-to-face surveys

- • undertaking a separate study to ascertain the differences between listed and non-listed fishers and use the results to calibrate the survey.

Each of these options has pros and cons, but it appears that undertaking a separate study to assess any difference between listed and unlisted fishers is the most appropriate in the Australian context and would assist with ensuring the repeatability of national recreational fishing surveys. The other options are less attractive due to issues of lacking statistical robustness or trustworthiness (in the case of assuming there are no differences), lacking political support or unlikely to occur before a national recreational fishing survey is implemented (in the case of a national fishing licence or register) or being cost-prohibitive at large scales (in the case of implementing face-to-face methods). Further discussion of changes in telecommunications technology and the implications for obtaining a valid sampling frame is included in Chapter 8.

Other disadvantages of off-site surveys include that they can be affected by recall bias (see, for example, Lyle 1999) and non-response errors (see, for example, Tarrant et al. 1993; Fisher 1996). Non-response occurs when fishers simply do not want to participate in surveys (refusals), or if fishers may not be able to answer questions due to unavailability or other reasons such as language constraints. Mail surveys are a possible alternative to telephone surveys, but can result in biases because there is no mechanism (that is, a trained interviewer) to probe respondents and rectify misunderstandings that could arise from a mail survey. Additionally, responses to mail (and web-based) surveys tend to be related to survey content and hence are potentially biased (Fowler et al. 2002).

On-site survey methods

On-site methods are based on a sample of fishing locations and times. The sampling frame may be a lake, estuary, a particular fishery or a stretch of coastline, and the primary sampling unit is usually a survey day or hours. Fishers or fishing parties are usually counted and surveyed as they are fishing, or soon after, at key access points like boat ramps. The main advantages of on-site surveys are that data can be validated to some extent by interviewers, and as a result may be more accurate than if fishers reported the data themselves. On-site methods are generally more viable and cost-effective at small spatial and temporal scales. However, techniques such as aerial surveys can be used to cover large areas (for example, for estimating fishing effort), but these will usually need to be complemented by creel (on-site) surveys to determine species and to collect size structure information. On-site surveys can be used to validate components of the off-site survey methodology and by doing this, help to provide the most accurate expanded estimates of fishing effort, harvest (numbers of fish) and size structure information (Steffe et al. 2008).

Numerous factors, including the increasing incidence of 'catch and release' fishing in Australia (PIRSA n.d.; NSW DPI n.d.) and internationally (Bartholomew and Bohnsack 2005), may increase the effect of recall biases in off-site and on-site surveys of some fisheries or groups. Non-response biases, including refusals, may also occur. To ensure the highest response rates for off-site and on-site surveys, it is important to try to avoid conducting surveys when contentious fisheries policy or planning issues are prevalent in the media or within social groups in a particular area of interest (A. Steffe, personal communication, 2015).

Respondent-driven survey methods

Respondent-driven (or 'self-selecting') recreational fishing surveys and other data collection processes are increasing in popularity in Australia, particularly with recreational fishing

organisations (Wise and Fletcher 2013). Examples of these include online surveys sent out via existing networks or the use of smartphone applications. These surveys can provide information on catch rates, key species, expenditure, attitudes and so on. However, they are not representative of the general population of recreational fishers and cannot be readily extrapolated to the entire fishing population. These methods are often affected by non-response and avidity biases; the latter referring to a situation in which a disproportionate number of fishers may not be involved while a larger number of enthusiasts—with extremely high levels of avidity, including catch, effort and expenditure—may participate even though these enthusiasts only represent a limited percentage of the fishing population (McIlgorm and Pepperell 2013).

Despite these shortcomings, particularly over large spatial scales, some evidence suggests that more sophisticated respondent-driven survey methods may provide a statistically robust and cost-effective option for sampling elusive components of recreational fishing, such as in specialised sport fisheries (Griffiths et al. 2010). However, more recent research (Moore et al. in prep.) suggests that surveys that seek to sample elusive components of recreational fishing need to be tailored to the context, and may need to use a combination of off-site and on-site methods.

6   Implementation approaches

Preferred implementation approach and timeframe

The project explored several approaches for implementing regular national recreational fishing surveys. These were:

1) Regular temporal alignment of recreational fishing surveys conducted by Australia's states and territories (the preferred approach)

2) A centrally coordinated national survey undertaken independently from, or in place of, statewide surveys

3) A national survey of the social and economic contribution of recreational fishing undertaken independently from statewide surveys. This approach would only partially address the objectives.

The approach preferred by the majority of stakeholders involved in this project is to temporally align current jurisdictional surveys (approach 1) so that data can be aggregated to provide a statewide and national picture of recreational fishing. This approach would provide the most relevant, accurate and defensible data for use by key stakeholders for a variety of applications.

While it would be possible to undertake a national survey independently of these state and territory surveys (approach 2), such an approach may be impractical because of reduced buy-in from other jurisdictions. Furthermore, a centrally coordinated approach that is dependent on a significant injection of additional funding may not help to build a long-term legacy of cooperation and coordination.

Importantly, this project sought to develop a framework that could be applied to approaches 1 and 2. Consequently, the core survey methods proposed are applicable to both, but costs presented for these methods and components of details on project management and reporting may only be applicable to an approach that involved a centrally coordinated national survey. Similar to the NRIFS, both approaches would collect catch and fishing effort, social (including demographic, participation and attitudinal) and economic (expenditure) data that could be aggregated to form a jurisdictional and national picture of recreational fishing. Survey questions and some methodological components would be modified to account for changes that have occurred since the NRIFS, and to incorporate the findings of this project.

The preferred approach will require flexibility in the interval between national surveys in order to align with jurisdiction-based surveys and, as a result, a five-yearly timeframe outlined in the Australian Government's *Policy for a more competitive and sustainable fisheries sector* may need to be adjusted. As can be seen in Table 4, it may be impractical or unnecessary for some jurisdictions to undertake another survey sooner than 2017–18. Table 5 outlines the specific timelines for the survey approach, and includes additional work that would need to be undertaken before implementation of a national survey. This additional work is described in detail in Chapter 9 and estimated costs are provided in Chapter 10.

On the basis that the preferred approach (1) involves the alignment of state and territory surveys, and the differing timing requirements of the various jurisdictions, the suggested implementation timeframe is to seek to align all jurisdictional surveys in 2017–18. This would accommodate current survey processes and legislated requirements by some jurisdictions to report on components of their recreational fisheries. In reality, it may be likely that only a

number of jurisdictions will be able to align statewide surveys at this time. Additional funding may be necessary to ensure that all jurisdictions could commence a survey using consistent methods in 2017–18.

If full alignment of jurisdictional surveys is not possible in this timeframe, a commitment from all jurisdictions in subsequent years (for example, 2021–22 and 2025–26) would ensure that momentum towards national coordination and cooperation is maintained, and help to build on the legacy of the 2000–01 NRIFS, subsequent statewide surveys and the outcomes of this project.

Table 4 Timeline of jurisdictional-wide off-site recreational fishing surveys undertaken in Australia since 2000

-	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
National	A	A																D	D
NSW/ACT	A	A												A	A			D	D
Victoria	A	A					B	B										D	D
WA	A	A										C	C	C	C		C	C	D	D
SA	A	A						A	A					A	A			D	D
Tasmania	A	A						A	A					A	A			D	D
NT	A	A								A	A							D	D
Qld	A	A	A	A		A	A				A	A		A	A			D	D

A		Statewide phone–diary surveys
B		Statewide survey of licenced fishers
C		Statewide phone–diary surveys (boat-based fishing)
D		Recommended national survey implementation timeframe

Source: Adapted from Griffiths et al. 2014

Table 5 Proposed timeline for implementation of preferred approach

Development of methods, costs and implementation approach (this project)	2014–15
Further development*	2015–17
- Further investigation of 'hybrid' methodology	
- Develop plan for assessment of differences between White Pages® listed and unlisted fishers	
- In consultation with stakeholders, develop operational plan and data management strategy	
Survey implementation	2017–18
Analysis, reporting and promulgation of national results	2018–20

*Discussed further in Chapters 9 and 10

Project management and implementation

For both models—that is, a centrally coordinated approach or alignment of jurisdictional surveys—a national project manager would have primary responsibility for national survey results and would oversee administration, management, timelines and coordination of national analysis and reporting. A state or territory manager (to be appointed by the responsible agency in each jurisdiction) would be responsible for the survey in each of the jurisdictions involved (or in some cases, may be responsible for multiple jurisdictions). As for the NRIFS and subsequent New South Wales surveys, it might be possible for New South Wales to have responsibility for the Australian Capital Territory. The responsibilities of these state or territory managers would include management, recruitment and training of survey staff, if required. These survey staff would be responsible for interviewing, data entry and initial editing and tabulation of survey data. Analysis of data for each state and territory would be the responsibility of the jurisdictional project managers.

Reporting

A national summary report would be produced by the national project manager. It would describe survey methods and key results relating to the objectives to collect catch and fishing effort, social (including demographic, participation and attitudinal) and economic (expenditure) data at the national level. Individual jurisdictional or issue-specific reports would be the responsibility of the states and territories or other stakeholders. Ideally, these would be undertaken concurrently to a national report.

Metrics to be reported at a national scale would include the following:

- Recreational fishing participation
  - number of fishers
  - age and gender

- other characteristics, including boat ownership
- Recreational fishing effort
  - total effort
  - interstate fishing effort
  - fishing frequency
  - effort by water body type
  - effort by fishing method
  - effort by fishing platform
- Recreational catch (finfish and non-finfish)
  - total harvest (numbers)
  - harvest of key species (numbers) caught and retained and caught and released
  - release rates
- Expenditure by recreational fishers
  - attributable expenditure by regions
  - attributable expenditure by item/service category
- Fisher attitudes and awareness, including motivations for fishing.

Griffiths et al. (2014) investigated the development of a national recreational fishing data portal, which would allow public access to data to answer key questions about recreational fishing in Australia. The project developed a functional prototype that can be accessed at www.nature.cc/recfish/index.html. A data portal such as this would achieve a high level of transparency and ensure access to information for a wide range of stakeholders. It could also be strengthened by providing links to the *Status of key Australian fish stocks reports*, which are also available online at www.fish.gov.au. Such a resource would provide a valuable 'one-stop shop' for information on recreational fishing and the status of relevant Australian fish stocks provided that valid and robust procedures are applied along with key assumptions.

Alternative approaches

'Business as usual'

Despite some limitations, current state and territory surveys are generally fit for the fisheries management purposes for which they are intended, and are conducted on an as-needs basis and importantly, when sufficient funding and resources are available. However, as noted elsewhere, this approach would not provide some jurisdictions with information on the catch and effort from visiting (non-resident) fishers. As discussed by Griffiths et al. (2014), it is currently not possible to aggregate current surveys to provide a national picture of recreational fishing.

Research also indicates that it may be more cost-effective to collect some issue-specific or rare event information needed by some stakeholders using targeted surveys (see, for example, Griffiths et al. 2010; Moore et al. 2015, in prep.) or other studies undertaken independently from national, state and territory survey processes. A limitation of the proposed approach is that it may not collect some information at a sufficiently fine scale for use in spatio-temporally or issue specific applications.

National social and economic survey

Recognising that the resources to implement the preferred approach may not be available, a reduced national survey that only focuses on components of the objectives may be considered. A national social and economic survey (approach 3) could be undertaken separately from existing state and territory recreational fishing surveys. The advantage of this approach is that it may require significantly less resources than a survey that also aimed to collect catch and fishing effort information, and could potentially be undertaken sooner. This approach may satisfy the information needs of some stakeholders. However, it would not address crucial information gaps including the impact of recreational fishing on stocks that span jurisdictional boundaries, nor would jurisdictions be able to quantify effort moving between the states and territories (however, it should be noted that some more recent statewide surveys are collecting information on non-resident fishers). A key knowledge gap inherent in this approach is the inability to estimate the quantum of effort and catch by the recreational sector, which is key information in any genuine attempt to improve the management of fish stocks for all stakeholders involved in the use of a shared resource.

Longer-term alignment of jurisdictional surveys

Another approach, touched on above, is to consider longer-term alignment of jurisdictional surveys; for example, temporally aligning eastern and southern jurisdictions and then western and northern jurisdictions with a view to providing a national picture of recreational fishing at some point in the future. This could be facilitated by annual or biennial national reporting on the status of recreational fishing and fisheries in Australia. Similar to the *Status of key Australian fish stocks reports* (Flood et al. 2012; 2014), this approach would encourage consistent data collection and reporting. It would highlight data gaps and may help to build a long-lasting legacy for regular national recreational fishing surveys. However, without a coordinating role driving this process and adequate funding, it is unlikely that this approach would deliver well-coordinated data in perpetuity. The *Status of key Australian fish stocks* reporting process, for example, has so far required a $1.5 to $2 million resourcing contribution by the FRDC, ABARES and states and territories for each of the biennial (2012 and 2014) reports.

These approaches would result in the collection of information that is useful and relevant for different management objectives, for different stakeholders, and at a range of spatio-temporal scales. The preferred approach is the most feasible and cost-effective way to collect the high quality information required for improved management of fisheries resources shared between various stakeholders. The preferred approach would deliver information against the agreed national objectives. A comparison of these approaches is presented in Table 6.

Table 6 Comparison of recreational fishing survey approaches

Attributes	'Business as usual'	Regular national social and economic survey	Temporal alignment of jurisdictional surveys in 2017–18 (and regularly thereafter) OR centrally-coordinated national survey
Biological information	✓ (limited to state/territory and regional scales)	✕	✓
National scale social information	✕	✓	✓
National scale economic information	✕	✓	✓
Cost	High (>$8 m based on previous surveys)	Unknown – dependent on scale	$6–7 m for centrally-coordinated approach
Data accessibility and timeliness	Variable	High	High
Data uses	• Stock assessment • Resource sharing • Refining management measures • Informing infrastructure investment and development • Informing policy and communication	• Supporting recreational fishing bodies • Informing infrastructure investment and development • Refining management measures • Informing policy and communication	• Stock assessment • Resource sharing • Refining management measures • Supporting recreational fishing bodies • Informing infrastructure investment and development • Informing policy and communication
Repeatability	Variable	Dependent on available sampling frames	Dependent on available sampling frames
Ability to monitor trends over time	High if based on consistent method across surveys	High	High

7   Survey output specifications

Off-site survey components

Prepared by L. West, Kewagama Research

The information presented in this section is a summary of the full output specifications document included at Appendix D.

Introduction and key assumptions

The following information was prepared to facilitate broad design and costing of a telephone–diary survey to provide direct comparability with the NRIFS, together with improved data quality and utility as required. Representatives from the various jurisdictions and stakeholder organisations were encouraged to use this document as an initial platform to provide comments in terms of their data needs and priorities.

As agreed after the November 2014 workshop, the proposed overall methodology for the survey is effectively identical to that employed in the telephone–diary survey component of the NRIFS and the various statewide surveys conducted since then. Importantly, this choice of method reflects an acknowledgment that the methodology is highly effective and appropriate. The greatest concern in terms of the future repeatability of this methodology relates to the coverage and cost-effectiveness of appropriate sampling frames.

Various technological advances in data collection methods for off-site surveys were considered through this work. For example, for some time now, Computer Assisted Telephone Interview (CATI) systems have been used successfully in recent recreational fishing phone–diary surveys in Western Australia and New Zealand. It is envisaged that a CATI system of some kind would be employed in parts of the screening and diary phases of a future national survey, whether it is in the form of temporal alignment of statewide surveys, or centrally coordinated. Further to this, the use of text messaging (as per the recent New Zealand survey) for parts of the diary survey (for example, 'Y/N' for any monthly fishing activity) were explored.

Given the separate work to identify objectives and information needs for economic (Chapter 4; Appendix B) and social (Chapter 4; Appendix C) aspects of recreational fishing surveys, the survey components and data elements in this document are largely focused on collection of participation, catch and fishing effort data. However, fishing-related expenditure, attitudinal data and various social dimensions are broadly discussed.

National survey objectives

For the resident population of Australia (private dwellings only), the objectives of the survey are to quantify recreational fishing in terms of:

- participation rates and numbers among various population sub-groups, together with other profiling data

- annual catch, effort and catch per unit effort for the main target fish and other species

- annual expenditure directly-attributable to recreational fishing

- fisher awareness and opinions on fisheries-related issues.

These objectives largely align (and data would be directly comparable) with the NRIFS.

Survey scope and other criteria

Geographic scope

The geographic scope of a national survey would incorporate the whole of Australia, including offshore islands and seaward to the Australian Exclusive Economic Zone boundary.

Households in scope and primary sampling unit

The primary sampling unit (PSU) for the survey would be the 'private dwelling household' (Australian Bureau of Statistics definition).

People in scope and age criteria

Residents are defined as having their usual place of residence in Australia (private dwellings with a landline telephone connection) and would be in the scope of the survey. Residents of non-private dwellings are out-of-scope and currently account for around two per cent of the total resident population. Overseas visitors are defined as having their usual place of residence overseas and would be out-of-scope. Three age criteria would be applied in relation to survey information for residents: (i) all ages for total population/benchmarking purposes; (ii) those aged 5 years or more for recreational fishing assessment; and (iii) those aged 15 years or more for any awareness and attitudinal questioning.

Activities in scope

For all survey purposes, recreational fishing is to be defined as any attempted harvesting (or release) of aquatic animals for non-commercial purposes, including line fishing, prawning, crabbing, spearfishing, or collecting oysters or aquarium fish. Commercial fishing activity and Indigenous customary fishing would be excluded from the survey scope, noting that any recreational fishing by a commercial or Indigenous fisher would be within the scope of the survey.

Three terms would be applied to catch information: (i) catch—all aquatic animals captured whether harvested or released; (ii) harvest—the retained component of the catch; and (iii) released—the released component of the catch.

Temporal and other scope

Recreational fishing participation would be assessed on a 'previous 12 months' basis prior to the screening survey and also for a defined 12 month period immediately following the screening through the diary survey. Detailed fishing activity would be collected for the diary period, including for all day/night fishing, platforms and water bodies. Fishing-related expenditure data would also be collected for the 12 month diary period.

Survey components

As for the NRIFS and all subsequent statewide surveys, the off-site survey methodology would comprise four key survey components (Figure 2), with all interviews routinely conducted by telephone. The four key survey components are:

1) Initial screening survey—principally to measure participation and identify 'intending fisher' households for the diary phase

2) 12-month diary survey—to collect detailed catch, effort and expenditure data from diarist households

3) Wash-up survey—conducted among all diary households at the end of the diary period, principally to provide awareness/attitudinal and additional profiling and expenditure information

4) Non-intending fisher follow-up survey—conducted at the end of the diary period, among a relatively large, stratified sample of non-diarist households from the original screening to assess unexpected fishing activity and to 'round-out' participation assessment for the diary period.

Figure 2 Schematic showing survey components
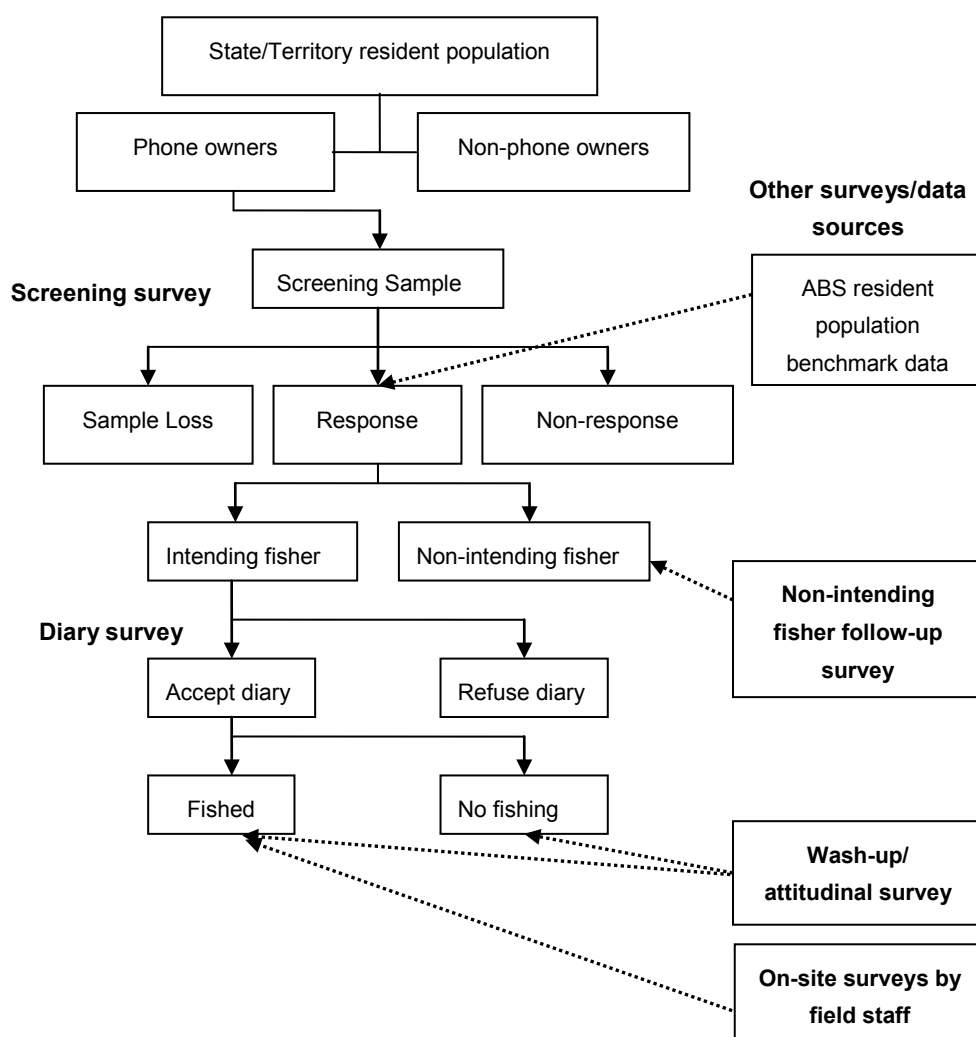
Source: Kewagama Research
Note: Phone owners refers to the population living in households with a publically listed landline telephone.

Data elements

The output specifications document was written primarily for those with direct expertise in survey design and implementation. Accordingly, various attachments to assist the reader were provided with the draft document. These included a range of survey questionnaires from the NRIFS and subsequent statewide surveys. These have not been provided as physical attachments to this report due to their technical nature and also because of intellectual property considerations. However, if required, this documentation can be provided digitally by ABARES on request.

Screening survey

A number of data elements are proposed for inclusion in the screening survey (additional detail for these is included in Appendix D):

(a) Household-based data

1) Response status

2) Number of usual residents (all ages)

3) Boat ownership.

(b) Person-based data—all households

1) Age at last birthday

2) Sex (M/F)

3) Within-household relationship.

(c) Persons aged 5 years or more—all households

1) Recreational fishing in the home state or territory in the previous 12 months

2) Recreational fishing elsewhere in Australia during this time

3) If fished anywhere in Australia in the previous 12 months, an assessment of 'avidity' (separate days fished)

4) Regardless of previous fishing activity, an assessment of intention to fish in Australia in the coming 12 months (the diary period). This question is the basis for inviting households to take part in the diary survey.

(d) Other data for persons aged 5 years or more—fishing households only

1) Membership of a recreational fishing or diving club or association.

(e) Diary survey invitation—intending fisher households

All households where one or more members aged five years or more report an intention to fish in the coming 12 months would be invited to take part in the 12 month diary survey. Those agreeing to take part (usually over 90 per cent) would then be sent a diary survey kit.

(f) Person-based data elements excluded (that is, not repeated from the NRIFS)

The following data elements are recommended for exclusion from the screening survey. However, some of this information could be collected at a later stage, if required:

1) Aboriginal and Torres Strait Islander origin—it is proposed that this information is collected during the diary survey

2) Recreational fishing licence holding—this questioning has been excluded from all statewide surveys since the NRIFS because of sensitivity issues in terms of perceptions of compliance assessment

3) Main language other than English spoken at home—Since the NRIFS, this question has been excluded from most of the later statewide studies, following various data utility assessments

4) Labour force status/occupation type/highest level of education attained—the ultimate utility of these data arising from the NRIFS was limited. However, the opportunity exists for inclusion of these data elements in the wash-up survey, if required, or for any other social dimensions assessment work

5) Specific questions to include or exclude temporary residents of households.

Diary survey

The sole criterion for a household's inclusion in the diary survey is an intention to recreationally fish in the diary period. While a majority of intending fishers ultimately do fish in the period (close to 80 per cent in the NRIFS), a minority do not. In the survey expansion process (which it is proposed will use the *RecSurvey* analysis package), these are referred to as the 'drop-outs'. On the other hand, a small minority of non-intending fisher households unexpectedly fish during the period (the 'drop-ins') and these are assessed through the non-intending fisher follow-up survey.

During the diary survey, interviewers would maintain regular contact with diarist households. At each contact, the interviewer routinely records any fishing and expenditure activity since the last contact and identifies any planned fishing activity for the near future.

Data elements for the diary survey are discussed below.

(a) Fishing data

For each fishing event, a range of fishing data would be collected, as detailed in Appendix D.

(b) Fishing-related expenditure data

Depending on ultimate needs, fishing-related expenditure can be readily collected during the diary survey. Appendix D contains more detail on how this is done.

Additional data elements may be required for the proposed survey in terms of any 'travel cost' assessment (see Chapter 4 and Appendix B).

It is proposed that sub-sampling within the diary phase be undertaken for expenditure data collection. For example, it may be that the required precision for such data could enable stratification of all diarist households into (say) four groups, where each would provide expenditure data for a different three month period within the 12 month diary period. This is potentially important to achieve high response rates (that is, by limiting respondent burden) and would reduce overall survey costs. Modelling (power analysis) may be necessary to determine suitable sub-sampling rates.

Wash-up survey

No detailed output specifications for the social dimensions component of the survey have been included here. However, the now standard wash-up survey has provision for the 'core' national questions identified in Appendix C. The standard wash-up survey also enables appropriate jurisdiction-specific questioning to be included (as for the NRIFS).

Jurisdiction-specific questioning does not need to be fully specified at this stage; rather, an agreed amount of 'average interview time' and specification of the kinds of information that can

(or cannot/should not) be assessed through this survey component. Furthermore, potential exists for customised 'follow-up' surveys of the social dimensions of recreational fishing.

An absolute maximum average interview time of around 13–15 minutes is recommended in order to limit respondent burden and achieve high response rates.

Depending on ultimate data needs, seven broad data components might be required:

1) Firstly, the need to verify the recreational fishing behaviour of all household members for the diary period

2) Additional expenditure data and verification for large-scale/less-obvious/annual items

3) Boat profiling information for all boats owned by the household

4) 'National' awareness/attitudinal questioning—for all jurisdictions

5) State and territory-specific awareness/attitudinal questioning

6) 'Open-ended' questioning to enable respondents to 'have their say' on issues of concern to recreational fishing or to provide suggestions

7) A final question sequence to assess whether and how respondents would like to receive a copy of the survey results and their availability for re-contact at a later stage.

Examples of questioning for all the above components are contained in various wash-up survey questionnaires, examples of which can be provided by ABARES on request.

Non-intending fisher follow-up survey

The non-intending fisher follow-up survey provides an assessment of unexpected fishing activity in the diary period. The resultant 'drop-ins' provide a counter-balance to the 'drop-outs' from the diary survey (those who unexpectedly did not fish) and therefore an overall participation estimate for the diary period. Whilst relatively low levels of unexpected fishing invariably emerge from these follow-up surveys, the large populations and expansion factors involved necessitate quite large sub-samples to reduce the standard error levels for ultimate participation assessment. In all subsequent statewide surveys, minimum samples of around 20 per cent of households have been drawn to achieve this. Data elements for the non-intending fisher follow-up survey are detailed in Appendix D.

On-site survey components

Prepared by A. Steffe, Fishing Survey Solutions

Introduction

This section presents the rationale for the selection of appropriate probability-based survey methods, output specifications and costing considerations for the two key on-site components that were identified at the national technical workshop held in November 2014.

The two key on-site components covered are:

1) on-site validation of the telephone–diary core methodology

2) on-site collection of size structure information to be used in converting off-site derived estimates of harvest numbers into estimates of harvest weight.

On-site validation of the telephone–diary core methodology

Need for validation study

The on-site validation study is needed for two main reasons:

1) Enhancing the scientific credibility of the results provided by the off-site telephone–diary methodology

Data recorded using off-site methods are self-reported, subject to various potential biases, and it is assumed that the estimates derived from these methods are accurate. There are no published validation studies examining the accuracy of the telephone–diary method for estimation of recreational fishing activities within Australia.

The recently completed nationwide panel survey of over 7000 marine fishers in New Zealand used meshblock-based face-to-face recruitment of panellists, a frequent and adaptable contact regime, and a structured questionnaire administered by telephone to record fishing details (Wynne-Jones et al. 2014). On-site surveys implemented at the same time as the nationwide survey were used to corroborate the results from the off-site panel methodology. However, it must be noted that the off-site methods used in New Zealand differ from the telephone–diary approach that is proposed herein. That is, the two studies used different sample frames that vary in their coverage of the fishing population to recruit panellists. This means that the findings of the on-site corroboration work done in New Zealand cannot be assumed to apply to the telephone–diary work previously done and planned for the future national survey in Australia.

Therefore, it is vital to design and implement an appropriate validation study to test the accuracy of the off-site estimation of recreational fishing activities in an Australian context.

2) Improving stakeholder acceptance of the results

Many recreational stakeholders, peak representative groups and fisheries managers have expressed concerns regarding the accuracy of the findings from the NRIFS. These concerns could be addressed directly by designing and implementing a validation study to assess the accuracy of the telephone–diary methodology results. In turn, the results from a validation study would be useful for demonstrating the utility of the off-site methodology and thereby improving stakeholder acceptance of the results.

Key concepts

Primary sampling unit

The PSU is the basic unit of replicate sampling for a probability-based survey. Each PSU must be selected *a priori* with a known (non-zero) probability from a sample frame before sampling commences. The PSU for the on-site component is the daylight period of a day (calendar date). The PSU for the off-site component is the private dwelling household.

Validation study

A validation study is a term that can be used to describe when two or more independent methods are used to estimate some population parameter and one method is used as a 'gold standard'. The estimates derived from the 'gold standard' method are then used to evaluate potential bias in the estimates from the method requiring validation and possibly provide a correction factor for any bias. A 'gold standard' survey provides estimates of superior quality, which serve as reference points, against which other estimates from different surveys may be compared.

Corroboration study

A corroboration study is a term that can be used to describe when two or more independent methods are used to estimate some population parameter and none of the methods used can be regarded as a 'gold standard'. The estimates derived from the different methods are then compared and their similarity is assessed relative to a predefined range of acceptable difference.

Features of a practical 'gold standard' method

Ideally, a 'gold standard' method would provide a census of the population with no measurement error. However, this is too costly or logistically impossible to implement in most cases. These are the same reasons that led to the development of sampling theory and a greater reliance on probability-based sample surveys (Cochran 1977; Groves et al. 2009; Thomson 2012).

The only practical solution is to design an on-site probability-based survey and implement the survey such that it minimises all sources of potential bias. This type of 'gold standard' survey has the following features:

(a) Data can be verified by direct observation and contact with potential fishing parties

Highly trained field staff can provide high-quality identification, counts and measurements of harvested fish. Similarly, field staff can validate the activities (fishing and non-fishing) of parties returning to access points.

(b) Full spatial coverage of selected fishery

All access points to the fishery should be included in the survey coverage. Unequal selection probabilities can be used to allow coverage of low usage access points.

(c) High level of sampling intensity (temporal coverage across PSUs)

Large sample fractions should be used to protect against random sampling artefacts that can occur when sample sizes are small. The reliance on data expansion decreases as the sample fraction of full PSUs increases. Larger sample fractions (assuming measurement error is absent) provide benefits to the accuracy and precision of survey estimates. It must be noted that there will be a trade-off between cost and the level of sampling intensity achieved.

Alternatively, the coverage across PSUs can be maximised by collecting auxiliary data on non-scheduled survey days and then using a double sampling approach to incorporate these data into the estimation procedure (Cochran 1977; Steffe et al. 2008; Thomson 2012). It costs less to collect auxiliary data on additional days as opposed to increasing the sample size of PSUs.

(d) Full coverage of the PSU for fishing effort and harvest estimation

The coverage within PSUs should be complete to eliminate another source of potential bias (that is, internal expansion of PSU data to provide estimates of full PSUs). This means that it would be preferable to select a survey method that does not use (or minimises) internal expansion of PSU data.

Validation compared to corroboration

Figures 3 and 4 provide a graphical representation of the potential difference between a validation study and a corroboration study. The example in Figure 3 shows a 'gold standard' method (denoted by z) has produced data that tightly cluster around the real population

parameter (denoted by the centre of the target). The data from the second survey method (denoted by x) show a similar distribution and are also clustered around the real parameter value. In this example it can be said that the second method has been validated by the 'gold standard' method.

In contrast, the example in Figure 4 shows that the data from two independent methods have similar distributions and that these methods provide similar estimates of some population parameter. However, both methods provide biased estimates of the real population parameter (that is, they have missed the target). In this example, it can be said that the second method has been corroborated by the first method. The issue arising from this example is that unless the real value of the population parameter was known beforehand it would be likely that the investigator would conclude that the two methods have produced consistent and unbiased estimates of the population parameter.

Figure 3 A graphical representation of data from two independent surveys that have been used in a validation study
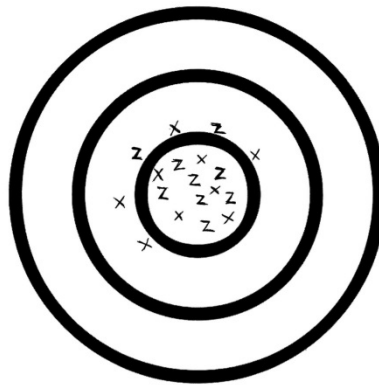
Note: z denotes data from the 'gold standard' survey; x denotes data from survey 2. The centre of the target represents the real population parameter that is being estimated by the two surveys.
Source: Fishing Survey Solutions

Figure 4 A graphical representation of data from two independent surveys that have been used in a corroboration study
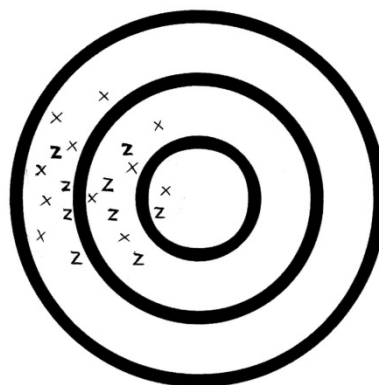
Note: z denotes data from the "gold standard" survey; x denotes data from survey 2. The centre of the target represents the real population parameter that is being estimated by the two surveys.
Source: Fishing Survey Solutions

The distinction between a validation study and a corroboration study is important because the utility of the data collected by these different comparative methods will influence:

- assessment of accuracy and precision
- effectiveness of future management responses
- stakeholder acceptance of survey results
- survey output specifications
- survey cost.

Information that can be validated

A properly designed and implemented validation study can provide validation of some, but not all, data elements collected during the survey. Information that can be validated during an on-site survey includes:

- expanded estimates of fishing effort
- expanded estimates of harvest (number of fish)
- size structure information.

These data need to be correctly weighted taking the sample selection probabilities into account.

Information that can be corroborated

A properly designed and implemented validation study can corroborate:

- expanded estimates of fish released
- expanded estimates of economic expenditure or other economic variables
- expanded estimates of social/attitudinal/opinion data

The data used to derive these expanded estimates are self-reported and they do not need any adjustment for respondent avidity.

- average number of fish released per party or fisher
- average expenditure per party or fisher
- average perception (for example, attitude) or average opinion per party or fisher.

The data used to derive these average estimates are self-reported. Corroborative comparisons of averaged data collected by on-site methods to similar data collected by off-site methods would require that the on-site data be corrected for differences in respondent avidity.

Rationale for designing and implementing a validation study

The rationale of the validation study is to test for any methodological bias that may exist in the proposed off-site method. The intention is to implement a well replicated validation study that strictly controls variables that could introduce bias into estimates from either the off-site or on-site survey components of the validation study. The value of this approach is that variables that could confound the survey comparisons are removed thereby allowing better interpretation of any comparisons made between the estimates derived from the different methods. This does not mean that the selected fishery is atypical or unrepresentative of other regional fisheries. The selected fishery still has many of the same characteristics as other regional fisheries and we are better able to control some variables that may confound the interpretation of methodological comparisons. That is, we are better able to make 'apple-with-apple' comparisons between methods and investigate any potential methodological biases.

Controlling variables that may introduce bias

It is important to state that the validation study is mainly focused on testing for any methodological bias that may exist in the off-site method used to provide statewide and national estimates of recreational fishing activities in Australia. Thus, it is vital that the validation study is designed and implemented to control for the effects of variables that may introduce bias into either the off-site or on-site components of the validation study. There are two main types of issues that need to be addressed for the successful implementation of a validation study. These are:

a) the selection of an appropriate fishery. The challenge is to identify a fishery in which it is possible to control the effects of variables that may introduce bias into either the off-site or on-site estimation process. A list of selection criteria is provided in Table 7; and

b) the matching of the scope and output specifications for the off-site and on-site survey components to achieve meaningful comparisons. Table 8 provides a summary of these matching issues.

Table 7 Fishery selection criteria for identifying a suitable regional fishery for validation

Fishery selection criteria	Comments
1) Non-specialised fishery with a large level of fishing effort and harvest	Need sufficient data to allow robust comparisons between methods
2) Very high level of public access to fishery	On-site coverage is affected by amount of private access to fishery
3) Relatively few access points	On-site coverage is easier and cost-effective
4) Large resident population	Allows inclusion of additional diarists to enhance statistical power of off-site component
5) Low proportion of non-resident fishers	Regional off-site survey cannot provide coverage of this group
6) Cost effectiveness	On-site sampling is not done in remote locations

Table 8 Scope and output criteria for the off-site and on-site components of the validation study

Scope and criteria	Off-site component	On-site component	Comments
Spatial coverage	Regional	Regional	Matching coverage
Temporal coverage	1 year	1 year	Matching coverage
PSU	Private dwelling Household	Day (Calendar date)	Restrict coverage to daylight hours

People in scope	Residents within region	Residents within region	Matching coverage
Age Criteria	5 years or older	5 years or older	Match to off-site output specification
Activities in scope	Line fishing, spearfishing, bait collection	Line fishing, spearfishing, bait collection	Match to on-site output specification
Fishing effort	Trips, Party hours, Fisher hours	Trips, Party hours, Fisher hours	Matching units
Harvest	Main groups	Species	Species can be aggregated to main groups
Released component	Main groups	Main groups	Match to off-site output specification

Sample sizes

There is an inherent risk that a validation study may produce an equivocal result because of a lack of statistical power to detect a meaningful methodological difference between the two methods. This can occur because of low sample sizes in either the on-site or off-site components. The solution is to: (a) increase the sample size for the on-site component (that is, add additional survey days); and (b) increase the sample size of the off-site component (that is, add additional diarists within the regional area of the validation study). It would be prudent to err on the side of over-sampling (thereby increasing the overall cost of the validation study) than to err on the side of under-sampling (thereby expending all of the resources without achieving a defensible result). Final decisions regarding sample sizes can only be made after selection of the regional fishery for validation is confirmed. Informed decisions regarding sample sizes (cost-benefit analyses) would be possible by a re-examination of any previous survey data collected from the selected regional fishery.

Selection of fishery for validation study

Participants engaged in the national technical workshops were emailed a list of selection criteria (Table 7) and asked to nominate any regional fisheries within their jurisdiction that met the criteria. A discussion of the suitability of the nominated regional fisheries was held at the second workshop.

Two candidate fisheries were identified: (a) a coastal marine trailer boat fishery in the Illawarra region of New South Wales; and (b) a coastal marine trailer boat fishery in the West Coast Bioregion of Western Australia. Previous survey information that can be used to determine appropriate sample sizes has been collected in both regional fisheries.

The preferred option for a validation study is the Illawarra fishery in New South Wales because it better meets the validation study criteria and there is no need for any within-PSU expansion of on-site survey data. It would also be cheaper than undertaking the validation study in the West Coast Bioregion because of the different characteristics of the two regions.

Selection of on-site methods for validation study

A brief description of various on-site survey designs and their associated estimation methods is provided in Table 9. More detailed descriptions of these methods and their estimation methods can be found in various publications (Cochran 1977; Pollock et al. 1994; Steffe et al. 2008; Thomson 2012). A comparison of the on-site survey design options is provided in Table 10. The roving survey design, complemented roving-access design, any design that uses multi-stage sampling, and the bus route design all rely on expansion within the PSU as part of the estimation method used. This means that these designs are not potentially as good as designs based on traditional access point methods for providing a 'gold standard' method. The supplemented access point method is the preferred survey option because it is an improvement to the traditional access point method and uses a double sampling approach to provide increased coverage of the temporal sampling frame for fishing effort (Steffe et al. 2008). Web cameras will be used to census (assuming equipment failures do not occur) the fishing effort at all access sites. Validation of the web camera images will be derived from direct observation on scheduled survey days and this will provide the correction factor for non-fishing trips. The supplemented access point design also improves the accuracy and precision of harvest estimates because the estimation of harvest and its precision incorporate the improved measures obtained for fishing effort and its variance. A detailed description of this method and the estimation procedures used can be found in Steffe et al. (2008).

Table 9 Characteristics of various on-site survey designs

Survey design	Survey method	Description of estimation method	References
Roving survey design	Roving(Effort) Roving(Harvest)	Effort estimation derived from instantaneous counts, progressive counts or time interval counts. Harvest rate estimation based on interception of fishing trips in progress.	Pollock et al. 1994
Complemented design (roving-access)	Roving(Effort) Access(Harvest)	Effort estimation derived from instantaneous counts, progressive counts or time interval counts. Harvest rate estimation based on data from completed fishing trips.	Pollock et al. 1994
Multi-stage sampling design	Access(Effort) Access(Harvest)	Effort and harvest can be estimated by direct expansion within PSU and then within strata. Stratum totals are added to obtain final population estimates.	Pollock et al. 1994
Bus route design	Access(Effort) Access(Harvest)	Effort and harvest can be estimated by direct expansion within PSU and then within strata. Stratum totals are added to obtain final population estimates.	Pollock et al. 1994
Traditional access	Access(Effort)	Effort and harvest can be estimated by direct expansion within strata.	Pollock et al.

| point design | Access(Harvest) | Stratum totals are added to obtain final population estimates. | 1994 |
| Supplemented access point design | Access(Effort) Access(Harvest) | Extension of traditional access point design. Auxiliary data used to increase coverage of temporal sampling frame for fishing effort and are validated on scheduled survey days. Double sampling approach improves relative accuracy and precision of fishing effort and harvest estimates. | Steffe et al. 2008 |

Table 10 A comparison of on-site survey designs with respect to their ability to meet the features of a 'gold standard' method

Features of a practical 'gold standard' method	Roving survey design	Complemented roving-access design	Multi-stage sampling design	Bus route design	Traditional access point design	Supplemented access point design
Data can be verified by direct observation and contact with potential fishing parties	Yes	Yes	Yes	Yes	Yes	Yes
Full spatial coverage of selected fishery	Yes	Yes	Yes	Yes	Yes	Yes
High level of sampling intensity (temporal coverage across PSUs)	Yes	Yes	Yes	Yes	Yes	Yes
Full coverage of the PSU for fishing effort and harvest estimation	No	No	No	No	Yes	Yes

Survey costs

The high level of rigor provided by a validation study comes with a relatively higher cost when compared to a corroborative study. It should be noted that a 'gold standard' survey can be reduced to a corroborative survey if sampling intensity is too low or if sampling biases are not strictly controlled. Even the best survey design can be undone by high levels of non-response,

which could, for example, occur if the validation survey is implemented when a contentious management issue is being debated within the recreational sector.

Costs (GST inclusive) for the validation study were estimated and ranged between ~$400 000 (for a three-site, six-month, six survey days per month survey) to over $1 million (for a six-site, 12-month, eight survey days per month survey). The option that represented best value for money was for a $595 000, three-site, 12-month, six survey days per month survey.

Regional differences in fisher behaviour, attitudes and regulations

Regional differences in fisher behaviour, attitudes and regulations would not be expected to change the relative effectiveness of the off-site and on-site survey methodologies. Therefore, it does not matter in which region the validation study is done. However, it is still vital that the validation study must have high levels of replication and be designed to strictly control potential sources of bias so that comparative results are unambiguous.

There is no evidence to expect that misreporting rates would vary regionally or spatially in some systematic manner. Contentious management decisions (for example, regional implementation of Marine Parks) would be expected to increase the level of non-response for both off-site and on-site surveys but not the rate of misreporting from only one sampling method. Secondly, this problem (if real) has not arisen because of a deficiency in the inherent logic of the standard sampling protocols or estimation procedures used in the off-site methodology. Instead, the focus of investigation should be to examine if differences exist in the application of the off-site survey instrument in different regions. Thirdly, the validation study was not designed or intended to detect or explain regional differences in the potential mis-application of the off-site survey instrument. Implementing multiple regional corroborative or validation studies would not provide any additional insight regarding this issue.

Acceptable effect size

Opinions from the project working group on an acceptable effect size to be used as a benchmark for comparisons between estimates derived from the off-site and on-site survey were requested but were not received before publication of this report. Consequently, the recommendation for an acceptable effect size is 10 per cent.

Power analyses

The supplemented access point survey method has been recommended for the on-site component of the validation study. This method will use web cameras to census fishing effort at all access points. There is no need to undertake power analysis for fishing effort. Harvest rate information will be collected at the access points. It would be useful to undertake power analysis for determining the number of days to be sampled. However, it is known that harvest rates can change annually and this would also change the among day variances. Power analysis assumes that the variance between periods or studies is constant. This means that the results from the power analysis should be treated cautiously providing only a general indication of the level of sampling required. Similarly, results from a power analysis to determine the optimal level of sampling for the off-site diary component within the region should be treated cautiously.

Recommendations for validation study

- A validation study that uses an on-site 'gold standard' survey method should be implemented.
- The preferred survey method is a supplemented access point design that uses web cameras to collect auxiliary information at all of the access points.

- The coastal marine trailer boat fishery in the Illawarra region of New South Wales is the preferred fishery for the validation study. This regional fishery in the Illawarra is the best fit to the fishery selection criteria that were used to assess the feasibility of controlling variables that may introduce bias into the validation study.

- Effect size for the comparisons of fishing effort and total harvest (all species combined) should be set at 10 per cent.

- Simulation study to confirm the above.

On-site collection of size structure information

Need for robust and defensible weight estimates

It is important to have robust and defensible estimates of the biomass of fish taken by the recreational sector for a variety of reasons that include:

- the assessment of sustainability of recreational only and shared fisheries

- the allocation of fisheries resources among between and within sectors

- as input data for stock dynamics models.

The telephone–diary core methodology collects information on the number of fish harvested. This methodology does not provide an unbiased metric of fish size (that is, either length or weight). This means that an unbiased estimate of average weight (for main groups of species) is needed to convert the numbers of fish harvested into estimates of the biomass of fish harvested. Currently, this unit conversion issue is addressed in various jurisdictions by using information from a variety of convenient sources. Possible bias resulting from this conversion requires ongoing investigation.

Size information that needs to be collected

Ideally, weight information could be collected directly but in many survey situations it is not possible to do so. Alternatively, length information can be collected and then converted to weight using an appropriate length–weight key.

Rationale for collecting and using size structure data

Practical approaches for collecting size structure information

It is impractical to implement an on-site survey that provides appropriate size data on a national scale. However, there are some practical options available that may be used to collect appropriate size information on a regional or fishery specific basis. These options may be divided into two main categories: (a) targeted on-site surveys; and (b) existing programs. These survey options should be implemented to cover the same time period as the off-site telephone–diary survey.

Targeted on-site surveys

The use of targeted on-site surveys provides a practical, defensible and robust option for collecting size structure information. The design issues that these targeted surveys need to address are not as onerous as those needed for a 'gold standard' survey for validation of other off-site metrics. The main design issue is to obtain unbiased estimates of the size structure of harvested fish and this is achieved by having matching temporal coverage of the fishery (as per the telephone/diary survey) and by using probability-based sample selection procedures. There is greater flexibility in the choice of sampling designs. For example, the survey is not constrained by the origin of fishers, PSUs can be subsampled, and levels of replication can be set at lower levels than the 'gold standard' survey approach. A list of important elements and tasks

associated with the design and implementation of a targeted on-site regional survey is provided below. This type of targeted survey may be used to directly convert harvest numbers into harvest biomass for the region that was surveyed.

Important elements and tasks associated with the design and implementation of a large regional on-site survey include:

1) PSU = day

2) Spatial frame = coverage of all access points within regional fishery

3) Temporal coverage = 1 year

4) List and rank fishing sites by relative usage

5) Stratify according to size of sites (small, medium, large)

6) Stratify by day-types (weekdays, weekends and public holidays)

7) Stratify by season

8) Use two-stage sampling for different periods within the survey day (4x6 hour periods or day/night)

9) Assign selection probabilities to sites

10) Assign selection probabilities to periods within day (PSU)

11) Use random sampling protocols to select a sample.

The charter boat fishery in some jurisdictions provides an opportunity to design and implement a targeted survey that can collect size structure information that can then be used as a proxy for other boat-based user-groups in the coastal marine fishery. This may be a cost-effective way of obtaining size structure data for a large proportion of the boat-based fishing user-group. A list of important elements and tasks for designing on on-site survey of charter boat fishing include:

1) PSU = day

2) Second stage sampling of ports with unequal probability (SSU = port)

3) Spatial coverage = coverage of all ports within a jurisdiction

4) Temporal coverage = 1 year

5) List and rank ports by relative use

6) Stratify by region and/or different fisheries targeted by charter operators

7) Stratify by day-types (weekdays, weekends and public holidays)

8) Stratify by season

9) Assign selection probabilities to ports

10) Use random sampling protocols to select a sample.

Existing programs

There are existing programs in many jurisdictions that have the potential to provide unbiased size structure information. The data from these programs may be useful as proxies for other similar user-groups thereby providing a cost-effective alternative to running an on-site survey. The utility of these existing programs should be rigorously assessed. That is, they should only be used if it is highly likely that the data collected are unbiased. Examples of existing programs that may prove to be useful are the gamefish tournament monitoring program (for some species of large pelagic fish) and some routine commercial monitoring programs (assuming there is no size grading of harvest by commercial fishers and that the commercial fishery targets the same part of the population as the recreational sector). Similarly, some jurisdictions use charter fishing boat operators to provide fish length data but these data are subject to the same limitations as those described for commercial fisheries.

Correct weighting of size frequency data

The successful use of targeted on-site surveys and existing programs to provide information for converting harvest numbers to estimates of biomass relies on correct weightings being applied to the size structure data. Simply pooling size data without using the known selection probabilities of the samples is a form of pseudoreplication. Individual fish sizes are not true replicates. Instead, the average size of a species or main group for a PSU (in this case a day) is the true replicate. Correct weighting of these size data requires that average sizes for each PSU be calculated prior to averaging them across PSUs. Of course, appropriate weighting also needs to be given to account for any stratified or multi-stage sampling used in the survey design.

Costs

Each jurisdiction will need to prioritise their needs for size structure information and identify the target population for the survey. Once this is done it will be possible to estimate the cost of that specific survey. The costs of these surveys are not included in the costings provided in Chapter 10.

Recommendations and comments for on-site collection of size structure information

- It is important to have robust and defensible estimates of the biomass of fish taken by the recreational sector

- Any survey must ensure that the size structure data collected are unbiased

- Jurisdictions should prioritise their needs for size structure information and define the target populations to be surveyed

- Many practical options are available for using targeted on-site surveys and some existing programs to collect size structure data

- Collection of size structure information may only be cost effective in some fisheries.

- Correct weighting of size structure information is vital.

8   Discussion

Implications of changing technology

Technology has changed significantly in the years since the NRIFS was undertaken. The influence of technology change is multi-faceted, not only influencing the behaviour of fishers and other characteristics of recreational fishing, but also the availability of sampling frames and the methods and approaches that can be used for recreational fishing surveys.

Telephone sampling frameworks

The NRIFS, which included phone survey and diary components, was based on a representative sample frame derived from public White Pages® telephone directories. As Australians use a wider range of communications devices to suit their individual needs, the use of traditional fixed-line telephones has declined.

At the time of the NRIFS, 81 per cent of all residents households in Australia were assessed as having a White Pages® listed home phone (based on ABS data and digital White Pages® listings that were available through various commercial agencies). Since then, these digital listings have become illegal to use, yet physical sampling of public telephone books is permitted. All statewide population surveys since the NRIFS have relied on this approach.

According to a report released by the Australian Communications and Media Authority (ACMA 2014), at June 2014, 27 per cent of the total adult population—4.9 million Australians aged 18 and over—were estimated to be without a fixed-line telephone service in the home and were mobile-only users (Figure 5).

Figure 5 Growth in population with a mobile phone and no fixed-line telephone
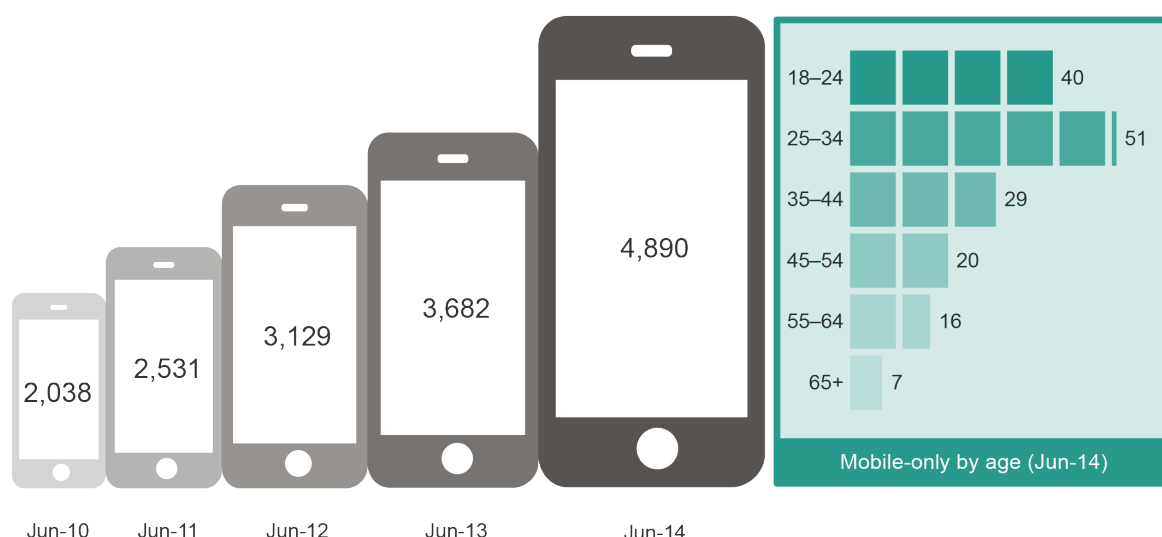
Note: Data relates to people aged 18 years and over ('000s) in the 12 months to June of each year. Mobile-only data relates to percentage of people in each age group.
Source: Roy Morgan Single Source in ACMA 2014

The ACMA is responsible for the Integrated Public Number Database (IPND) scheme, which contains details of all telephone numbers in Australia (over 80 million, including all domestic and mobile (listed and unlisted), business, government numbers, etc.). Since late 2014, several discussions with ACMA and the IPND Manager (Telstra) have established that the IPND would

almost certainly be available as a sampling source for the proposed project under the criterion of official Commonwealth (not state) government research.

However, the ultimate cost of this approach would likely be prohibitive due to the requirement that all phone numbers within each 'nominated' postcode are routinely provided and that the proposed survey would require provision of all postcodes (and therefore all phone numbers). Also, the coverage provided by this option is likely to be very similar to the hard-copy White Pages® directories, as 'un-listed' numbers cannot be contacted. In discussions with staff at ACMA and the IPND manager, it was fully confirmed that random sampling of listed domestic numbers within each postcode (with a view to lowering costs) was not possible.

Random digit dialling is a telephone sampling method developed many years ago for market research, whereby landline prefixes strongly correlated with regional geography (but less so now). However, even where a database was 'built' over-time to identify or flag un-listed, business and government numbers, the cost-effectiveness of random digit dialling is still inappropriate for the proposed methods presented herein. Further to this, the prefixes of all mobile numbers provide no indication as to regional geography, unlike for the small proportion of White Pages® listed mobiles.

These changes are important considerations in the design of new survey methods and mechanisms. Selecting a sampling frame and sampling population that adequately represents the broader population is fundamental to obtaining information that is suitable for decision-making and management in a more general sense than 'households who participated in the survey'. Change over time to a researcher's ability to reach out to the Australian population is perhaps one of the largest challenges in conducting a survey that contributes to consistent and meaningful understanding of recreational fishing. For the preferred approach and associated methods, fixed line telephone surveys using publically accessible telephone directories currently appear to provide the most cost-effective sampling frame from which to collect accurate data over large spatial and temporal scales, but also represents a substantial challenge in maintaining long-term consistency and repeatability.

Telephone listings vs. face-to-face sampling

For many years, the ABS has conducted general population surveys (for example, the monthly Labour Force Survey) using multi-stage area sampling and face-to-face interviewing at randomly selected households or dwellings throughout Australia. This methodology provides optimum coverage (all phone and non-phone owners and all White Pages® listed and un-listed households), and is very much 'gold standard' for large-scale population surveys.

However, the costs of this approach may currently be prohibitive for recreational fishing surveys in the Australian context due to:

- the costs of establishing/purchasing an appropriate 'street-block' sampling frame

- the recruitment and travel costs of interviewers for the screening component

- privacy legislation for the ABS meaning that it would be unable to conduct the screening phase only, then 'hand-over' a diary sample to national and jurisdictional survey managers.

However, it may be possible and appropriate for ABS to assist with assessment of any differences in recreational fishing participation rates between White Pages® listed vs. un-listed households.

While it appears that the use of a 'hybrid' sampling frame (that is, the White Pages® supplemented by fishing licence databases) is currently the most cost-effective and pragmatic option in the Australian context, the use of face-to-face sampling frames warrants careful consideration, particularly for surveys in coming decades. This is highlighted by the New Zealand experience, where creel survey data collected at the time of the New Zealand National Panel Survey of Marine Recreational Fishers in 2011–12 (Wynne-Jones et al. 2014) indicated clear evidence of a significant and demographically biased decline in the incidence of fishers being listed in the White Pages® (B. Hartill, personal communication). Despite the relatively high costs of the New Zealand survey methods, this supported the decision to adopt a face to face sampling frame.

In the absence of a White Pages® sampling frame as the primary means of contacting a population, which seems somewhat inevitable at some point in the future, it appears that the only two options for ensuring the repeatability of representative, probabilistic national recreational fishing surveys are face to face methods, or a national recreational fishing licence or registry.

National licence or registry

A national recreational fishing licence would provide a cost-effective sampling frame for surveys of this kind. A national list of fishers could be created from licences either issued or administered through specific jurisdictions, or through a national registry of recreational fishers. Although four jurisdictions (New South Wales, Victoria, Tasmania and Western Australia) currently have general or specific recreational fishing licences, additional population sampling is still required in the proposed method to provide coverage of exempt fishers (for example, pensioners or under-18s in some states) or fishing activities for which a licence is not required (for example, shore-based fishers in Western Australia).

There are a number of problems with using licence frames for surveys that need to be considered, such as the various exemption categories (minors, Aboriginal and Torres Strait Islanders and pensioners, for example) and various compliance-related issues. Without investment in compliance and potential penalties for non-compliance, it may be difficult to convince recreational fishers of the benefits of obtaining licences or voluntarily signing on to a registry.

The key requirements of a national licence or registry are that it should have high coverage levels and mandatory contact details for all licence holders (that is, phone numbers and address information). Particular species targets or endorsements could also be included in the application or renewal process, to facilitate focused research for comparatively uncommon species (for example, southern bluefin tuna).

Novel approaches

This project investigated a number of novel approaches for surveys or associated survey components. Technology that has become available since the last national survey can provide efficiencies with data collection, entry and analysis, and could help to provide more accurate and defensible data. Examples and a brief discussion of these approaches is included below.

Text messaging

It is proposed that text messaging is used as a prompt for the diary survey component of the preferred survey approach and methodology. A simple text asking 'Any fishing? Y/N' would

enable the interview staff to quickly gauge fishing activity, which could then be followed up with a phone call. This would create less respondent burden and may result in cost savings. Despite these apparent benefits, the use of text messaging in this form may need to be validated because potential biases associated with its use are not well understood.

Webcams for on-site validation study

Chapter 7 contains the proposal to use webcams for the on-site validation study, which will result in better accuracy. It is also likely to result in cost savings, and is considered to be cheaper than employing staff to undertake the same coverage on-site. However, it should be noted that there are still costs of installing and monitoring gear and in reviewing and analysing data.

Computer Assisted Telephone Interview (CATI) technology

Both Western Australian and New Zealand have used a CATI system in their most recent surveys, demonstrating that good results (including retention rates) can be achieved. Importantly, both Western Australia and New Zealand have highlighted that high quality interviewer training and familiarity with the topic is required. The standardisation and efficiencies that a CATI system should provide strongly suggest that components of future surveys adopt this methodology, where appropriate. As well as reducing inefficiencies with double-handling data, and reducing potential errors in data entry and management, using CATI systems enhances the survey's appearance of professionalism and can help to demonstrate an adoption of novel and beneficial technologies. Further discussion on the use of CATI systems is included in the global review of national scale recreational fishing surveys below.

Smartphone applications

The use of smartphone applications for collecting recreational fishing information is increasing in popularity. Smartphone applications could be used to collect a variety of data related to recreational fishing including fish length, species, distribution of effort, attitudes, expenditure and so on. When collected as part of a survey, these data are subject to the same biases as encountered with other surveys.

Fisheries Queensland has recently developed a prototype smartphone application intended to collect fish length data from recreational fishers (J. Webley, personal communication). The application uses the smartphone camera to photograph the fish next to a ruler and then applies a formula to provide an estimate of length. The results show that estimates of fish length provided by the application are generally accurate.

The benefits of this technology include that it can:

- be cheap to develop and deploy

- potentially reach a large number of fishers

- provide data in 'real time', thus lowering costs

- provide feedback and information to users

- be accessed by anyone with a smartphone and the appropriate software platform.

To avoid biases, data collection using smartphone applications should be done using a probabilistic survey method. A respondent driven approach is unlikely to provide representative information.

Global review of national scale recreational fishing survey methodologies

Prepared by S. Tracey and J. Lyle, Institute for Marine and Antarctic Studies, University of Tasmania

This review considered 13 national level recreational surveys from 11 countries (Appendix E—Table 14). All involved off-site methods, either as the primary source of data or complemented with an on-site survey component. In the latter instance, the off-site surveys typically provided effort information and the on-site surveys catch rate information. Where off-site methods represented the primary survey instrument, there were two main approaches. The simpler approach involved collection of retrospective catch and effort information, whereas the alternative approach involved a screening survey to profile the fisher population followed by a panel survey in which catch and effort information was collected. Six surveys used telephone as the primary contact method, five used mail surveys and two used face-to-face interviews. Several studies conducted secondary contact with alternate methods; for example, Finland used a mail survey, but followed up non-response via telephone (Finnish Game and Fisheries Research Institute 2007). Some also used one method for screening and another method for secondary components. For example, New Zealand used face-to-face for screening, and telephone for the panel (diary) component of their survey (Wynn-Jones et al. 2014).

For all studies assessed, the primary sampling units were either reported or clearly identifiable and appropriate for the survey technique. Additionally, with the exception of the Brazilian survey (Freire et al. 2012), each reviewed study had clearly defined and stable strata, implemented probability based sample selection and had a sampling protocol in place that was adhered to. All surveys with the exception of the Brazilian survey utilised appropriate statistical approaches to analysing the collected data, and with the exception of the Brazilian survey, all reported precision estimates.

Different contact methods affected the assessment of how comprehensively the sampling frame covered the target population. Face to face surveys (New Zealand [Wynne-Jones et al. 2014] and the United Kingdom [Hargreaves et al. 2013]), and household mail surveys were considered to have full coverage of the target population. Licence-based surveys were not considered to have full coverage as most had age-based exemptions (an exception was the Canadian survey [Fisheries and Oceans Canada 2012], which had compulsory permitting, but payment exemptions) and non-compliance was often reported as an unknown component. Telephone surveys were not considered to have full coverage of the target population as the proportion of fishers without phone listing was unknown.

Response rates were reported for surveys with the exception of the Canadian survey, which utilised mail as the primary contact method; the French survey (Herfaut et al. 2013), which used a random digit dialling telephone survey; and the Brazilian survey, which used a mail response method presented on the back of angling licences did not report response rates. It was not clear whether the response rates were not calculated or just not reported.

Response rates for offsite surveys varied between surveys and within primary survey method. Response rates for surveys using telephone as the primary contact method for screening (both random digit dialling and phone directory) ranged from 14 to 80 per cent. Australia (phone directory; Henry and Lyle 2003) and the Dutch (internet-based; van der Hammen and de Graaf 2012) reported the highest response rates for screening at 80 per cent. The high response rate from the Dutch survey is largely due to the fact that the respondents were selected from a quasi-representative population that had already agreed to be available for a broad range of surveys,

as well as the provision of incentives in the form of air-mile rewards. The United States hunting and fishing survey (US Department of the Interior et al. 2014) reported a response rate at screening of 77 per cent. The German inland waters survey (Dorow and Arlinghaus 2011) reported a lower rate of 51 per cent, while the United States Marine Recreational Information Program survey (NOAA Fisheries Service, n.d.) reported the lowest response rate at 14 per cent utilising random digit dialling. Face-to-face screening surveys were used by New Zealand, which reported the highest screening response rate (86 per cent) of the surveys assessed, and the United Kingdom, which reported a response rate of 58 per cent.

The highest enrolment rate of participants into secondary survey phases (where applicable) was reported by New Zealand, who used face-to-face screening to recruit those eligible with 91 per cent agreeing to participate. Australia, using telephone as the contact method, had the second highest enrolment rate at 89 per cent. The German inland waters survey, which also used telephone to communicate, reported the lowest enrolment rate of 57 per cent.

The Australian, New Zealand and Dutch surveys used a panel design for the secondary phase of their surveys all reported high retention rates of participants of between 84 per cent and 93 per cent. The full response to the Netherlands survey was 58 per cent but with adjustments based on non-response, follow-up was increased to 89 per cent.

The highest response rate to a mail survey was reported by Denmark (Sparrevohn 2013; Sparrevohn and Storr-Paulsen 2012), with 73 per cent of the target sample returning the survey questionnaire. The response rate to the survey conducted in Finland (Finnish Game and Fisheries Research Institute 2014) was 60 per cent; follow up telephone calls to non-respondents improved this rate slightly to 63 per cent. The German inland waters survey reported a mail response of 58 per cent from the target sample identified during the telephone screening survey. The German marine waters survey (Strehlow et al. 2012) had the lowest mail response rate of less than 10 per cent. Of those surveys that used an ancillary on-site survey, only the United Kingdom reported response rates (94 per cent).

The recall period appeared to be excessive for many of the studies assessed. The US game, hunting and wildlife survey and the Brazilian, Canadian and French recreational fishing surveys all used 12-month recall periods to estimate catch and effort. The surveys conducted in Denmark and Germany (marine recreational fishing) used six-month recall periods to collect information including catch and effort. The Finnish survey used a four-month recall for information including catch and effort. The study in the United Kingdom used a three-month recall period for information including catch and effort. The German inland recreational fishing survey used four panels to account for recall bias while the US Marine Recreational Information Program survey used a two-month recall period for effort. These recall periods were considered long but marginally appropriate. The off-site panel surveys conducted in New Zealand and Australia had regular contact to minimise recall bias. The survey conducted in the Netherlands also minimised recall bias with a one-month recall period.

Eight of the assessed surveys employed an ancillary on-site survey component to either estimate catch or validate catch, species and/or size composition. Four of these were considered to be comprehensive both in regard to survey methodology and spatial coverage, namely the United States Marine Recreational Information Program, German (marine recreational fishing), French and United Kingdom surveys. The German inland recreational fishing survey as well as the Dutch and New Zealand studies utilised on-site surveys but these were limited to large regional areas rather than implemented at a national level. Australia had some on-site components but these were very limited in terms of validating national catch, species and size composition. The Canadian, Brazilian, Danish and Finnish surveys did not use any form of ancillary onsite survey.

Species identification was assumed to be correct for surveys that utilised trained on-site interviewers to assess catch, including the United States Marine Recreational Information Program, French and United Kingdom surveys. Australia, New Zealand, Germany (both surveys) and the Dutch surveys considered species identification and either had limited species that were caught, leading to the assumption that identification was not a significant issue, or provided educational material to improve species identification by respondents. The Canadian, Brazilian, Danish and Finnish surveys did not report on the issue of species identification and hence it was assumed this issue was not addressed.

Most surveys clearly defined retained catch separately from released catch. Exceptions were the Brazilian, Finnish and French surveys, which referred simply to catch.

Discussion of global recreational fishing surveys

Relatively few countries carry out comprehensive national recreational fishing surveys and these tend to be dominated by North America, including Canada, and several European countries in the northern hemisphere as well as New Zealand and Australia in the southern hemisphere.

Several countries conduct large regional scale recreational fishing surveys, including South Africa (Dunlop and Mann 2013; Dunlop and Mann 2012), Spain (ICES 2014) and Argentina (Llompart et al. 2012). These tend to be based on on-site survey methods. It is not clear in all cases whether these surveys have been designed to target an area of interest or cost limitations have necessitated limiting the spatial scope to priority areas rather than implementing a full national survey.

The United States have conducted a national survey every five years since 1955 reporting on participation demographics and expenditure for recreational activities including fishing and hunting (Interior et al. 2014). Furthermore, since the *Magnuson Fishery Conservation and Management Act of 1976* (MFCMA - Public Law 94-265) mandated a national program for management of fishery resources in the Exclusive Economic Zone (EEZ), which ranges from 3 to 200 nautical miles from shore, the United States has conducted an annual national survey of marine recreational fishing catch and effort since 1979. Both these surveys have different objectives and provide information for multiple stakeholders. The survey methodologies have evolved over time to balance the need for statistical rigor with consideration of the cost of implementation.

Legislative requirements have also led to commitments to survey marine-based recreational fishing activities in the European Union (EU). Since 2009 EU member States have been required to establish survey programs to estimate non-commercial catch of several key species (cod, European seabass, eels, Atlantic salmon and Bluefin tuna according to the International Council for the Exploration of the Sea—ICES area) in order to meet the requirements of the EU Data Collection Framework (EC Regulation 199/2008 and EC Decision 2008/949/EC).

Beyond legislative requirements, it is becoming increasingly evident that quantifying recreational catch is an important endeavour, and that inclusion of recreational harvest into stock assessments is a sound objective for many fisheries around the world (Coleman et al. 2004; Cooke and Cowx 2004; Cooke and Cowx 2006). As well as quantifying catch and effort trends of recreational fishing, there is an acknowledgement that understanding the scale of social and economic benefits of recreational fishing is also important in terms of resource management and policy development. A code of practice for recreational fisheries presented by Arlinghaus et al. (2010) highlights the importance of gathering essential data that include the catch; the harvest; the catch structure (for example, age and length structure by species the recreational-fishing effort; and angler preferences, attitudes and behaviour. The code of practice

also stresses the need for monitoring of the social, economic, marketing and institutional conditions affecting recreational fishers and fisheries.

Common limitations of national recreational fishing surveys

One of the most common challenges facing each of the national surveys reviewed was the ability to utilise a sampling frame that covered the entire target population. Face-to-face and national mail surveys were relatively effective at addressing this issue through access to private dwellings (households), but both methods have secondary issues that require consideration. Face-to-face sampling of an appropriate sample fraction is costly at a national level, while mail surveys tend to have lower response rates. Telephone surveys are considered one of the most cost effective methods of contacting a large proportion of the target population, but in recent years, fewer people are listing telephone contact details in phone directories or have landlines as we move to a society dominated by mobile and online communication mediums. In the absence of a national registry of all recreational fishers, the issues of coverage of the target population are likely to increase.

Length of recall and implications for reporting bias was also a considerable issue for many of the surveys reviewed, particularly those that used one-off contacts with respondents, whether it be telephone or mail based contact to collect effort and or catch data. The Australian, New Zealand and Dutch surveys minimised this issue by tailoring contact frequency to respondent avidity through the panel phase of their respective surveys. A downside to frequent contact is increased survey cost, but the benefit of minimising bias is an important cost trade-off consideration.

An effective on-site component, both in terms of methodology and spatial coverage, was identified as a key component to determine catch rates or validate catch, species identification and size composition and weight if harvest numbers are to be converted to harvest weights. As on-site surveys tend to be expensive, thought needs to be given to the survey design, particularly regarding coverage and sampling frequency.

Limited consideration of non-response and reporting biases (for example, avidity bias) was also common amongst the reviewed surveys. While high response rates can minimise these biases, for surveys that had lower response rates non-response follow up represents an effective method to adjust for these effects.

Data collection, respondent management and technology

Technological advancements, particularly mobile telephones and computer-based online platforms, are providing opportunities to enhance data collection and respondent management for off-site surveys. However, it is important to consider the cost–benefit of using these technologies in the context of the statistical rigor of the survey design and burden on respondents.

The most common off-site national recreational fishing survey methods reviewed involved either the use of telephone or mail for initial contact and either telephone, mail or online for reporting. Telephone surveys tend to have the highest response rates, and it is generally accepted that the personal contact encourages participation, reduces respondent burden, reduces misinterpretation and enhances reported data quality.

Six of the national surveys that were reviewed used enhanced telephone technology or online programs to improve respondent management. Most commonly, this was in the form of computer assisted telephone interview (CATI) technology to assist in standardising interviews and online data entry by respondents to provide flexibility and reduce respondent burden. In each case that this technology was used for data collection, standard probability based methods

were still used for sample selection. Only the Brazilian survey used a self-selection voluntary respondent driven method; that is, where a respondent chooses whether to participate in a survey or not with no probabilistic selection of participants. The use of this method led to significant shortcomings in the assessment of the Brazilian survey methodology.

Common technological approaches to improve telephone-based surveys include computer assisted telephone dialling and CATI, which can be used exclusively or in combination. The former is used to randomly dial numbers from a known population, but careful consideration needs to be given to the target population database as well as the potential requirements regarding targeted sample weighting. For example, it may be difficult to stratify the random numbers to increase sample size for pre-identified target regions or demographic groups unless this information is contained within the database from which the telephone numbers are being selected.

CATI is a system to standardise survey responses with the interviewers provided a scripted interview form, generally online, from which the interviewer is guided through the questions with logic steps tailoring the questionnaire depending on the respondent's responses. Forms of the CATI system were used in the New Zealand, United States (Marine Recreational Information Program) and French surveys. The logical progressions within CATI systems can minimise survey time which reduce respondent burden and improve interviewer efficiency as well as improve data accuracy as the program has 'check' logic that allows the interviewer to identify entry or reporting errors. Data entry efficiency can also be improved, with the responses entered directly into a central database. The use of a CATI system does not negate the need for data quality checks within the database and also removes the flexibility for more complex responses that may not have been anticipated when the questionnaire was designed.

The New Zealand panel survey also used mobile phone texting technology to simplify respondent management by sending regular texts to respondents asking whether they had engaged in any recreational fishing since last being contacted. The respondent then texted a binary 'yes' or 'no' response, where 'no' indicated no fishing effort over that period, and a 'yes' instigated a phone call from an interviewer that would then administer the CATI-based questionnaire to collect the information of the fishing events that had occurred. While this method improves the efficiency of respondent management, it has the potential to increase under-reporting or soft refusals, with respondents provided an opportunity to respond 'no' to avoid an interview or if they had low or zero catches that they may feel are not worth reporting.

A more recent technology used for telephone surveys is automated computer telephone interviewing, although this method was not used by any of the surveys reviewed. This method uses voice recognition software and asks respondents a series of questions and stores the answers. While this method may reduce survey costs by negating the need for interview staff, it may reduce response rates due to the reluctance of respondents to engage with an automated, computerised system. It also removes the flexibility provided by a trained interviewer to explain questions to respondents or clarify ambiguity in responses.

Mail surveys are an effective means of contacting a target population, particularly for a national household based survey. They overcome the issue of unlisted telephone numbers, but tend to suffer from lower response rates. The Danish survey improved response rates marginally by following up non-response with telephone calls. The Danish survey also provided respondents with the choice to respond to the survey by mail or complete the questionnaire online or if followed up by phone to complete the survey with an interviewer. This provided respondents flexibility to respond with a medium, and at a time, that was most convenient to them.

Online platforms as well as applications for smart phones or tablets are becoming increasingly popular for data collection. While attractive in regard to efficiency and providing a contemporary method to collect information, there are important considerations to be made. Self-selection, voluntary response surveys, which are common in 'citizen science' style data collection, remove the ability to initiate probability-based sampling design, as in the case of the Brazilian survey. Not all of the target population may have internet access, but more importantly, there is an increased potential for avidity bias, whereby only those respondents that are very active or are particularly enthusiastic about providing data respond, an issue also common to voluntary response mail surveys. They also tend to suffer from low response rates. This can be addressed in part by additional methods, such as telephone follow-ups, as were conducted during the Danish survey. These additional measures will increase survey costs and may offset the benefits of using an online or application-based system.

While technological advancements can enhance the efficiency of delivering national recreational fishing surveys, careful consideration is required of the potentially negative effects that could compromise the accuracy of the survey results. This can be particularly problematic if the data is to be used for stock assessment or other more complex fisheries management applications.

Future proofing recreational fishing surveys

In the face of changing technology and societal values, the need to develop strategies to ensure the repeatability of survey methods is fundamental for the collection of representative information about human activities. In this regard there are three major challenges for recreational fishing surveys:

4) representative coverage of the target population (sample frame)

5) access to the target population (survey method)

6) survey response (non-response and reporting quality).

All elements of surveys can introduce biases that, if not controlled (minimised) or accounted for in the analyses, will compromise data reliability and the ability to make inferences about trends through time. Coverage, access and response are particularly relevant issues for off-site survey methods, which are typically used in large-scale fishing surveys (either standalone or in complemented survey designs). In relation to future proofing surveys, the US has been particularly proactive in trying to address issues relating to coverage and response rates.

Coverage and access

The main issue of coverage is the absence of a comprehensive sample frame, such as a register of all recreational fishers, from which random (representative) samples can be drawn. A key recommendation of the review of the US marine recreational fishing survey, formerly Marine Recreational Fisheries Statistics Survey (MRFSS), now known as the Marine Recreational Information Program, was that all fishers, without exemption, should be registered to provide a complete sampling frame from which to survey the recreational fishery (NRC 2006). This objective has been endorsed by US Congress but has yet to be fully implemented in all states. As is the case in Australia, existing licence frames are incomplete due to various categories of exemption. Furthermore, where registries exist, they rarely include complete and correct contact details (phone, address, and/or email) for all licensed fishers. For instance, recent pilot studies in the US established that around 20 per cent of licence holders were unreachable by phone due to incorrect, out of service or missing numbers. Similar issues apply to licence databases in Australia.

In the absence of a comprehensive registry of fishers, some form of general population sampling is necessary, undertaken as a separate survey or as a multi-frame survey design. There are three main options for general population sampling, namely telephone, mail and face-to-face. The first two are also relevant if sampling from a licence database or registry.

Traditionally, telephone surveys have used random digit dialling or directory lists to access the population and are thus limited to households with landlines. However, the trend away from landline to mobile phone ownership has meant that a growing portion of the population is no longer covered by these surveys. In an attempt to deal with the under-coverage of mobile only users, dual-frame surveys using landline and mobile numbers are now being developed. There are, however, numerous challenges in such designs, especially in how to deal with dual users (that is, persons with both landline and mobiles in the household).

Mail surveys are used in several countries to collect fishery data, with questionnaires mailed to randomly selected licence-holders or to the general population (randomly selected addresses). Databases of residential addresses, for example the Postal Address File in Australia, or the United States Postal Service address database, have the potential to provide more or less comprehensive sampling frames from which to survey households. Recognising the potential for mail surveys to overcome some of the coverage issues experienced using phone surveys, the US is currently trialling mail surveys as an alternative to the Coastal Household Telephone Survey, which has traditionally provided effort estimates for their on-going marine recreational fishing survey, Marine Recreational Information Program.

Face-to-face surveys represent an alternative method of sampling the general population (dwellings), overcoming many of the problems associated with phone ownership. The most recent recreational fishing surveys in New Zealand and the UK used this approach. In New Zealand, the method was explicitly adopted as a strategy to 'future proof' their national survey.

Survey response

Telephone survey response rates for both general population and licence frame surveys in Australia have remained high (75 to 85 per cent) over the past two decades. Interestingly, while refusal rates have remained low—generally less than 10 per cent—non-contact rates (in some instances a passive form of refusal through call screening) are increasing. By comparison, response rates to the face-to-face household survey in New Zealand were high and similar to recent Australian state-wide phone surveys (Lyle et al. 2014).

In the US, telephone response rates to the random digit dialling-based the Coastal Household Telephone Survey are currently under 15 per cent and unlike Australia, there was only a marginal improvement in response rates when sampling from a licence frame (that is, Angler License Directory Telephone Surveys). Given poor response rates and coverage issues associated with phone surveys, the US is proposing to switch from phone to mail surveys as a key strategy to future proof their Marine Recreational Information Program effort survey. Interestingly, a number of pilot mail surveys have been conducted in the US, some involving dual frame sampling (that is, from postal service address and licence address lists), and they have generally achieved response rates around 40 per cent, which is consistently higher (by a factor of two to three) than concurrent telephone surveys.

Regardless of contact method, response rates to surveys are declining, a trend expected to continue over time. As such, this represents a major challenge for all on-going surveys and will necessitate careful survey design and consideration of how to account for non-response biases.

9   Further development

Data management strategy

Surveys such as that proposed generate a large amount of information. Before implementation of a national survey, a comprehensive data management strategy will need to be developed in consultation with managers, scientists and other stakeholders who will be responsible for, and use, the database. Development of a data management strategy for regular national recreational fishing surveys was out of scope of this project. The objectives of any data management strategy should include development of a common data model so that data can be aggregated to the national level; address issues of data custodianship and archiving; and investigate data security and exchange policies. Any data management strategy should also consider the findings of Griffiths et al. (2014), who explored approaches to filling key information gaps and began development of systems, protocols and a prototype portal to allow data to be stored, aggregated and analysed.

Because of the complexity of aligning jurisdictional recreational fishing surveys that use slightly different survey methods (for example, different sampling frames, tailored questions and so on), it may only be possible to produce a national data management strategy for key national metrics.

Operational workplan

A national operational workplan will need to be developed once funding and timelines are more clearly defined. This workplan will need to identify specific responsibilities, governance and administration procedures, budgets, reporting processes and outputs.

Assessment of participation rate differences between White Pages® listed and unlisted households

For some time now, extra questions have been included in various on-site surveys (for example, at boat ramps) to assess any differences in the behaviour of fishers from White Pages® listed versus unlisted households. To date, no significant differences have been detected in terms of avidity profiles, catch, and other key characteristics (S. Conron and J. Webley, personal communication 2015). More recently, two licence frame telephone–diary surveys conducted in Western Australia have classified respondents as White Pages® listed or not and a detailed comparative analysis of the avidity profiles, catch will be undertaken in the near future (K. Ryan, personal communication 2015). A similar analysis will also be completed for the recreational fishing licence component of the recent New South Wales/Australian Capital Territory survey.

Importantly, the above analyses can only assess any behavioural differences amongst fishers (in terms of White Pages® listed versus not), as opposed to participation rates. By contrast, any differences in the latter can only be assessed through some form of general population sampling (for example, ABS-style face-to-face interviews at households).

It is recommended that a survey to establish any differences in participation be undertaken in three different jurisdictions and in three separate regions (for example, capital city, coastal and inland) before any national survey. Depending on results, detailed assessment may be required during the ultimate screening survey to provide calibration and adjustment factors for each jurisdiction and regions within. Further discussion and costing of such work is contained in Chapter 10.

Further investigation of the 'hybrid' sampling frame approach

In the absence of a national licence frame and due to the limitations of the various options discussed above, a dual-frame, 'hybrid' survey methodology has been identified as the most cost-effective approach for the proposed method. This approach would use the White Pages® telephone directory as a primary sampling frame and supplement this with other existing sampling frames, namely recreational fishing (or boat fishing) licence databases available in New South Wales, Victoria, Tasmania and Western Australia. The key benefits of using a hybrid approach are the lower overall screening costs (due to higher 'hit-rates' for fishing households with recreational fishing licence versus 'hit-rates' for White Pages® sampling) and substantially improved overall precision (relative standard errors) for all catch and effort estimates from the survey data (through natural 'over-sampling' of more avid or active fishers). This approach also provides coverage of the vast majority of fishers through the two sampling frames (that is, White Pages® listed versus un-listed and licensed versus exempt fishers).

New South Wales Department of Primary Industries has made considerable progress with development of the hybrid survey design and in their 2013–14 survey, extensive sampling was undertaken for both the White Pages® and recreational fishing licence sampling frames. Estimated costs for further development of the hybrid methodology are included in Chapter 10.

The full suite of necessary work should include:

- full documentation and publication of the hybrid survey methods used in the 2013–14 New South Wales statewide survey
- exploration of alternative sampling frames, for example boat registration or boat licence lists
- a full review of the pros and cons of the method
- a review of the preferred method on a state by state basis
- recommendations for using the approach as part of a national recreational fishing survey.

Ongoing communication strategy

If implementation proceeds, it will be critical to continue and enhance the existing communication strategy to ensure contact with relevant stakeholders before, during and after any national survey in order to ensure improved buy-in and acceptance by fishers and other stakeholders. This will need to occur at relevant jurisdictional and regional levels.

10 Estimated survey costs

The estimated survey costs presented are applicable to an approach that involves a centrally coordinated national survey undertaken independently to state and territory surveys processes. In reality, this scenario is unlikely given funding constraints and because this approach may result in less buy-in from the jurisdictions.

Consequently, these costs need to be viewed with caution because they do not consider the implications of current and planned statewide data collection processes, the contribution of funding by various stakeholders, and the need to ensure a long-lasting legacy of national cooperation and coordination. Each jurisdiction currently funds their own surveys based on the required level of precision and hence sample sizes. If these are considered in the context of the preferred approach to temporally align jurisdictional surveys, then the additional resources required may be less than the estimates given here. Furthermore, the availability of different sampling frames in some jurisdictions also affects potential survey costs in these jurisdictions. Because of these factors, it was not possible to estimate a cost for the preferred approach to align jurisdictional surveys.

The value of the overall figure is that it provides a benchmark that indicates what a national survey might cost if it were centrally coordinated and used consistent methods and sample sizes.

All estimated costs presented below include Goods and Services Tax.

Preferred approach

Off-site survey components

A cost of $5.6 million (in 2017 dollars) for the off-site method (Chapter 7) was estimated by Kewagama Research. The key assumptions for this estimate are that:

- because all jurisdictions have asked for improved precision to that provided by the NRFS, there is a 20 per cent increase in the diary survey households target (that is, the number of households completing the diary survey) compared to the NRFS. The preference for this increase is compounded by decreasing recreational fishing participation rates. Consequently, the screening survey target (that is, the gross number of households contacted) is necessarily higher than that for the NRFS

- expenditure data would be sub-sampled in the diary phase using four sub-strata, each for three months duration

- the estimate is based on the proposed hybrid survey methodology—a supplementary sample of recreational fishing licence holders would be included from licence frames provided by New South Wales, Victoria and Western Australia to minimise the White Pages® screening costs in these jurisdictions.

A detailed budget for the off-site survey components was produced for this project. It is available for the purpose of further developing and implementing a national survey and with prior permission from ABARES and Kewagama Research.

On-site survey components

Validation study

Costs for the validation study were estimated by Fishing Survey Solutions and ranged between about $400 000 (for a three-site, six-month, six survey days per month survey) to over

$1 million (for a six-site, 12-month, eight survey days per month survey). The option that represented best value for money was for $595 000, which was the cost for a three-site, 12-month, six survey days per month survey.

A detailed budget for the validation study was produced for this project. It is available for purpose of further developing and implementing a national survey and with prior permission from ABARES and Fishing Survey Solutions.

Harvest weight estimation

This cost for this survey component will vary between jurisdictions and will depend on identifying key species for which information is required, the different characteristics of fisheries, any existing size structure information and the level of accuracy and precision that is required for this information. Consequently, these costs have not been included in this report.

Further development of the hybrid survey methodology

The cost of further development of the hybrid survey methodology, which would be required should implementation of the preferred approach proceed, was estimated by ABARES, Kewagama Research and New South Wales Department of Primary Industries to be around $150 000.

Development of operational workplan and data management strategy

The cost of development of an operational workplan and data management strategy are embodied in the off-site survey costs and included in the detailed budget spreadsheets produced for the project by Kewagama Research.

Assessment of participation rate differences between White Pages® listed and unlisted households

The cost for this survey component was estimated by Kewagama Research to be between $95 000 and $365 000. A cost of $230 000 has been assumed for the calculation of the total cost of further survey development and implementation.

Other costs

Strengthening of analysis for on-site validation studies

Additional diarists in the stratum proposed for the on-site validation study—the Illawarra region in New South Wales—would increase the quality of the study and increase the likelihood of the study being a true validation study, as opposed to a corroboration study (see Chapter 7 for discussion).

The costs for additional diarists in the Illawarra stratum was estimated by Kewagama Research to be between $80 000 to $150 000, with a cost of $115 000 assumed for the total survey cost.

Additional expert oversight of survey

After completion of the current development project, additional refinements and inputs by specialist staff may be required in the lead up to and commencement of the survey. Estimates of this cost provided by Kewagama Research are between $85 000 and $170 000, with a cost of $127 500 assumed for the total survey cost presented.

Total survey cost for the preferred approach

Using the figures presented above, the total estimated cost for the preferred survey approach is approximately $6.8 million.

National social and economic survey

Estimates of the cost of a social and economic survey are highly variable, depending on the information needs of different stakeholders, the purpose for which the information is intended and the accuracy and precision of data required by stakeholders. For example, if a survey of recreational fishing expenditure was intended to produce a national figure of total expenditure (based on an average level of expenditure per person and expanded using participation rates), high-resolution data may not be required. However, if expenditure data were needed for an application of the travel cost method to assess the impact of changes in access to a specific resource in a particular region, then much higher resolution data would be required.

Similar to expenditure data, the accuracy and precision of data on the social dimensions of fishing is related to who wants the information, what it is going to be used for and at what scale. Consequently, the cost of a national and social and economic survey cannot be estimated until stakeholders better define their specific information needs and uses.

National social and economic survey

11 Conclusions

This project has highlighted that there are clear benefits in coordinating the collection of recreational fishing data in Australia. This information is needed by various stakeholders, over different spatial and temporal scales and for numerous fisheries assessment, management and fishery development applications. This complexity influences the breadth and cost of information that can be collected.

Useful surveys represent a trade-off between precision and cost. This project provides a preferred approach that meets the objectives of providing a 'best-practice' method and proposing a cost-effective and repeatable framework for national recreational fishing surveys. This is highlighted by the work undertaken to benchmark the proposed method against recreational fishing survey methods used internationally.

A significant achievement of the project was generating discussion around, and achieving consensus by participating stakeholders on, shared high-level objectives for national recreational fishing surveys. The project explored several approaches for implementing regular national recreational fishing surveys that would achieve these objectives. Most stakeholders involved in this project supported an approach that involved the temporal alignment of jurisdictional surveys to collect recreational fishing data that can be aggregated to provide a national picture of recreational fishing. The preferred method is to use a telephone–diary survey complemented by an on-site validation study. The output specifications provided here provide the baseline for consistent data collection across jurisdictions, either through the temporal alignment or jurisdictional surveys or through a centrally coordinated national survey.

A significant constraint to the repeatability of the preferred method relates to changes in the ability to contact fishers using the White Pages® sampling frame. Because of the extensive uptake of mobile phone technology and a decreased reliance on fixed landline telephones, it will be necessary to establish if there are participation differences between households that are listed in a telephone directory and households that are not. To assess differences between these strata, it is proposed that face-to-face surveys should be undertaken in a number of representative regions during the main telephone–diary survey.

Importantly, the support for the preferred approach and method is an acknowledgement that it is highly effective and appropriate for providing the necessarily high-quality information. The evidence for this rests in the enduring legacy of the NRIFS—which is still used as the baseline for national recreational fishing data in Australia—and subsequent statewide and Northern Territory surveys that have been based on the NRIFS methodology.

Other methods for national recreational fishing surveys that collect the information required by most stakeholders were explored, but were found to lack the necessary accuracy and precision or to be cost-prohibitive at this time. However, the use of novel methods and technology have been considered through this project and may provide efficiencies. These have been incorporated into the proposed methods where they provide efficiencies or improve accuracy and precision.

Despite the benefits of national recreational fishing surveys that collect a broad suite of data that are useful for a range of applications, it may be more cost-effective to use targeted surveys to collect some issue-specific or rare event information needed by stakeholders.

The main constraint to implementation of regular national recreational fishing surveys is a lack of resourcing and the absence of a commitment by most states and territories to undertake regular, periodic recreational fishing surveys. To implement the preferred approach and proposed methods, funding will need to be committed by the Commonwealth, the state and territory jurisdictions and potentially other key stakeholders in order to produce a national survey that satisfies the needs of all stakeholders and builds a long-term legacy of cooperation and coordination.

Acknowledgements

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Appendix A: Stakeholder perspectives on national recreational fishing survey objectives and information needs

Australian Recreational Fishing Foundation and Recfishing Research

The Australian Recreational Fishing Foundation (ARFF) represents Australia's recreational fishing community. ARFF's objectives are to:

- educate and promote the benefits of sustainable recreational fishing to the public to ensure the maintenance and growth of fish population throughout Australia.

- educate the fishing community on the ethical, environmental and safety aspects of sustainable recreational fishing.

- raise awareness of and promote the health benefits of sustainable recreational fishing.

- educate the public on how to protect, preserve and care for the environment, while recreationally fishing, including land care, flora and fauna and marine conservation.

- promote the accessibility of sustainable recreational fishing activities to persons of all age groups, genders and ethnic origins.

- do all such other things that may be considered to be incidental or conducive to these objectives.

Recfishing Research is a national subprogram for the Fisheries Research and Development Corporation, which was established to guide investment in national and multi-jurisdictional research, development and extension initiatives addressing key priorities of the recreational fishing community. Importantly, Recfishing Research also plays an important role in communicating research results to the recreational fishing community.

The ABARES project to develop a framework for regular national recreational fishing surveys was supported by ARFF and Recfishing Research, both of which would like to see full implementation of a national survey.

The key objectives for a national recreational fishing survey outlined by the ARFF and Recfishing Research were to:

- implement the data collection framework developed through the ABARES project

- estimate the economic value of recreational fishing in Australia

- estimate the social impact of recreational fishing in Australia

- estimate catch and effort levels for recreational fishers in Australia

- explore methodological solutions that advance us beyond longitudinal phone surveys.

Key attributes of a national survey included that estimates must be repeatable, and durable over time; that surveys must be cost-effective; and that they must reflect state and territory data needs, but be able to be aggregated to provide a national picture. Economic data must include the full range of activities, services and jobs that recreational fishers undertake to contribute to the economy. It was expressed that it is highly desirable for this data to be directly comparable to commercial sector valuation methods, and recommended that previous valuation methods

used by the Australian Government (see, for example, 2000–01 NRIFS; Campbell et al. 2005) be adopted.

ARFF and Recfishing Research raised the question of whether social and economic data can be collected at a lower resolution than catch and effort data and reiterated that catch and effort information must be collected at an appropriate scale to inform management at the jurisdictional scale.

A key use identified by ARFF and Recfishing Research for social and economic data was the headline valuation of the sector, noting that there were differing views on whether this information could be used to inform resource sharing and allocation negotiations or discussions. The key uses identified for catch and effort data included that it enables trends to be monitored and that it can be used to inform assessment of sustainability.

ARFF and Recfishing Research expressed that significant stakeholder engagement, including with funding and peak bodies, was required from the outset of the project. They also expressed scope to advance co-management through engaging fishers in survey implementation.

Tasmanian Department of Primary Industries, Parks, Water and Environment

The recreational catch for some species in Tasmania, for example flathead, can be five times that of the commercial catch. Getting recreational fishers to understand their individual impact, and the overall cumulative impact, is one of Tasmania's key challenges. The Tasmanian Department of Primary Industries, Parks, Water and Environment's (DPIPWE's) objectives for a national recreational fishing survey are to:

- determine the participation rate and profile the demographic characteristics of recreational fishers

- quantify recreational catch (and discards) and effort by method, region and key species

- report on trends and to be able to compare with previous surveys

- understand contribution and impact of transient or visiting fishers.

Current Tasmanian recreational fishing surveys collect information on recreational fishing by recreational fishers and establish attitudes and awareness of recreational fishers to issues relevant to their fishery.

The key uses for this information relate to management of recreational and commercial fisheries, communications, and education. Currently, the Tasmanian statewide survey provides good information for key species, but targeted surveys are still required for certain species or questions.

Key concerns from DPIPWE's perspective relate to questions of scale; what is relevant at the national scale may not be relevant at a regional scale.

Primary Industries and Regions South Australia

Key fisheries management objectives for Primary Industries and Regions South Australia (PIRSA) are:

- the ongoing sustainability of the resource, specifically the conservation and management of aquatic resources and the protection of aquatic habitat and ecosystems

- to share access so the whole community gets the maximum possible benefit

- to foster recreational and commercial fishing activities.

Catch data from recreational surveys is used in models for key recreational and commercial species stock assessments, and is the highest priority and key objective for statewide surveys. Key recreational species in South Australia include snapper, garfish, blue swimmer crab and King George whiting.

South Australia's *Fisheries Management Act 2007* allocation policy calls for the best available information to be used for allocation of access to fisheries resources between fishing sectors. Catch estimates are compared to commercial and traditional catch to define first allocations. Increasingly, management is making proportional changes to allocations—that is, when catch levels increase or decrease for one sector, increases or decreases are proportional in other sectors.

Social indicators are currently being considered for inclusion into South Australia's recreational fishery management plan. Information needs include participation, attitudes, satisfaction with fishing and how the catch is used.

A national recreational fishing survey could benefit South Australia by providing additional information from interstate visitors. It may also reduce costs by combining resources. However, South Australia have recently undertaken a statewide survey and will not require a full scale survey until 2018–19. South Australia aims to conduct recreational fishing surveys every five years.

Key concerns expressed by PIRSA were that national scale surveys may not collect information at a useful scale, that the timing of a national survey may not align well with their timelines, and funding and resources to support their primary objectives and information needs are limited.

Queensland Department of Agriculture, Fisheries and Forestry

Key objectives for a national recreational fishing survey for Queensland's Department of Agriculture, Fisheries and Forestry are that:

- most importantly, the survey methodology should be scientifically robust and approved by all participating jurisdictions so that data will be used to make a valuable contribution to fisheries management

- the survey should contribute to the participation, catch and effort time series that has been developed over time, representing a substantial investment by the Queensland government. Therefore, methods should be similar or directly comparable to the recreational fishing surveys completed in 2001 (Henry and Lyle 2003), 2011 (Taylor et al. 2012) and 2014 (Webley et al. in preparation).

- a national survey should estimate catch and effort for recreational fishers visiting Queensland from interstate and, if possible, overseas.

Queensland identified a number of types of information that should be collected by a national recreational fishing survey, including:

- participation—currently Queensland Fisheries uses estimates of the regional recreational fishing participation rate for 16 residential regions. Some of these regions have significantly different recreational fishing participation rates. Regional participation rates should be estimated and broken down by age and gender of the fishers.

- catch and effort—this information should be collected as part of a national recreational fishing survey. Queensland currently does this on a fishing event, rather than daily, basis. An event is based on location, gear type and species targeted. Information collected for each event should include:
  - the number and species of fish caught, released and retained
  - the effort expended (hours or days)
  - the gear used
  - the species targeted
  - the location fished.

Economic information would be desirable for Queensland Fisheries. To be valuable, the methodology needs to be robust and accepted by all stakeholders, including economists, recreational and commercial fishers and fishery managers. Queensland Fisheries expressed enthusiasm to be involved in the development of a robust and reliable method to collect economic information.

Sufficient information should be collected so as to make reasonable estimates of catch and effort at spatial scales relevant to the stocks being managed. For several species, Queensland has sufficient information to enable these required sample sizes to be estimated.

Queensland also noted that a national recreational fishing survey provides the opportunity to quantify interstate recreational fishing effort and catch across Australia, which is difficult and costly to achieve independently. It also allows for synchronous estimates of catch and effort for fish stocks that span jurisdictional boundaries. Synchronous cross-jurisdictional estimates remove the confounding effects of weather (for example, floods) or regulation changes over time, thereby allowing estimates collected from different jurisdictions to be confidently used when managing cross-jurisdictional stocks.

New South Wales Department of Primary Industries

New South Wales Department of Primary Industries identified the following issues:

- surveys must be more cost effective that the previous national and state surveys
- it will be important to ensure consistency of methodology wherever possible between past and future surveys, both statewide and nationally, to measure any changes in the recreational fishery that may have occurred, or to ensure that any new, more cost effective methods provide outputs that can be combined with, and/or compared to, outputs from existing surveys
- the surveys should also seek to collect social and economic information relating to recreational fishing, on a state and national basis.

Northern Territory Department of Primary Industries and Fisheries

Northern Territory (NT) Department of Primary Industries and Fisheries noted that recreational fishing is an iconic pastime in the Northern Territory and this status has been confirmed by previous studies. The NRIFS illustrated that the NT had the highest resident participation rate of any jurisdiction in Australia (32 per cent, or 44 000 residents; and a total expenditure of $35 million directly related to recreational fishing). The recreational fishing sector in the NT also accounts for significant proportions of the total catch of some key vulnerable fish species, for example golden snapper.

The NT noted that a recent survey (2009–10) used the same methodology as the NRIFS, but had no ability to survey visiting (interstate) angler activity via on site surveys dues to cost constraints. This remains a critical knowledge gap. Notably, in some areas of the NT, visitor fishing effort can constitute greater than 95 per cent of the total fishing effort. Given the significance and expected growth of recreational fishing in the NT (especially among visitors), appropriate monitoring of this sector is essential for effective management and future sustainability of these fisheries.

NT also noted that decisions regarding resource access and the allocations of resource shares to users are central to providing stakeholder certainty and generating optimal and equitable outcomes. For some areas and fishery resources, access and allocation decisions have been made in the NT to the emphasis of recreational fishing benefits. This has resulted in a loss of traditional knowledge derived from commercial fishing activity (logbook) data. Consequently, the need for recreational activity data as a proxy for resource condition is now critical.

Contemporary data about recreational fishing activity and expenditure (by both resident and visiting fishers) in the NT is fundamentally important to future decision-making. In recognition of the importance of recreational fishing data to future management, the NT government recently committed to an ongoing annual survey program to collect recreational fishing data in targeted regions of the NT, via boat ramp surveys. The program is modest in scale and has been designed to complement knowledge that would be derived from a more sophisticated, multi-method survey conducted regularly at a national scale.

To be valid, the NT noted that it is important that any national survey is progressed in a way that allows for analysis of trends based on the results of previous surveys and that a new survey lays down the next phase of a time-series approach to recreational data collection.

The overarching objective for a national recreational fishing survey should be to provide sufficient data for the ongoing sustainable management of Australia's fish resources. Specific objectives should include:

- quantification of catch, effort and catch per unit effort for the main target fish and other species
- collection of information on expenditure on recreational fishing
- determination of participation rates
- establishment of awareness of, and attitudes towards, various issues concerning recreational fisheries management.

Victoria Department of Environment and Primary Industries

The Victorian Department of Environment and Primary Industries (DEPI) noted that preliminary work to inform a future statewide survey of recreational fisheries had been undertaken, although current resources meant that the survey cannot be undertaken at this time.

DEPI suggested that the objectives for regular national recreational fishing surveys are similar to the proposed Victorian phone–diary survey, which are primarily to:

- determine the participation rate in recreational fishing throughout Victoria by Victorian residents and to profile the demographic characteristics of these recreational fishers

- quantify the catch (including discards) and effort of the Victorian recreational fishing sector, with special reference to key target species (rock lobster, abalone, snapper, King George whiting, black bream and freshwater species to be determined)

- assess attitudes and awareness of recreational fishers in terms of various state fisheries-related issues.

DEPI noted that it is important that a national survey allows for estimates of total harvest ranging from the statewide to regional level. Demographic, attitudinal and economic information is of interest and provides information about the sector. It is particularly important to collect information in a way that allows comparison with previous and future surveys. It would also be desirable to allow for the integration and benchmarking with other information collection activities being undertaken for stock assessment and management purposes.

DEPI noted that with increasingly limited resources, there would be some benefit in developing a standardised and more efficient framework for phone–diary surveys, with complimentary on-ground surveys designed and managed at a jurisdictional level. This information could be particularly beneficial for the management of straddling stocks and for collecting information about interstate fishers.

Department of Fisheries Western Australia

Department of Fisheries Western Australia identified the following objectives for regular national recreational fishing surveys:

- Annual recreational shore and boat-based robust estimates are required at the state and bioregional scale for key species. Depending on funding available this objective can be expanded to include broader range of species, monthly estimates and refined location estimates

- Comparisons with estimates from previous surveys (for example, NRFIS, statewide surveys).

Information collected as part of a national survey should include estimates of participation, catch by species and social and economic information, at appropriate spatio-temporal scales.

Australian Government

Technology changes have made offshore fisheries resources more accessible to recreational fishers and this has increased the overlap with many commercial fisheries, including those managed by the Commonwealth. A priority identified at a March 2015 meeting of the Commonwealth Fisheries Research Advisory Body is to build a better understanding of the recreational catch of commercial species managed by the Commonwealth, recognising that recreational catch is increasing across a number of fisheries. The Commonwealth Fisheries Harvest Strategy (DAFF 2007) requires all aspects of exploitation, including recreational fishing, to be accounted for in setting total allowable catches.

Some of the Commonwealth stocks for which recreational catch constitutes an important part of the total catch include tunas, billfishes, gummy shark, school shark, gemfish, blue-eye trevalla and redfish. A recreational data collection program for some of these key species would need to be statistically robust, cost-effective and trusted by stakeholders.

A national recreational fishing survey such as that proposed herein is likely to provide some useful information on Commonwealth species that are caught by recreational fishers, but is unlikely to provide the necessary precision to enable what are often rare-event catches to be aggregated to regional or national scales. Consequently, targeted surveys such as that proposed

by Moore et al. (2015, in prep.), or alternative approaches, such as a licensing system for key Commonwealth species, are likely to be needed in order to account for the recreational catch of these species in a way that it can be used effectively for fisheries management purposes. Alternative methods, such as sophisticated respondent-driven sampling techniques, may provide a more robust and cost-effective way of collecting information on hard-to-reach components of some specialised fisheries (Griffiths et al. 2010).

Assessment and management—regular estimates of total catches

Recreational catch is of high importance where the target species of are also primary targets of commercial fishers. Griffiths and Pepperell (2006) estimated that 245 species, including tuna, billfish and deepwater finfish, are targeted by both recreational and commercial fishers. They also showed that the potential for recreational fishers to access Commonwealth waters has increased in recent years, due to improvements in technologies (for example, boats, global positioning systems, safety equipment) and improvements in fishing gear. The cost of these technologies is also decreasing and fishers now have relatively easy access to novel technologies such as electric reels, which are increasingly being used to target some deepwater finfish.

Over the last few years, fishers are increasingly networked and are able to respond quickly to reports of fishing opportunities, which are often broadcast widely on social media or reported on the internet. This has significant implications for highly seasonal or aggregating stocks, including southern bluefin tuna and yellowtail kingfish, where effort is often quickly mobilised when reports emerge that fish are present in certain areas.

Reliable estimates of total recreational catches are required for stock assessments and quota-based management. Estimates are available for several species from state surveys, but not for pelagic species. Organised game fishing activities (for example, tournaments or charter boats) are relatively easy to survey, but the Commonwealth also needs information on the non-organised component. This includes the proportion of fish retained and released.

A similar situation exists for southern bluefin tuna, with the need for maintaining the integrity of the domestic Individual Transferable Quota system and international reporting requirements being prominent issues.

The development of a new Commonwealth Bycatch Policy and a revised Harvest Strategy Policy will also raise the need for data on species that are classified as 'bycatch' and secondary commercial species. Several of those species are important recreational targets.

Resource access—social and economic value, participation rates

Commonwealth fisheries interact with several important recreational species, such as tuna and billfish. However, there is little socioeconomic information on the value of these species to game fishers, or the value of game fishing to the wider community. Valuing fishing activities is crucial for addressing resource allocation issues; it provides information on the merits of spatial management options and regulating catches of particular sectors. This information is becoming increasingly important to fishery management and policy that must consider the interests of all resource users. Similarly, marine bioregional planning and monitoring the performance of closed and multiple-use areas will benefit from spatial data on recreational catches and fishing effort. A national survey is not expected to provide data at that scale, but might provide sampling frames for dedicated surveys.

Protected species—interactions and fate

'Protected species' include all species listed under the *Environment Protection and Biodiversity Conservation Act 1999*, including species listed under international conventions and agreements to which Australia is party. This includes listed migratory species such as some sharks, birds and mammals. The Australia government needs information on recreational interactions with protected species, including reliable species identification, mortalities, total catches and numbers release alive.

Attitudes—effective communication

From time-to-time, Commonwealth management issues attract the attention of recreational anglers and their representative organisations, for example, commercial catches of striped marlin, harvesting of small pelagic fish and southern bluefin tuna. The Australian government needs information on the attitudes and concerns of the recreational fishing community and effective means of communicating with those groups.

Appendix B: Theoretical concepts for resource allocation issues and the travel cost method

The travel cost method uses observed consumer behaviour in relation to demand for recreational goods to estimate the non-market benefits that individuals derive from participation in recreational activity (Ward & Beal 2000). These benefits are estimated from the underlying demand function, evaluated through the method, for consumption of the recreational good. This demand function is estimated from survey responses on the cost of travel to access the environmental good and the visitation rate. As expected from economic consumer theory, quantity demanded for recreational goods is inversely related to the price of access to the good, as the longer the distance travelled to visit a site, the higher the cost of travel, and the lower the rate of visitation (Randall 1994).

As the travel cost method is based on expenditure to visit a site, the models tend to underestimate (as they only value the use values) the consumer surplus—the area under the evaluated demand function—of the recreational good (Randall 1994). The travel cost method concentrates on expenditure to participate in a recreational activity rather than on the whole non-market benefits, including non-use values. Other common problems with applying the travel cost method are choice of dependant variable, multi-purpose trips, multi-destination trips, calculation of distance costs, holidaymakers versus residents, availability of substitute sites that may affect values, and time and sampling biases.

While more sophisticated methods such as Choice Modelling or Contingent Valuation could be used to estimate 'use' and 'non-use' values of recreational fishing, the most common and relatively least expensive method used for the estimation of the recreational use values is the travel cost method. While this method does underestimate the value of the recreational sector by not capturing the non-use values, it provides a valid indication of willingness to pay per trip. The average willingness to pay per trip multiplied by the total number of recreational fishing trips undertaken to the location provides information about (at least) the minimal annual net economic value of that sector.

The estimates obtained from the travel cost method can be used in a standard cost-benefit analysis framework to determine the optimal allocation of resources by comparing the aggregated annual net economic value of different sectors. More specifically, the framework is based on estimating the value of consumer surplus and producer surplus that make up the net economic value. When measuring the economic benefits of resource allocation, the net economic value of each choice can be measured and compared.

The net economic value is inherent in the total economic value. The total economic value of a good or service is the level of satisfaction that people derive from consuming that good or service. This satisfaction is expressed through the total willingness to pay for the good or service, which is often above what they actually pay.

Consumer surplus is the net willingness to pay, which is the difference between what consumers actually pay (expenditure measured in market price) and what they would be willing to pay (represented by their total willingness to pay). With the availability of price and quantity data, the demand for a good can be determined and the net economic value can be estimated. With the availability of price and quantity data for fish produced for food, the demand for fish can be

determined and the net economic value of commercial fisheries can be estimated. In Figure a, the net economic value is the sum of consumer surplus (CS) and producer surplus (PS). Consumer surplus is the value to buyers (net willingness to pay) minus amount paid by buyers. Producer surplus is the amount received by sellers minus cost to sellers. The vertical axis described as 'Unit Cost ($)' represents the price for fish and the horizontal axis described as 'Quantity' represents the number of fish consumed.

Figure a The concept of net economic value
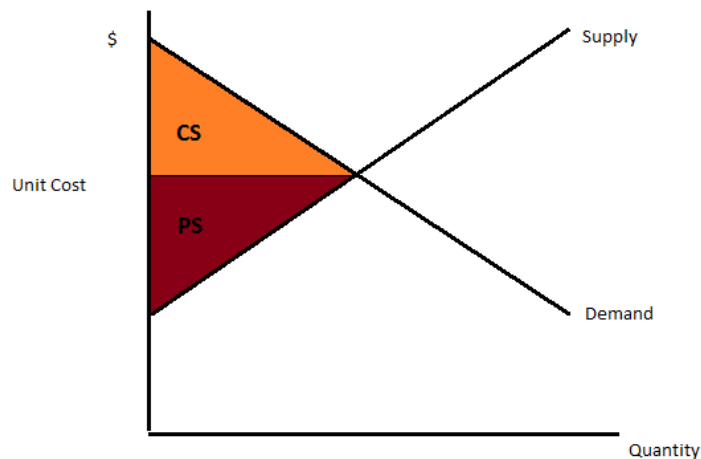
Notes: **CS** Consumer surplus. **PS** Producer surplus.

Unlike commercial fishers, who sell their catch in organised markets, recreational fishers do not have to pay directly for fish caught recreationally and, therefore, do not reveal the associated value they gain from catching fish. Therefore, non-market valuation techniques are often used to estimate fishers' willingness to pay for recreational fishing. In seeking to estimate the net economic value of recreational fisheries, it is important to recognise that these fisheries usually provide a range of values that can be categorised into 'use' and 'non-use' values. The net economic value derived from recreational fisheries is composed of an aggregation of both these type of values.

For recreational fisheries, the direct use value represents the value that fishers derive from participating in recreational fishing activities. Indirect use values from recreational fisheries include maintaining sustainable and ecologically healthy fisheries (Tietenberg 2010). Non-use values include the value that the community places on knowing that these fisheries exist, that options for future exploitation are retained and that these environmental assets can be bequest to future generations (Perman et al. 1999). Estimating the full range of these values is complex and economic analysis to date has mostly focused on estimating direct use value.

A travel cost method is a common method used to estimate recreational use value (TEEB 2011). This method has been applied effectively in the Australian context to assess the economic impact of changes in access to resources, for example when implementing expanded marine park zones in Queensland's Moreton Bay region (Pascoe et al. 2014a).

The travel cost method is based on expenditure to visit a site to participate in recreational activity. Due to the absence of price information for fish obtained from recreational fishing, the demand therefore is derived indirectly by assuming that the travel cost of a recreational fishing trip can be used as an alternative for price. Consumer willingness to pay for fish increases with each additional good but at a decreasing rate. This applies to situations in which fish is used

either for food or for recreational activity. This means the additional satisfaction from consuming fish or participating in additional recreational fishing trips gets smaller, the more the consumption or recreational fishing continues. The changes in the quantity of fish consumed or the quantity of recreational fishing trips made over time affects the relationship between the price of a fish or price of a trip. This relationship is commonly used to indirectly determine the demand function for recreational goods, allowing for the measurement of their net economic value in terms of consumer surplus (Figure b), where the vertical axis represents the 'Unit cost' of a fishing trip and the horizontal axis represents the number of fishing trips ('Quantity') pursued at each unit cost level.

Figure b The concept of estimating the net economic value for recreational fishing, which is the consumer surplus (CS)
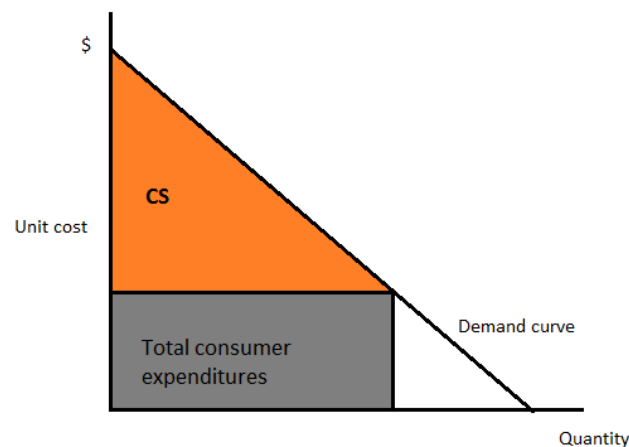
An average consumer surplus per trip per fisher can be estimated from the travel cost method and multiplied by the number of recreational trips undertaken to a certain location over a period of time to obtain the net economic value of recreational fishing at a particular location. This net economic value of recreational fishing can be compared with the net economic value of commercial fisheries at the same location and an optimal access of resources can be found as presented in Figure c. By estimating the net economic value of both sectors for different resource allocation scenarios, the option that maximises the net social benefits can be chosen. Such estimations are generally recommended where there are competing users and any changes in resource allocation in terms of quota or resource access for a certain resource or location should result in an increase in economic welfare.

Figure c presents how quota (or resource access) can hypothetically be shared between both commercial and recreational fisheries in a way that maximises net social economic benefits for a hypothetical example where there is eight units (for example, tonnes) of total allowable catch (TAC) to be shared between the fisheries. There are three possibilities: allocate all of the TAC to the recreational sector; allocate all of the TAC to the commercial sector; or share the catch between the commercial and recreational sector. As drawn, net social benefits are not maximised by allocating all of the TAC to either sector, despite the net benefit of allocating the total TAC to the commercial sector ($140 million) being greater than the net benefits that would be derived by allocating the total TAC to the recreational sector ($90 million). Nor does any sharing arrangement need to be equal, in the sense that the allocation between commercial and recreational sector should be shared equally between the two sectors.

In this hypothetical example, granting a TAC of six units to the commercial sector and two units to the recreational sector maximises net social benefits at around $180 million, which is higher than either sector can generate on its own. This allocation is unique in the sense that the marginal benefit of an incremental movement to that allocation offsets the marginal loss experienced by the sector losing quota. At all other allocations it pays to adjust the allocation toward the optimum because the winning sector would be able to compensate the losing sector and still be better off, a condition for moving toward a 'Pareto optimum'[5]. Quota should be adjusted between the fisheries until the marginal benefit of an extra unit of quota exactly offsets the marginal loss in the other sector from losing a unit of quota, where the benefits and losses are defined in terms of changes to consumer surplus and producer surplus.

The optimal allocation shown in Figure c is just one possible outcome for a particular location, targeting a particular stock. Every location will be unique and lead to a different maximal allocation, with the final allocation depending on the marginal benefit attained from an additional unit from the respective sectors, and how this benefit changes as additional units of quota are allocated. It is also possible that it is socially optimal for the entire TAC to be taken by one sector. This will be the case where the net benefit attained by one sector from fishing is always greater than the loss accruing to the alternate sector across all feasible allocations of the TAC. An example would be a commercial species that recreational fishers rarely target despite the resource being available to them, indicating a low total net benefit and marginal benefit from targeting for recreational fishers. In this scenario, it is optimal for the entire TAC to be taken by the commercial sector. The converse is true for a species that offer high sport value but little commercial value, which will result in recreational fishers taking the entire TAC.

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[5] Pareto optimality is a state of economic efficiency in which it is impossible to make an individual better off without making at least one individual worse off.

Figure c Total net benefits from allocation of quota between commercial and recreational fisheries
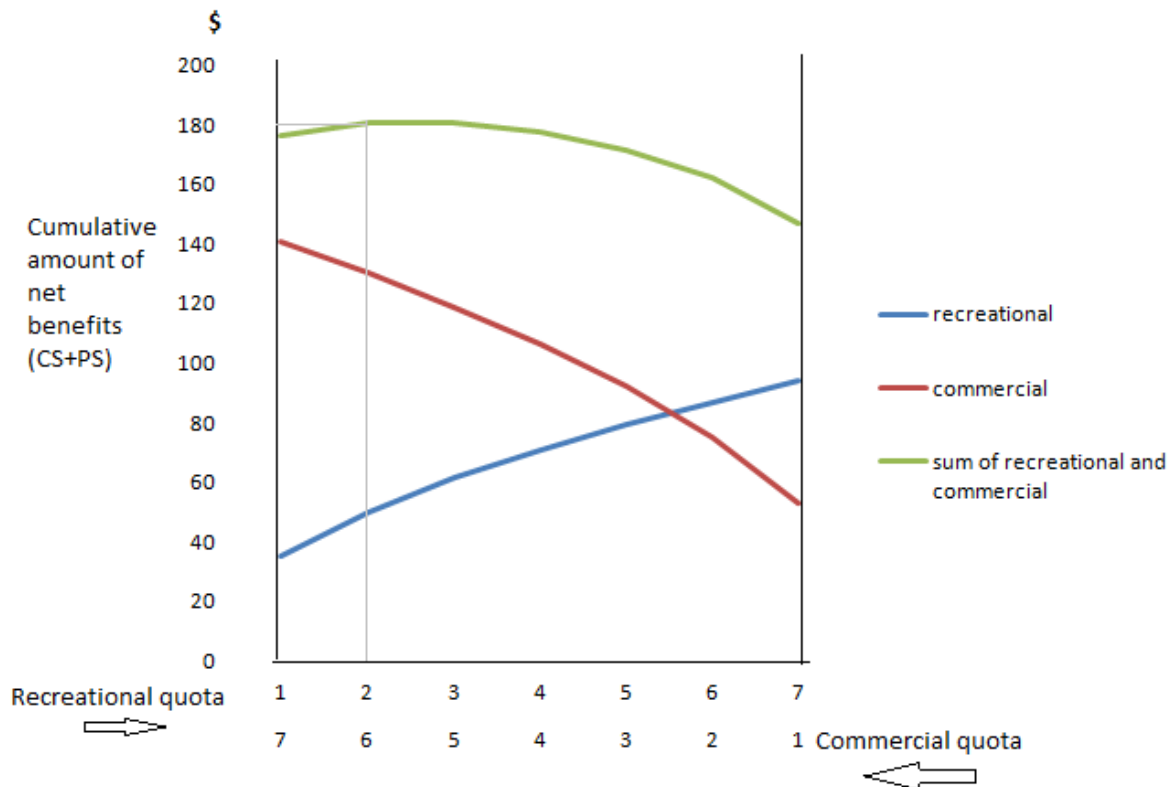
Source: Adapted from Edwards (1990)
Notes: CS Consumer surplus. PS Producer surplus.

Resource allocation questions are necessarily complex, and we have suggested one way in which this complexity can be overcome. As shown, it is unlikely that expenditure data collected through a national recreational fishing survey could be used on its own to address specific resource allocation questions in specific locations. Consequently, a cost-effective alternative to collection of the necessary data may be through targeted, issue-specific studies. Alternatively, a number of jurisdictions, including South Australia and Western Australia, have developed methods for resource allocation as part of their fisheries management frameworks.

Application of the travel cost method to an existing recreational fishing survey expenditure dataset

A subset of the data from the Northern Territory 2009–10 recreational fishing survey (Darwin and Mary River fishing events) was analysed to test if an existing dataset of recreational expenditure can be used to determine consumer surplus using a travel cost method. In this testing exercise, raw data from the Northern Territory survey was used without detailed knowledge about the survey process and questionnaire design. It is important to note that the dataset itself was presumably 'fit for purpose' for the survey objectives and scope, and the limitations identified in this exercise are only related to the attempted application of a travel cost method. To apply the method, data from the Northern Territory data set needed to be combined for two different locations as insufficient data were collected to conduct travel cost method exercise for a single location. This highlighted one of the potential limitations of the data

showing that insufficient sample sizes for a specific location could prevent application of the travel cost method. Further analysis of the data involved data cleaning, gap filling, assumptions and modelling to determine how the questionnaire should be adjusted in order to obtain sufficient information for a standard travel cost exercise. The data cleaning process identified any ambiguities, incomplete or missing data, which can create some difficulties in using similar datasets for travel cost method estimations. Based on this exercise some minor suggestions to the questionnaire were suggested. It was proposed to clearly define terminology such as:

- 'fishing trip' as a trip from home (place of usual residence) to a fishing spot

- 'distance travelled' as a trip from home (place of usual residence) to a fishing spot and then home again

- total distance travelled over the entire duration of a fishing trip (included distance travelled while on a fishing trip).

One difficulty with understanding the dataset was related to missing data—it was sometimes unclear whether missing data could be interpreted as 'not available', 'not applicable' or 'zero'.

To improve any future national survey, respondent address should be confirmed for each fishing event in case the respondent changed address during the survey period.

To facilitate application of a travel cost method as part of any future national recreational fishing survey, additional information about each trip is proposed for collection, including:

- the name of a fishing spot and a nearby town

- the type of transport (car and engine size, plane, bus, boat and size etc.) for a trip from home to a fishing spot. If a combination of transport mode was used to travel from home to a fishing spot, distance travelled using each of the transport modes should be provided

- specifying if a vehicle used for a trip (from home to a fishing spot) was towing a boat

- the main purpose of a trip.

- the main species targeted.

Considerations of respondent burden will limit the amount of data that can be collected as part of national recreational fishing surveys, particularly those that collect catch, fishing effort, economic, demographic, attitudinal and other social data. To reduce cost and respondent burden, it is proposed that expenditure data are sub-sampled during the diary phase (that is, four sub-strata for three months each).

Appendix C: Social dimensions of recreational fishing

Rationale for collection of data under proposed social themes and sub-themes

Theme 1: Fisheries management and policy

This theme relates to fisher behaviour, attitudes towards and awareness of regulations, including licensing requirements, compliance, resource access, the social acceptability of fishing, and engagement, consultation and communication.

Sub-themes:

- regulations and compliance (bag limits/gear restrictions, licensing)

- fisheries management performance (including trust in fisheries management)

- access to fishing spots (marine protected areas, commercial fishing, facilities/infrastructure)

- social acceptability

- engagement, consultation and communication.

Rationale for data collection

Fisheries agencies are responsible for the day-to-day management of fisheries, including regulating fishing effort, managing harvest rates and monitoring changes in habitat. Significant challenges exist for agencies in managing fisheries including the risk of overfishing, the degradation of habitat, illegal fishing, the complexity of management arrangements and the constraints on fisheries compliance resources (NFCC 2010).

In Australia, state and territory jurisdictions manage recreational fishing activity in inland freshwater, marine waters out to three nautical miles, and in Commonwealth waters adjacent to state and Northern Territory waters. Therefore, jurisdictions require information to better understand fisher acceptance of regulatory changes, their knowledge of and attitudes towards fisheries management, issues and areas of conflict such as resource sharing, education and communication needs, behaviour change, and to improve compliance with rules. This information can provide assurance to the wider community that fishery resources are being maintained at sustainable levels and that aquatic habitats are being protected (NFCC 2010).

A number of jurisdictions have collected social data on fisheries management in recent surveys (Henry & Lyle 2003; DPI Fisheries Victoria 2010; Schirmer 2012; West et al. 2012; McInnes et al. 2013; Lyle et al. 2014). While the general structure of fisheries management questions in these surveys is similar, the specific focus, content, language and phrasing is jurisdictionally contextual.

Brookes et al. (2015) and Triantafillos et al. (2014) provide a number of reasons for collecting social data, which include the need to measure progress towards specific social objectives for Australian fisheries management. Information collected through national surveys could inform indicators of progress put forward by Brooks et al. (2015), and over time, show trends towards achieving longer term social objectives for fisheries management. Some of the reasons for collecting social data include showing whether:

- there are appropriate mechanisms for fisher involvement in development of fisheries management advice

- fishers have the ability to participate effectively in fisheries management advisory processes

- industry stakeholders have a high level of trust in the management of fisheries.

Given the current review of Commonwealth MPAs, an important issue could be to know the level of support among recreational fishers for marine park areas (MPAs), and on resource sharing with commercial fisheries. Linking social perspectives to spatial locations could be a useful way to present the social data because the attitudes could be linked to specific fishing spots and allow for targeted and appropriate management responses.

Other useful information for fisheries managers are the circumstances in which people are more or less likely to comply with recreational fishing regulations, including, for example, bag and size limits. This is useful for understanding how to target compliance efforts or generate compliance behaviour, including helping design appropriate communications, incentives or actions that would encourage fishers to voluntarily comply. Useful information that would inform fisheries management strategies could include attitudes towards licensing, such as whether people think fishing licences are needed, licensing fees and views on a national recreational fishing licence.

Social licence refers to the community's views on the level of acceptability of recreational fishing and community perceptions of whether fisheries resources are being wisely used and protected. Arnot (2012) defines social licence as 'the privilege of operating with minimal formalised restrictions (legislation, regulation, or market requirements) based on maintaining public trust by doing 'what's right''. It may have little to do with whether or not legal or regulatory requirements have been met. While this concept has not been the subject of any recreational fishing surveys in Australia, it is related to a number of the themes. A social licence for recreational fishing might, for example, be driven by beliefs and attitudes held by the wider community about the way that recreational fishing affects the environment (for example, pressure on fish stocks), animal welfare practices (for example, catch and release methods and/or mortality), social and community benefits and other policies and practices relating to recreational fishing. The social acceptability of commercial and recreational fishers in Australia has been investigated in-depth by Mazur et al. (2014) in their *Let's Talk Fish* study.

Social licence is a relatively new area for recreational fishing, but it may be worthwhile considering whether this is a valuable concept for future data collection as it helps to understand how to promote the activity to the wider public and ensure the future of the activity.

Theme 2: Environmental attitudes and awareness

This theme relates to the awareness and attitudes of recreational fishers to the environment in which fishing activity takes place. Recreational fishers are active participants within various environments where their actions can affect fish stocks and habitat. Due to their presence in this environment they are valuable observers of the aquatic environment and of those active within it.

Sub-themes:

- sustainability/fish stocks

- stewardship (also a precursor of compliance)

- surveillance

- threats to environment (habitat).

Rationale for data collection

It is unclear the extent to which recreational fishers believe in and actively undertake beneficial environmental practices. Having clearer information about fishers' environmental attitudes and awareness to threats is important to understand their role in protecting critical habitat and resources.

Recreational fishers can improve natural environments through volunteering and programs run by fishing clubs and associations to develop improved green spaces and aquatic habitats. Fishers can also engage in monitoring (surveillance) of ecosystems and environmental health (Brown et al. 2012).

State and territory jurisdictions and recreational fishing groups require this information to understand views that fishers hold about sustainability of fish resources and the natural environment in which they fish. It would also be useful to understand and enhance the current role (and potential role) of recreational fishers as stewards of the natural environment, through potential participation in activities for improving and rehabilitating fish habitat and associated freshwater, marine and terrestrial environments.

Other indicators of stewardship could include fishers' level of compliance with fisheries management rules and regulations (included in Theme 1), reporting of illegal fishing or habitat destruction to authorities (for example, NSW Fishers Watch[6]), and the contribution of fishers to science (for example, tag and release).

Participation in activities to improve environments might not be the only indicator for stewardship; fishers voluntarily clean up aquatic and riparian environments while they fish. They also make decisions about which exotic fish to retain or discard. Information on how these decisions are made could be useful for promoting certain practices (for example, active removal of exotic species from sensitive habitats).

Theme 3: Personal benefits from fishing

This theme relates to the personal outcomes and benefits that fishers experience from participating in recreational fishing. Evidence suggests that there are links between recreational fishing activity and a range of personal benefits such as physical and mental health benefits. However, these links are not well understood—particularly at the national level.

Sub-themes:

- health and wellbeing benefits (physical, mental, social capital)

- satisfaction with fishing experience

- successful fishing experience

- skills, knowledge and transfer of cultural experience and lessons.

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[6] http://www.dpi.nsw.gov.au/fisheries/compliance/report-illegal-activity

Rationale for data collection

Information on personal benefits derived from recreational fishing can help understand and promote the benefits of recreational fishing to Australian society, including for disadvantaged groups, young people, families and children, and the elderly. Personal benefits derived from engaging in fishing activity are currently not well understood and therefore, those benefits cannot be demonstrated or enhanced.

Health and wellbeing benefits

Fishing activity can play a positive role in improving public health and wellbeing. Social researchers in the United Kingdom propose there are three ways that health and wellbeing benefits are derived from recreational fishing:

1) It incorporates a range of physical activity levels and encourages activity among the inactive, those recovering from illness and older age groups, through improved physical activity and access to natural environment.

2) It incorporates therapeutic engagement and contact with natural spaces ('blue-green spaces') and through this, maintains positive mental health by providing stress relief and opportunities for relaxation.

3) It provides opportunities for social interaction that facilitates relationship building, connection and participation in social life (Brown et al. 2012).

Physical inactivity is a major risk factor in global mortality (WHO in Brown 2012). Health research in developed countries has shown that physical activity is declining, particularly for children and adolescents[7]. Because of this, a number of government commitments have been made to improve outdoor physical activity, particularly for young people, in Australia. The Australian Government is committed to promoting healthy lifestyles, addressing obesity, and taking preventative measures to improve the health of all Australians through initiatives that include promotion of physical activity, such as:

- Get set 4 Life—Habits for Healthy Kids

- Healthy Spaces and Places

- Learning from Successful Community Obesity Initiative

- Healthy Weight information and resources[8].

State and territory governments also have strategies in place to promote physical activity through participation in sport and recreation. New South Wales Health, for example, launched a strategy for preventing obesity in 2013. A key goal of the strategy is to 'increase participation in sport, recreational, arts and cultural activities by 10 per cent from 2010 levels in rural and regional New South Wales and in Sydney by 2016' (NSW Health 2013). Similarly, the South Australian 'Eat Well Be Active' strategy aims to provide opportunities for physical activity

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[7]A longitudinal study of children and adolescents in Australia by Cleland et al. (2010), for example, found that the time children spent outdoors markedly decreased over five years from 2001. They found major factors related to participation in outdoor activities included the opportunities for social interaction, parental encouragement and parental supervision.
[8] http://www.health.gov.au/internet/main/publishing.nsf/Content/programs-initiatives-menu;
http://www.health.gov.au/internet/main/publishing.nsf/Content/phy-activity

participation, including through support for organised sports and recreation programs and services (Government of South Australia 2011). The Victorian Government's *Public Health and Wellbeing Plan 2011–2015* highlights physical activity as a priority issue for promoting health (Victorian Department of Health 2011).

Recreational fishing provides opportunities for different levels of outdoor physical activity. The distinctions that recreational fishing offers compared with other more high profile sports is that it provides opportunities for physical activity for the less able that other sports do not. It can be done throughout people's lives, keeps people active later in life and provides sustained duration of physical activity (Brown et al. 2012). Recreational fishing is unique in that it is accessible to most people, regardless of age, ethnicity, physical or mental ability.

Recreational fishing activity can assist in improving mental health. Much of the evidence for a link between mental health benefits and recreational fishing activity comes from international literature. A number of studies found links between nature contact and mental health (see, for example, Korpela 2003, Nielsen and Hansen 2007 in Townsend & Weerasuriya 2010). United Kingdom non-government organisation researchers, Brown et al. (2012), report that their extensive research has shown that recreational fishing provides an activity that develops positive mental health in people through benefits such as relaxation, rest and escaping crowds and noise. Fishing was seen as an important opportunity for stress release and breaks in sustained cognitive patterns. It is also an activity that can be used in a targeted way to treat mental health problems.

There are a number of recreational fishing programs run in Australia by government fisheries management agencies, peak fishing bodies and private organisations that recognise the benefits of outdoor fishing activity for young people, including:

- Fishing workshops[9] (NSW Primary Industries Fishing and Aquaculture)—designed to teach responsible fishing practices to children aged 8 to 14 years

- SunSmart Fishing Clinics (Recfishwest)—teaching children aged 10 to 17 years how to fish and take care of the ocean[10]

- Young Guns Fishing Adventures—provides fishing lessons to children of all ages and adults, including for the disabled community[11] and runs outreach programs for young people aimed at exposing them to fishing industry career pathways and addressing the negative effects of drug and alcohol abuse.

Research quantifying the links between mental and physical health and recreational fishing activity, such as through the above programs, is not well established in Australia. In the United Kingdom, Pretty et al. (2007) quantified the improvement in physical and mental health (self esteem, mood status) derived from a range of sports, including fishing. They found that green exercise regardless of type, level of intensity and duration had significant mental health benefits.

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[9] http://www.dpi.nsw.gov.au/fisheries/recreational/info/workshop

[10] http://recfishwest.org.au/community/sunsmart-fishing-clinics/

[11] http://www.younggunsfishing.com.au/

Successful fishing experience

Studies have investigated what makes a successful fishing trip or experience. Among these are Sutton (2006), Ormsby (2004) and, in the context of gamefishing, Ward et al. (2012). Previous studies found that important factors in judging the success of recreational fishing trips and experiences are the derived personal and social benefits, natural environment experiences, weather conditions and catch related outcomes (Ormsby 2004). However, a number of studies showed that catching fish is a relatively less important factor in a successful recreational fishing experience than previously thought (Ormsby 2004). This was even the case for fishers participating in gamefishing tournaments[12] (Ward et al. 2012).

Studies investigating successful fishing experience suggest that fisheries managers require this kind of information in order to understand how and why recreational fishers access and use the resource. The effects of management decisions on the satisfaction and enjoyment of recreational fishers is another use for the information. Fishing experience information can provide insight into fishers' needs and preferences and can help to engage the sector on issues that are important to them.

Satisfaction with fishing experience

Satisfaction is the extent to which personal benefits are being obtained from fishing compared to expectations (Ormsby 2004). Investigations have found fishing satisfaction to be the result of a complex interaction of social, psychological and environmental factors (Ditton 1980 in Ormsby 2004).

To assess satisfaction, an agreed set of indicators that measure the concept are needed. These indicators may be measurable through combining a number of other themes, for example, catch rates, motivations for fishing, expectations, skill levels, specialisation, access to fishing spots, perception of management and regulations, views on facilities and frequency of fishing, among others. Graefe and Fedler (2009) proposed a model for measuring fishing satisfaction, which integrates the subjective and situational factors associated with satisfaction as well as the consumptive and non-consumptive elements of fishing. They conclude that there are relatively weak correlations between satisfaction and the objective harvest measures.

A number of surveys have also investigated satisfaction with fishing experience using direct questions to survey respondents about their overall subjective satisfaction (in Schirmer 2012; McInnes et al. 2013)[13].

There may be a partial utility in asking about satisfaction with fishing. Some of the reasons given for satisfaction ratings are unlikely to have utility for fisheries managers because the reasons for satisfaction involve personal or lifestyle choices, such as equipment upgrades, or changes in availability of leisure time. However, there are factors that could be influenced by fisheries

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[12] In the study by Ward et al. (2012), 66 per cent of gamefishers participating in the survey agreed that a game-fishing trip could be successful even when no fish were caught.
[13] In the survey by Schirmer (2012) conducted for PIRSA, for example, South Australian fishers were asked 'How satisfied are you with your recreational fishing activities?'. Those who said their satisfaction had increased (roughly 30 per cent of respondents), commonly gave reasons such as that they had bought or upgraded their boat, had more time or 'opportunity' to fish, were retired with more time to fish, improved their fishing skills or had unspecified personal changes.

management such as improved access to fishing spots, facilities for recreational fishers and the quantity of catch (plentiful fish).

By understanding how and why people fish, fisheries managers can create satisfying and sustainable fishing opportunities. Managers can find out how fishers are likely to react to changes in fisheries management, and what influences their decisions to fish more or less.

Skills and knowledge

Personal benefits can include development of skills and knowledge associated with fishing activity, including water safety, boating safety, nature based knowledge (for kids) and personal development. Learning to fish is associated with social and family networks, with fishing skills, techniques and information being passed to young people from parents, grandparents, friends or extended family (Brown et al. 2012).

Collecting this data can help inform understanding of the broader factors that help to contribute to learning and skill development in recreational fishing and satisfaction with the fishing experience.

Theme 4: Participation in fishing activity

This theme relates to current participation rates in recreational fishing, trends in recreational fishing participation, avidity and the factors that influence participation.

Sub-themes:

- motivations/importance of recreational fishing
- constraints to participation.

Rationale for data collection

It is useful to know who participates in recreational fishing and understand the factors influencing participation—specifically, the motives for and constraints to participation—in order to understand how the resource is being used and how to influence behaviour. There is an opportunity to find out what constitutes 'participation' in recreational fishing.

Data on the avidity of recreational fishers (occurrence and level of fishing activity), for example, can contribute to spatial assessments of potential fishing pressure.

If collected regularly, these data can inform us about trends in participation over time. Recent studies in Australia (see, for example, Schirmer 2012; McInnes et al. 2013; Lyle et al 2014) have indicated a decline in recreational fishing participation in South Australia, Queensland and Tasmania. This trend has also been observed in other parts of the world (for example, in Canada[14]). If the aim were to reverse this trend there would need to be a clear understanding of why people are participating, disengaging or not taking up this activity.

Information about motivations to fish needs to go beyond 'just going fishing'. Understanding constraints to participation in fishing activity (for example, for socially excluded groups) can

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[14] In Canada, survey trends show that numbers of recreational fishers have decreased at an average annual rate of 2 per cent during the ten years prior to 2005 (Hoffman 2008).

help in the design of programmes and targeted interventions to overcome those constraints—for example, fishing related youth programmes. Programmes encouraging youth participation in angling in the United Kingdom (Brown et al. 2012) have been successfully designed to lead to wider personal and community benefits, such as providing personal and social development opportunities, improving achievement in education and employment, and diverting young people from crime and anti-social behaviour.

Data on participation in recreational fishing activity is related to a number of other themes, and together can provide insights into the benefits of recreational fishing for individuals, families and communities.

Theme 5: Demographics of fishers and characteristics of recreational fishing activities

This theme relates to understanding the demographics of recreational fishers and the characteristics of their recreational fishing activities, such as club membership, modes of fishing, and years of experience. This information can be used to segment and group recreational fishers according to their views on a range of items collected within a survey, such as participation, personal benefits, environmental attitudes and awareness.

Sub-themes (demographics):

- age
- sex
- occupation
- education
- personal/household income
- cultural and linguistic diversity (CALD)
- Indigenous status
- disability
- residence (state, town).

Sub-themes (characteristics):

- fishing licence
- fishing club membership
- boat ownership
- fishing mode – shore, hire boat, private boat
- fishing techniques and technology used
- years experience
- time spent fishing.

Rationale for data collection

There is currently insufficient regular data that characterises recreational fishers across Australia. The collection of demographic data allows survey responses to be segmented based on demographics. There are a number of ways this type of data can then be utilised, for example:

- understanding 'who' makes up the recreational fishing cohort

- social stratification/representation (social inclusion)

- differences between groups

- scope of representation provided by peak bodies and other representative groups

- constraints to participation for different segments.

Demographic information is essential for understanding change within the recreational fishing cohort. Research from the United States (Murdock et al. 1996; Floyd et al. 2006) suggests that the recreational fishing cohort in the United States is changing, with an increase in the number of CALD participants and a decrease in younger people and participants aged above 60 years.

Changes in the demographic structure of the recreational fishing cohort will bring with it different values, beliefs, behaviours, preferences and needs. Furthermore, communication and engagement approaches and pathways may need to be adapted.

Understanding the structure of the recreational fishing cohort will also help guide program design to increase recreational fishing participation. As previously highlighted, increasing participation in physical activity, such as through outdoor recreation, is a key area of focus for governments in Australia as it provides numerous positive physical and mental health, social, economic and environmental outcomes for individuals, families and communities[15].

Gaining an understanding of other characteristics such as modes of fishing, techniques, technology used and boat ownership will support fisheries management decision-making.

Theme 6: Community benefits

This theme relates to understanding the benefits recreational fishing brings to local communities.

Sub-themes:

- economic activity and diversity

- health and wellbeing

- social vitality (live, grow and develop to improve quality of life)

- social capital (the bonding and ties that hold communities together)

- cultural heritage and collective identity

- social integration within communities (including inter-ethnic connections and intergenerational exchange)

- local environment, 'blue and green' spaces, recreational and cultural facilities.

Rationale for data collection

There is currently a lack of data and information on the dimensions of community benefits from recreational fishing. This is especially the case for understanding the link between social

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[15] See state government health programs listed under *Theme 3: Personal benefits from fishing*.

outcomes reflected in concepts such as social capital, localism[16] and increasing social integration, and recreational fishing. Research from the United Kingdom by Brown et al. (2012) provides strong evidence that local communities derive a diverse range of positive benefits from recreational fishing.

Recreational fishing activities can be an important source of economic activity for communities, such as through recreational fishing tourism—especially for those in remote, rural and regional areas. For example, the study by Brown et al. (2012) found that fishing tourism can lengthen the tourist season, offset declines in other forms of tourism and assist in sustaining the cultural heritage of rural communities.

Communities also benefit through the empowerment of citizens to greater participation in their local community (for example, through volunteerism), maintaining cultural heritage and local identity, and enhanced social integration (Brown et al. 2012).

Collecting data on the above sub-themes could provide evidence of the community benefits resulting from recreational fishing. A challenge, however, is the number of different concepts that could be used to gain insight into the community benefits. Indicators and measures would need to be developed for any concept in order to collect data on it. For example, if social vitality were regarded as an important outcome, indicators of social vitality would need to be developed along with relevant survey questions. Ward et al. (2012), for example, assessed social vitality in three Australian towns hosting gamefishing tournaments. The researchers asked people visiting or residing in the towns to rate how important fishing tournaments were for the social vitality of their community[17]. They found that between 41 and 75 per cent of respondents thought fishing was important to the social vitality of their community, depending on the town.

At the macro level this information can be used to advocate the virtues of recreational fishing for Australian society. At a local level these data illustrate and provide a greater understanding of ways that community development opportunities could be harnessed, and would support the design of initiatives and programs.

Moreover, the value of these data extend beyond the recreational fishing sector in that they provide a baseline and build a platform for understanding the status of a community across a range of social, economic and environmental indicators. Assessing this status will enable communities to ensure the sustainability of the community, improve its liveability, and the wellbeing of residents and visitors.

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[16] In the UK, the Localism Bill was passed in 2011, which aims to encourage decentralised decision-making, create greater local involvement in delivery of 'public services', 'empower communities' to increase social enterprises, co-operatives and 'civil society organisations' and to encourage 'citizen involvement' in volunteering, and in owning and running community assets (Brown et al. 2011). According to Brown et al. (2011) the 'localism agenda' offers new possibilities for recreational fishing in local communities by, for example, opportunities for local fishing organisations to run or own local assets and facilities that are important to local recreational fishers (Brown et al. 2011).

[17] Social vitality was defined as 'the capacity to live, grow or develop to support a vibrant community and includes activities that make the community a better place to live' (Ward et al. 2012).

Prioritisation of national-scale attitudinal and awareness questions

Table 11 Attitudinal and awareness questions for future national recreational fishing surveys

Themes	Sub-themes	Survey questions	Rationale / criteria	Source
Participation	Motivation	1A I'm going to read out some reasons why people go recreational fishing. As I read each one, please tell me how important a reason it is for you ... (and the fishing, diving for lobster etc. that you do). Firstly, a. to relax or unwind b. to be outdoors ... in the fresh air ... to enjoy nature c. to be on your own ... to get away from people d. to spend time with family e. to compete in fishing competitions of any kind f. for the enjoyment or sport of catching fish, lobsters etc. g. to catch fresh fish, lobsters etc. for food h. to catch a trophy fish i. to catch fish to share with friends and family *(Measured using an importance scale: Very important/Quite important/Not very important/Not at all important/Unsure)* B Which of these would say is the main reason why you go fishing, (crabbing etc.)? *(open ended)*	Reasons why fishers go fishing. Motives of participation can contribute to an understanding of how the resource is being used. Motivations are the psychological outcomes one desires from the fishing experience, and these vary considerably among different fisher populations (Sutton 2006). Q1A (items a, b) are part measures of mental health outcomes for fishers; and items c, d, i are part measures of social wellbeing outcomes derived from fishing.	2000–01 NRFS – all states/territories
	Importance of fishing	2A Please indicate the extent to which you agree or disagree with each of the following statements about recreational fishing: a. Most of my friends are in some way connected with fishing b. If I stopped fishing, I would probably lose touch with a lot of my friends c. I would rather go fishing than do almost anything else d. If I couldn't go fishing, I am not sure what I would do e. Other leisure activities don't interest me as much as fishing *(Measured using a five point scale of strongly agree to strongly disagree)* B If you could not go fishing, are there any other outdoor activities that would provide you with the same level of satisfaction and enjoyment that you receive from fishing? *(open ended)*	Measures 'centrality of fishing to life', which is the extent to which a fisher's lifestyle and social networks are connected to fishing (Kim et al.1997 in Sutton 2006), and includes measures of social capital (items a & b). 'Substitution of activity' question (2B) identifies other leisure activities that could give the same satisfaction as fishing, e.g. camping, hiking, etc.	Question 2A based on Sutton (2006). Question 2B based on Sutton (2006), also used in Ward et al. (2012).

Themes	Sub-themes	Survey questions	Rationale / criteria	Source

	Constraints to participation	3 (And) what would you say is the <u>main</u> reason that you/your household didn't do any fishing in the last 12 months … (when you/etc. originally expected to)?
		
		   a. Work/business related (e.g. more busy, shift work)
		   b. Personal health/fitness
		   c. Personal preference (e.g. new sport/recreation)
		   d. Home/family related (e.g. renovating, new baby)
		   e. Social related (e.g. friend stopped fishing)
		   f. Location related (e.g. moved to different area)
		   g. Other 'access' related (e.g. sold boat, jetty closures)
		   h. Fuel costs (boat, car etc)
		   i. Other cost-related (please specify)
		   j. Fishing quality/catch rates (e.g. worse)
		   k. *Different kinds of fishing/targeting (N/A for non-fishers)*
		   l. All weather/environmental issues
		   m. Other reason (please specify)
		   n. No reason/unsure
		(Select one of the above responses)
			Understand why people stop fishing ('lapsed fishers'), or reduce their fishing activity; with different reasons for different segments of fishers.
			
			Identifies any potential interventions that could increase or decrease participation rates of different populations of recreational fishers, particularly disadvantaged groups such as those with a disability, or other socially excluded groups such as young people, e.g. by changing access/ infrastructure, or program design to increase participation.
				Previously asked in *Non-intending fisher follow-up survey* (NSW 2013–14)

Characteristics of fishers and fishing activities	Fishing skills / ability	How would you rate your fishing ability? *(Measured on a scale from 1 to 5, where 1 is very limited skills or experience and 5 is an expert or very experienced fisher)*	Self rated fishing ability relative to other demographic and attitudinal characteristics.	2000–01 NRFS – Queensland
	Attitudes to risk taking	5 Do you take risks while fishing (e.g. not wearing life jacket, alcohol consumption while fishing, rock fishing)? *(Measured on a scale, where 1 is never, 2 is rarely, 3 is sometimes, 4 is often and 5 is all the time)*	Understand if people engage in dangerous / risk taking behaviour while fishing. Implications for health and safety of fishers.	Proposed question (based on technical workshop discussion)

	Successful fishing experience	6 I'm going to read you some statements about recreational fishing. As I read each one, please tell me whether you agree or disagree with the statement. Firstly …
		
		Do you strongly agree or mildly agree/disagree?
		
		   a. A fishing trip can still be successful, even if no fish are caught
		   b. I'd rather catch one or two bigger fish than ten smaller fish
		   c. I like to fish where there are several kinds of fish to catch
		   d. If I thought I wouldn't catch any fish on a trip, I would still go fishing
		   e. The more fish I catch the happier I am
		   f. I like to release most of the fish I catch
		   g. I prefer to fish where I know I may catch a very large fish
		   h. I would rather keep just enough fish for a feed than take the bag limit
		   i. I'm not satisfied unless I catch at least something
		   j. The bigger the fish I catch the better the fishing trip
		   k. I usually eat the fish I catch
			Indicates the degree to which a fisher values the specific catch-related outcomes of the fishing experience compared to other outcomes.	2000–01 NRFS

Themes	Sub-themes	Survey questions	Rationale / criteria	Source
Fisheries management & policy	Communication	**7 A** What is the main way you find out about things to do with fishing? *(Choose from list of options: govt. publications, govt. shows/displays, govt. websites, fishing magazines, newspaper, television, radio etc)* **B** Which of these do you consider trusted or reliable sources of information?	Data to better understand fisher communication needs and preferences to enable appropriate communication with fishers, e.g. about regulations.	2000–01 NRFS
Personal benefits	Satisfaction with fishing	**8A** Thinking of (all) the fishing, (diving for lobster etc.) that you've done over the last 12 months … in general, how satisfied were you with the overall quality of the fishing in that time? (Would you say—*Very satisfied/Quite satisfied/Not very satisfied/Not at all satisfied*) **B** Why do you say that? *(Open ended)*	Data to inform fisheries managers of how to create satisfying and sustainable fishing opportunities, such as through improved access to fishing spots, facilities for recreational fishers or the quantity of catch (plentiful fish).	2000–01 NRFS
	Household seafood consumption	**9A** How often is seafood and other fish **eaten** by members of your household… whether caught by you or other households … or purchased from a supermarket, fish shop or restaurant? *(Measured on a scale: never, rarely (e.g. once every few months), sometimes (e.g. once a month), often (e.g. 1-4 times a week), all the time (e.g. every day))* **B** Of <u>all</u> the fish and other seafood **eaten** by your household during the last 12 months, what proportion would you say was **recreationally caught**, …**as opposed to purchased**? *(Responses: All (recreationally caught)? Most? Some? None?)* **C** How **important is eating seafood** or other fish that you have caught recreationally, to your household's overall food requirements? *(Measured on a scale: Not applicable/Very important/Quite important/Not very important/Not at all important/Unsure)*	Data on seafood and fish consumption by fishing households, to understand how important recreationally caught fish is e.g. for nutrition (protein, omega fatty acids), or the food security of the household.	Modified question from 2000–01 NRFS

	Health and wellbeing outcomes:
	• general
	
	• physical
	
	• Psychological
		10 A The following question asks how satisfied you feel, on a scale from 0 to 10. Zero means you feel 'not at all satisfied' and 10 means you feel 'completely satisfied'.
		
		Overall, how satisfied are you with life as a whole these days?
		
		B Please indicate the extent to which you agree or disagree with each of the following statements about recreational fishing:
		  a. fishing is important to me being physically active
		  b. recreational fishing has helped my recovery from physical illness
		  c. I enjoy being outdoors experiencing natural environments
		  d. recreational fishing is a great reliever of stress
		  e. I get a sense of fulfilment from fishing
		  f. I feel positive about life when I am fishing
		  g. recreational fishing has helped my recovery from a mental illness
			We propose health and wellbeing (HWB) questions for subjective evaluation by individuals, in lieu of method used by Griffiths et al (forthcoming).
			
			HWB requires a general core question on life satisfaction (10a), to enable comparison with other world surveys.
			
			Also proposing domain specific questions to link fishing activity with physical, psychological and social wellbeing outcomes (Q10b).
				Proposed question based on OECD guidelines on measuring SWB (2013)
				
				Questions based on Sutton (2006), Brown (2012) and Ward et al. (2012).
				
				See also OECD guidelines on measuring subjective wellbeing.

Themes	Sub-themes	Survey questions	Rationale / criteria	Source
	• social	h. I really enjoy spending time fishing with friends i. My family relationships improve because I have fishing as an outlet		
	Skills and knowledge	11 Please indicate the extent to which you agree or disagree with each of the following statements about recreational fishing: a. I have gained useful skills from fishing b. I have in interest in learning about the marine environment c. I get a sense of achievement from fishing d. it is important to teach my children to fish e. me/my family have learnt about water/boat safety through fishing f. it is important to pass on skills and knowledge g. it is important that my family/children learn about the natural (marine) environment	Measures the skills and knowledge associated with fishing activity, including water safety, boating safety, nature based knowledge (for kids) and personal development. Learning to fish is associated with social and family networks, with fishing skills, techniques and information being passed to young people from parents, grandparents, friends or extended family (Brown et al. 2012). This data can help inform understanding of the broader factors that help to contribute to learning and skill development in recreational fishing.	Proposed question drawing on Brown et al. (2012)
Environmental attitudes & awareness	Threats	12 To what degree are the following, threats to recreational fishing? a. pollution b. over fishing by recreational fishers c. over fishing by commercial fishers d. destruction of habitat by development e. invasive species f. climate change impacts (e.g. warming waters, ocean acidification and sea level rise[18] g. closing areas to fishing h. other *(Measured on a scale: No threat/Minor threat/ Major threat/Don't know)*	Can inform understanding of threats or issues that recreational fishers believe are important or that potentially impact on recreational fishing.	Proposed question based on Sutton (2006)

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[18]Additional item included on fisher attitudes towards climate change impacts (for example, warming waters, ocean acidification and sea level rise) was suggested by participants of social dimension expert meeting (February 2015).

Table 12 Proposed demographic questions for future national recreational fishing surveys

Sub-theme	Survey questions	Delivery
Demographics	1 What was (your) age last birthday? **a** (years)	Question asked in *Diary Screening Survey*
	2 Is the person male or female? **a, b**	Question asked in *Diary Screening Survey*
	3 What is the person's occupation? **b** (open ended)	New question
	4 What is the highest qualification the person has completed? **b, c**	New question
	5 Please indicate your total household income (before tax) in 20XX/XX? (per week/per year) **d, e**	New question
	6 Does the person speak a language other than English at home? **b**	New question
	7 Is the person Aboriginal and/or Torres Strait Islander? **b**	New question
	8 Is any member of your household an <u>age pensioner</u>? (or receive a partial age pension)? **a**	Question asked in *Wash-up/Attitudinal survey – Section A Administrative*
	9 Does any member of your household receive a <u>Commonwealth Disability Pension</u>? **a**	Question asked in *Wash-up/Attitudinal survey – Section A Administrative*
Characteristics of fisher	10 Does anyone in your household own a boat? *(and other boat details: size, propulsion, type etc)*	Question asked in *Diary Screening Survey* & *Wash-up/Attitudinal survey – Section A Administrative*
	11 Can you recall how old you were when you first went (recreational) fishing? **a** *(Number of years ago/Never fished)*	Question asked in *Wash-up/Attitudinal survey – Section B Attitudinal and Awareness* (QLD 2013–14)
	12 Are you a member of a fishing/diving club or association?	Question asked in *Diary Screening Survey*

Note: **a** Question is asked in the National Recreational Fishing Survey 2000–01. **b** Question from the Australian Housing and Population Census. **c** Response options are: Primary school; Year 10; Year 12; Diploma or certificate; Tertiary degree; Postgraduate degree. **d** Income question is based on ABARES *A socio-economic evaluation of three eastern Australian gamefishing regions* project survey instrument (Ward et al. 2012). **e** Choose from list of responses for household income (using ABS categories): Negative income; Nil income; $1–$399 ($1–$20 799); $400–$799 ($20 800–$41 599); $800–$1249 ($41 600–$64 999); $1250–$1999 ($65 000–$103 999); $2000–$2999 ($104 000–155 999); $3000–$3999 ($156 000–$207 999); $4000–$4999 ($208 000–$259 999); $5000 or more ($260 000 or more).

Assumptions about survey components mentioned in tables above:

- The **Diary Screening Survey** is conducted with all potential fisher households upon first contact to invite them to participate in the diary survey.

- The **Diary Survey** is conducted with all participating diary fishers on a monthly basis during the 12-month diary period.

- The ***Wash-up/Attitudinal survey – Section A Administrative*** and the ***Wash-up/Attitudinal survey – Section B Attitudinal and Awareness*** are used with diary fishers at the end of the 12 month diary period.

- The ***Non-intending fisher follow-up survey*** is administered to a sample of the households who did not have a person participating in the ***Diary Survey***.

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Appendix D: Output specifications—off-site survey components

Prepared by L. West, Kewagama Research

1 Introduction and key assumptions

The following information has been prepared to facilitate broad design and costing of a telephone–diary survey to provide direct comparability with the 2000–01 National Recreational Fishing Survey (NRFS), together with improved data quality/utility as required. Representatives from the various jurisdictions and stakeholder organisations were encouraged to use this document as an initial platform to provide comments in terms of their data needs and priorities (whether referring to old, new or modified data elements etc.).

Detailed sampling strategies (size, stratification, the 'hybrid' survey approach etc.) are the subject of separate development work and documentation. Detailed budgetary assumptions and estimates have been provided to ABARES. A range of survey questionnaires from the original NRFS and subsequent statewide surveys were also provided to ABARES.

All potential on-site survey components for the project have been documented separately. These components include methods for validating estimates of fishing effort and harvest derived from the telephone–diary core methodology and issues relating to collection of size structure information to be used in converting off-site survey estimates of harvest numbers into estimates of total harvest weights.

As agreed after the November 2014 workshop, the proposed overall methodology for the survey is effectively identical to that employed in the telephone–diary survey component of the NRFS and especially so, in terms of the various statewide surveys conducted since then. Importantly, this choice of method is not a simple matter of being 'technique-driven', rather an acknowledgment that the methodology is highly effective and appropriate. Indeed, the greatest concern in terms of the future repeatability of this methodology relates to the coverage and cost-effectiveness of appropriate sampling frames (and as noted above, this is a matter for separate discussion).

However, various technological advances in data collection methods for off-site surveys will be considered in further development work. For example, for some time now, Computer Assisted Telephone Interview (CATI) systems have been used in market research –and successfully in recent recreational fishing telephone–diary surveys in Western Australia and New Zealand. As further detailed in support documentation, it is envisaged that a CATI system of some kind would be employed in (at least) 'high-level' data collection in the screening and diary phases of a future national survey. Further to this, issues such as the use of 'text messaging' (as per the recent New Zealand survey) for establishing core data in the diary phase (for example, 'Y/N' for any monthly fishing activity) will be fully explored.

Given the separate expert forums and documentation in terms of data needs for economic and social aspects of recreational fishing surveys, the survey components and data elements in this document are largely focused on data collection in terms of participation, catch and effort. However, fishing-related expenditure is broadly discussed in Section 5.2, b) and Section 5.3 (the Wash-up Survey). Similarly, attitudinal data and various social dimensions issues are broadly discussed in Section 5.3.

Sections 2 to 4 below refer to objectives, scope and methodological information. Section 5 addresses detailed data elements for the various survey components required for assessment of fishing activity.

Where differences occur in terms of proposed data elements versus those included in the NRFS, these have been noted/discussed, as appropriate. In many cases, these differences amount to a reduction in the level of detail collected, or a confinement of the data to narrower population sub-groups. Importantly, these refinements could only have occurred after analysis and utility assessment of the NRFS data, and were first applied in the South Australia and Tasmania surveys and then, in every statewide survey since. A key objective of these changes was to minimise respondent burden and an example of this is the basic boat ownership question (Y/N) is now routinely assessed for all households in the initial Screening Survey, with detailed boat profiling information now confined to fishing households and deferred to the Wash-up Survey (see later discussion in Section 5.3 below).

2 Study objectives

For the resident population of Australia (private dwellings only), to quantify recreational fishing, in terms of:

- participation rates and numbers among various population sub-groups (age, gender etc) together with other profiling data (for example, boat ownership/usage for fishing/global positioning system/echo sounder)

- annual catch (harvest and release by numbers), effort (days/hours fished) and catch per unit effort for the main target fish and other species

- annual expenditure directly-attributable to recreational fishing—disaggregated by expenditure items (tackle, vehicle travel costs, boat fuel, etc.). Inclusion of data elements to enable 'travel cost assessment' (valuation) has also been requested

- fisher awareness and opinions on fisheries-related issues, plus assessment of social contribution factors.

These objectives largely align (and data would be directly comparable) with the NRFS. Similarly, routine disaggregation of all survey results would be achievable both temporally and spatially (subject to standard error levels), for example a) participation rates by residential region within each state/territory, and b) total catch of a given species by season or fishing regions within the jurisdiction. However, two major new data elements were identified for Diary Surveys since the NRFS (and also for this project), namely for each fishing 'event': (i) to obtain/record detailed fishing site information to enable regional coding as per the NRFS, as well as more detailed/flexible coding (latitude/longitude-based) to align, for example, with commercial fishing zones and other spatial zones (as needed); and (ii) to routinely obtain 'reasons for release' information for the released component of the catch (for example under-size, catch-and-release, inedible etc.).

3 Survey scope and other criteria

3.1 Geographic scope

The geographic scope of the survey would incorporate the whole of Australia, including offshore islands and seaward to the Australian Exclusive Economic Zone boundary. A sample would ultimately be drawn across each jurisdiction to provide appropriate statistical strength and comparability for the various residential strata employed in the NRFS (a total of 49 strata across Australia). These strata would conform to current Australian Bureau of Statistics (ABS) Census boundaries (SA4, SA3 etc.) and related population benchmark data. A more detailed regional coding system would be used when collecting information on fishing activity (as discussed above and later in Section 5.2, a), Items 9) and 10).

3.2 Households in scope and Primary Sampling Unit (PSU)

The Primary Sampling Unit (PSU) for the survey would be the 'private dwelling household' (ABS definition)—whether the ultimate sample is drawn from either Telstra White Pages® listings or (as is now most unlikely) from the Australian Communication and Media Authority's Integrated Public Number Database (IPND). Similarly, for any hybrid survey design (where a supplementary licence or other frame is sampled), a household-based PSU would ultimately be required; that is, by converting any person-based licence frame to a household basis. Discussion is requested regarding person-based licensing in Western Australia.

3.3 People in scope and age criteria

Residents are defined as having their usual place of residence in Australia (private dwellings) and would be in the scope of the survey. Residents of non-private dwellings (for example, hotels, nursing homes, gaols) are out-of-scope and currently account for around two per cent of the total resident population. Overseas visitors are defined as having their usual place of residence overseas and would be out-of-scope. Three age criteria would be applied in relation to survey information for residents: (i) all ages for total population/benchmarking purposes; (ii) those aged 5 years or more for recreational fishing assessment; and (iii) those aged 15 years or more for any awareness/attitudinal questioning.

3.4 Activities in scope

For all survey purposes, recreational fishing is to be defined as any attempted harvesting (or release) of aquatic animals for non-commercial purposes, including 'prawning, crabbing, spearfishing, or even collecting oysters or aquarium fish'. Commercial fishing activity and Indigenous/traditional (or 'customary') fishing would be excluded from the survey scope, noting that any recreational fishing by a commercial or Indigenous fisher would be within the scope of the survey.

Three terms would be applied to catch information: (i) catch—all aquatic animals captured whether harvested or released; (ii) harvest—the retained component of the catch; and (iii) released—the released component of the catch.

3.5 Temporal and other scope

Recreational fishing participation would be assessed on a 'previous 12 months' basis prior to the Screening Survey (see Sections 4 and 5 below) and also for a defined 12 month period immediately following the screening (that is, the Diary Survey—see Sections 4 and 5 below). Detailed resident fishing activity (catch, effort, etc.) would be collected for the diary period, including for all day/night fishing, platforms (boat/shore) and water bodies (ranging from

private freshwater dams to offshore waters). Fishing-related expenditure data would also be collected for the 12 month diary period.

4 Survey components

As for the NRFS and all subsequent statewide surveys, the methodology would comprise four key survey components, with all interviews routinely conducted by telephone:

1) Initial Screening Survey—principally to measure participation and identify 'intending fisher' households for the diary phase

2) month Diary Survey—to collect detailed catch, effort and expenditure data from diarist households

3) 'Wash-up' Survey—conducted among all diary households at the end of the diary period, principally to provide awareness/attitudinal and additional profiling and expenditure information (for boats, for example)

4) Non-intending Fisher Follow-up Survey—conducted at the end of the diary period, among a relatively large, stratified sample of non-diarist households from the original screening to assess unexpected fishing activity and to 'round-out' participation assessment for the diary period.

Survey components

State/Territory resident population

Phone owners | Non-phone owners

Screening Sample

Other surveys/ data sources

ABS resident population

Screening survey

Sample Loss | Response | Non-response

Intending fisher | Non-intending fisher

Non-intending fisher follow-up survey

Diary survey

Accept diary | Refuse diary

Fished | No fishing

Wash-up/ attitudinal survey

On-site surveys by field staff
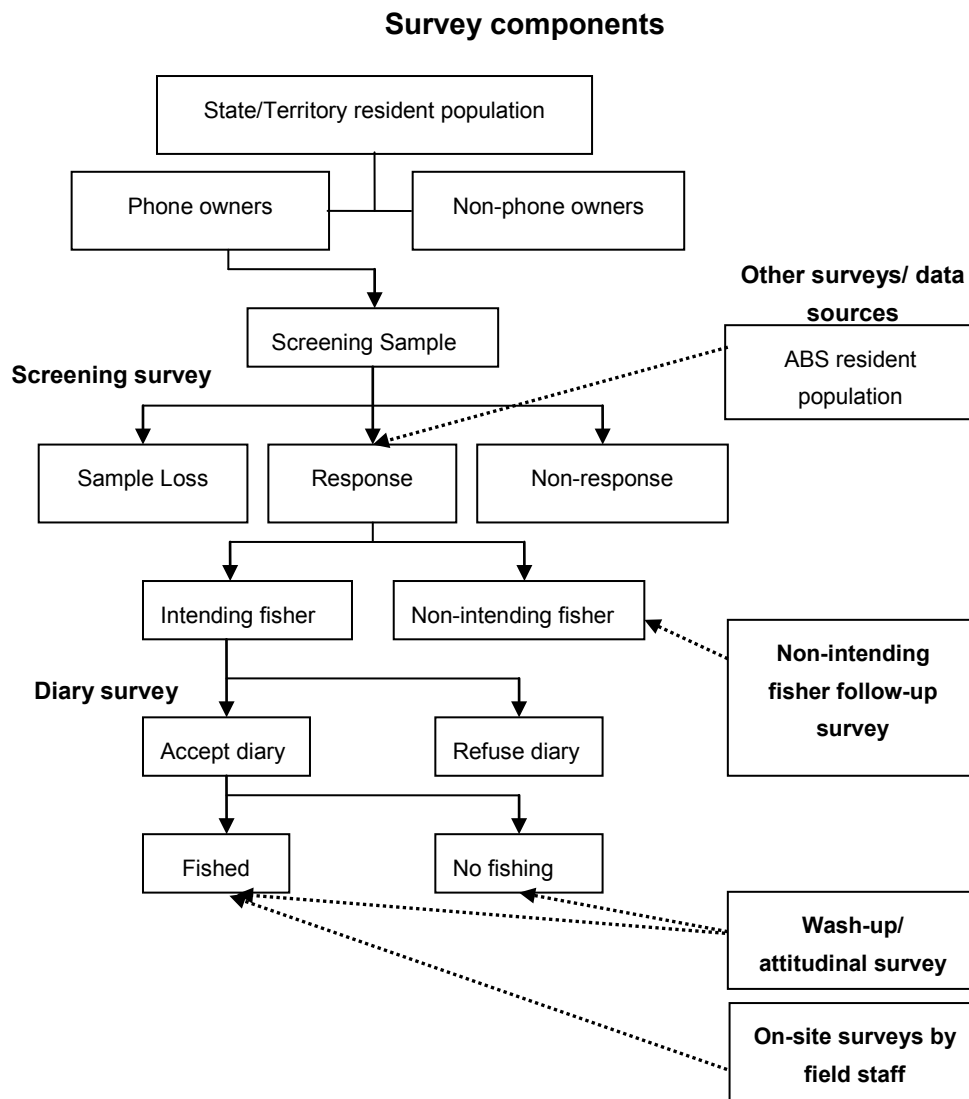
5 Data elements

This output specifications document has been written primarily for those with direct expertise in survey design and implementation. Accordingly, various attachments to assist the reader have been referred to and were provided with the draft document. These included a range of survey questionnaires from the NRFS and subsequent statewide surveys. These have not been provided as physical attachments to this report due to their technical nature and also because of Intellectual Property considerations. However, if required, this documentation can be provided digitally by ABARES on request.

5.1 Screening survey

Each selected household (telephone number) would be assigned a unique Sample Number ('SNUM' or HouseholdID), prefixed by an alphabetical character as per the NRFS to denote the state/territory (for example, N: NSW, Q: QLD etc.) and followed by 5 numerics. The SNUM is the primary database key and would carry through all survey phases (Diary, Wash-up etc.). Also, within each household, a unique Person Number ('PNUM' or PersonID) would be assigned to individual respondents in the survey database. While respondent names are helpful in the Diary phase, there is no database requirement for this or any other personal information. Other data would be routinely appended to each SNUM, including locality/residential stratum and related

ABS codes for statistical areas (for example SA4, SA3). These latter variables are required for expansion of the raw survey data to ABS resident population benchmarks.

(a) Household-based data

1) Response status for Screening Survey: 11 codes (1 = Fully responding, 2 = Full refusal, 3 = Part refusal, 4 = Full non-contact, 5 = Part non-contact, 6 = Language/ communication difficulties, 7 = Number disconnected, 8 = Business number, 9 = Fax/email line, 10 = Holiday home, 11= Other)

2) Number of usual residents (all ages)

3) Boat ownership (Y/N) as per NRFS definition, including canoes, kayaks, jet skis etc. As discussed in Section 1, detailed boat profiling (size, propulsion type, etc.) is more preferably collected for fishing households only and to enhance response/data utility, after completion of the Diary Survey (see 5.3 below).

(b) Person-based data—all households

1) Age at last birthday – age groups required only (ABS-basis): 0–5; 5–14;15–29; 30–44; 45–59; 60 or more

2) Sex (Male/Female)

3) Within household relationship – primarily an 'administrative tool' for interviewers (for example Husband (H), Wife (W), Son (S), Daughter (D), etc.).

(c) Persons aged 5 years or more—all households

1) Any recreational fishing in the home state/territory in the previous 12 months (whether caught anything or not)?

2) Any recreational fishing elsewhere in Australia during this time? (Note: when combined with Item 1 above, this allows direct comparison with the NRFS participation rate)

3) If fished anywhere in Australia in the previous 12 months, an assessment of 'avidity' (separate days fished) in terms of: less than 5 days, 5–9, 10–14, 15–19, 20 days or more. As shown from the NRFS and other studies, this is a critical determinant of future fishing behaviour, where the minority (around 20 per cent) of all fishers that form the high-avidity group (20 or more days per year), usually account for around 70 per cent of the total harvest (and often more for iconic species)

4) Regardless of previous fishing activity, an assessment of intention to fish in Australia in the coming 12 months (the diary period) in terms of: very likely; quite likely; not very likely; or not at all likely. This question is the basis for inviting households to take part in the Diary Survey (see Item (e) below). In most statewide surveys conducted since the NRFS, intention to fish in the home state/territory has been the criterion for invitation to the diary phase and accordingly, only home state fishing activity was recorded in these cases. However, in the two most recent statewide surveys (QLD and NSW/ACT – both 2013–14), the NRFS criterion was applied and any/all fishing in Australia was recorded for the residents of these two states.

(d) Other data for persons aged 5 years or more—fishing households only

Membership of a recreational fishing/diving club or association (Y/N). In the NRFS, this question was asked of all households and further details were collected in terms of number/types of clubs/etc. (for example, Australian National Sportfishing Association, Game Fishing Association Australia). Subsequent analysis revealed virtually no membership among non-fishers and due to the relatively small proportion of members (even) among fishers, the further detail on club type could not be effectively expanded/analysed. This additional detail has not been collected in any subsequent statewide survey. Also, in the recent NSW statewide survey, the general club membership question (Y/N) was deferred to the Wash-up Survey, to minimise interviewing time/respondent burden in the screening phase.

(e) Diary survey invitation—intending fisher households

All households where one or more members aged 5 years or more report an intention to fish in the coming 12 months (that is, at least 'quite likely' in Item (c) 4, above) would be invited to take part in the 12 month Diary Survey. Those agreeing to take part (usually over 90 per cent) would then be sent a Diary Survey kit (including 'memory-jogger' diary cards and species identification booklet) and for this purpose, mailing address information and alternative phone numbers are routinely recorded in the last section of the questionnaire. By design, the NRFS sought only to 'track' the fishing behaviour of intending fishers within each household over the 12 months. That is, any non-intending fishers were only broadly assessed in the Wash-up Survey. As another example of improvements arising from the NRFS, all subsequent statewide surveys have successfully included all household members in the monthly data collection process and this approach is recommended for the proposed national survey.

(f) Person-based data elements excluded (that is, not repeated from the NRFS)

The following data elements are recommended for exclusion from the Screening Survey. However, as agreed at the most recent workshop, such information could be collected at an appropriate/later stage, if required (for example, ethnicity/ Aboriginal or Torres Strait Islander assessment during the Diary Survey):

1) Aboriginal or Torres Strait Islander origin (respondent perception basis)—with the exception of the NT Survey (2009–10), this question was excluded from all statewide surveys since the NRFS. Note: discussion is requested in terms of inclusion for the NT (screening) component of the proposed survey

2) Recreational fishing licence holding—as a national survey, the NRFS included this questioning for all households, in all states/territories to enable assessment of licence holding (for example) for NSW by residents of all/other states. This information was also an important validation tool in the NRFS. However, this questioning has been excluded from all subsequent statewide surveys and especially so, due to sensitivity issues in terms of compliance assessment

3) Main language other than English spoken at home (if any)—since the NRFS, this question has been excluded from most of the later statewide studies, following various data utility assessments (discussion requested)

4) Labour Force Status/Occupation Type/Highest Level of Education Achieved—in combination, this profiling information (ABS-based) was collected in the NRFS for fishers, as a measure of socio-economic status (and a surrogate for 'income level'). Although a valid assessment, the ultimate utility of these data was limited and as for all statewide surveys

since the NRFS, exclusion is recommended here. However, the opportunity exists for inclusion of these data elements (or any others) in the Wash-up Survey component, if required or any other Social Dimensions assessment work (see 5.3 below).

5) Specific questions to include/exclude temporary residents of households: following a convention employed in ABS household surveys, these detailed (and necessarily 'invasive') questions were included in the NRFS Screening Survey to ensure an 'equal chance of selection' for all respondents. For example, a temporary resident of a selected household might have two chances of selection, where his/her 'other' household was also selected. Again, the experience from the NRFS and the real 'cost' of these questions in terms of additional non-response (they are very difficult to explain/justify to a suspicious respondent) led to a different approach for all subsequent statewide surveys. Put simply, the principles are still applied by interviewers, but only where the possibility of such a case emerges. Often, this occurs at a later stage—for example, in the Diary Survey—where an 'apparent' usual resident of the household is no longer there and it is revealed that he/she is in fact the usual resident (ABS definition) of another household. The obverse also applies, but the extremely low incidence of any such cases (as revealed by the NRFS) makes the process of amending various database records worthwhile.

5.2 Diary survey

By design, in the NRFS and subsequent surveys, the sole criterion for a household's inclusion in the Diary Survey has been an intention to recreationally fish in the diary period. While a majority of intending fishers ultimately do fish in the period (close to 80 per cent in the NRFS), a minority do not. In the survey expansion process (which it is proposed will use the *RecSurvey* analysis package), these are referred to as the 'drop-outs'. On the other hand, a small minority of non-intending fisher households ultimately/unexpectedly fish during the period (the 'drop-ins') and these are assessed through the Non-intending Fisher Follow-up Survey (see 5.4 below).

During the Diary Survey, interviewers would maintain regular contact with diarist households—usually monthly calls, but more frequently where required (mainly the highly avid anglers) and occasionally bi-monthly (or more), where a respondent is adamant that no fishing/expenditure will occur (and a refusal might otherwise result). At each contact, the interviewer routinely establishes/records any fishing and expenditure activity since the last contact and identifies any planned fishing activity for the near future (including an interview appointment for soon after). All fishing and expenditure activity would be recorded on a multi-purpose 'Event Sheet' (examples available on request).

(a) Fishing data

For each fishing 'event', a range of data would be collected, as detailed below. As for the NRFS, separate fishing events (that is, Event Sheets) would be recorded where changes in activity occur within a given fishing trip/outing in terms of specific variables, such as Fishing Region, targeting and fishing method. These variables are 'flagged' on the Event Sheet (and in the details below) by the term 'Split', meaning that where two or more answers might otherwise apply to the one field/variable, then the fishing event needs to be 'split' accordingly. This process enables consistent analysis resolution in the survey data (for example, discrete harvest levels by Fishing Region).

The following fishing-related data elements would be collected:

1) Sample Number (SNUM)

2) Event Number—unique within SNUM/Start Date

3) Person Number/s (PNUM) to whom the event applies—in some cases, 'shared effort' events are permitted

4) Start Date (DD/MM)—i.e. the start date of the fishing event; for example, crab pot usage often extends over-night (see Item 5, below)

5) End Date (if different)—i.e. number of additional days for completion of the event (left blank if same day/date)

6) Personal/proxy—whether all data was collected personally from the relevant fisher or partly/wholly on a proxy basis

7) Diarised data—whether all substantive data was diarised by the respondent/s or partly/wholly not diarised

8) Event Type ('split')—whether an expenditure event only, or a fishing and expenditure event. This is fundamentally a sequencing tool for the questionnaire, where "$ only" events are sequenced passed the remainder of the fishing-related questions (i.e. Items 9 to 23 below)

9) Fishing Region ('split')—in the NRFS, many hundreds of discrete region codes were applied to the various catchments or spatial regions in each state/territory. In subsequent statewide surveys, the need for additional resolution was identified and in some cases, NRFS region codes were dissected (see Item 10) below). Also to assist interviewers to accurately apply NRFS region codes, exhaustive alphabetical/look-up files were created for each statewide survey – with many thousands of fishing sites, creeks, rivers and so on, and their respective region codes included.

10) Fishing Site/Nearest Town—this is a new data element in that information which in the NRFS was only used by interviewers to code Fishing Regions (see above) has been routinely entered into the Diary Survey database for each Fishing Event. This approach has been successfully employed in all subsequent statewide surveys and not only enables improved data editing, but provides significant potential for later disaggregation of regional data (depending on cell sizes/statistical strength). For example, the catch and effort data for a coastal Fishing Region (say 41), might ultimately be sub-coded into 41a (say, ABC Beach), 41b (say, XYZ Bay) and 41c (elsewhere). Moreover, as discussed in Section 2 above, in the recent QLD and NSW/ACT statewide surveys, quite detailed data have been routinely recorded (for example, the name of an offshore reef, or the nearest town/locality on a major river), to enable latitude/longitude co-ordinates to be applied through GIS software. For many coastal/estuarine fishing sites, a resolution level of <5km has been achieved. Importantly, this highly-detailed approach is not intended to deliver dramatically greater spatial disaggregation in any catch or effort data; rather, it is about flexibility in terms of other regional classification/s (as discussed in Section 2 above) and enhanced graphical presentation of survey results (for example, maps depicting catch or effort density on a statewide or broad regional basis). Very importantly, this is not about divulging (nor being seen to) any 'secret fishing spots' of diarists.

11) Sub-region ('split')—separate 'water-body type' codes for off-shore (>5km), inshore (<5km), river/estuary (saltwater), river/stream (freshwater), lake/dam (freshwater – public), lake/dam (freshwater – private).

12) Targeting ('split')—primary and secondary species targets using NRFS species codes or general targeting codes for 'surface' or 'bottom' species (alternatively, no specific target at all). Since the NRFS, a number of extra species codes have been added for a total of 376 species/species groups.

13) Method ('split')—18 discrete codes, noting that some combined methods do not require 'splitting'; for example line fishing with bait and lures – unless another variable necessitated the split; for example, targeting.

14) No. of Pots/Nets—for certain Method codes only; for example, crab pots and seine nets.

15) No. of Hauls/etc.—only applies to drag/seine nets (not cast nets). Note: in most statewide surveys since the NRFS, this data element has been excluded (discussion requested in terms of the proposed survey).

16) No. of Persons—for single-person events, this field is left blank. For others, this information is needed to apportion the share of any reported catch to relevant diarists/etc. In some cases, for example, the catch from 10 crab pots might be shared among 4 persons, only 2 of whom are members of the diarist household. Where this occurs (and the data cannot be separated), half of the reported catch would be assigned in the database system to the 2 household members (i.e. one quarter each), and the remainder, effectively ignored. However, in most other cases (for example, line fishing events), respondents are encouraged to separate their catch data from any non-sampled anglers and indeed from other household members (especially where the catch rates differ). Note that in WA, the number of licensed fishers is recorded for boat-based fishing and it is proposed that this be collected in the WA component of a national survey.

17) Platform—in the vast majority of cases where both boat and shore fishing occur in the one fishing 'trip', the event will be 'split' for some other reason (for example, different targeting).

18) Boat Type ('split')—event 'splits' here are extremely rare here.

19) Boat Ramp Code ('split')—in some subsequent statewide surveys, this was a _new_ data element to enable comparison with relevant data collected through on-site survey components. Subject to the ultimate recommendations/design of any parallel on-site surveys for a proposed national survey (for example, a regionally focused validation study), this data element may be required – even if only for fishing activity in the prescribed area. Also, other related/comparable data might be required for the off-site survey, for example the time departed/returned to the ramp (refer to on-site output specifications).

20) Shore Type (main)—potential 'splits' were originally considered rare and un-necessary and this is still the case (hence "main" shore type). Also, due to the differing requirements of each state/territory, an exhaustive coding system (with 24 codes) was originally developed for the NRFS, where codes 1 to 4 applied to shore-based fishing activity in NSW; codes 5 to 7 for Victoria and so on. Notably, these 'unique' codes have been routinely applied in subsequent statewide surveys.

21) Times—start, finish and any breaks (with the latter routinely aggregated, where more than one break occurs in the one event).

22) Catch—the number of each species caught and (a) kept or (b) released for the particular fishing event. As mentioned above, some 376 NRFS Species Codes are potentially available and after analysis of NRFS data and any later surveys, the top-ranked/most commonly

reported species would be included on the new Event Sheet for each state/territory—depending on available space, after 'new' data elements have been accounted for (see below). For other 'un-structured' species, the interviewer simply records details in the vacant spaces below the listed species (for later coding).

23) Reasons for release—this is a <u>new</u> data element and has been successfully employed in all statewide surveys since the NRFS. These data provide important supplementary information for a variety of fisheries management/policy issues, such as improved assessment of bag/possession limit data (including cases where 'personal' bag limits are applied by individual fishers) and the incidence of 'catch and release' fishing (where 'size' fish are routinely released). Whilst a tailor-made system has been applied to the coding for each statewide survey, the following is an exhaustive list of codes and definitions that have been applied to date (see for example, latest NT and NSW/ACT Event Sheets, which can be provided by ABARES on request).

For each species, released in a particular fishing event, a dissection of the numbers released would be recorded for each reason code (as appropriate):

- TS* - any mention of <u>too small</u>, other than cases where words like 'legal limit' or 'under-size' are mentioned

- ≤S* - below the minimum legal size limit: any responses involving 'legal size limit'-type words (e.g. under-size)

- TM* - any mention of <u>too many</u> (e.g. did not want/need any more), other than cases where words like legal limit (bag limit etc.) are mentioned. Unlike for minimum size limits, the distinction between TM and >N is largely evident in the data (the number retained is recorded)

- >N* - above the legal bag/possession limit for the species, only where the respondent mentions <u>bag or possession limit</u> as a reason (and even if catches do not match the limits). This code also applies to protected species (where the bag/possession limit is zero)

(Note: by design, in the above 4 cases particularly, no prompting or probing is permitted by interviewers, to avoid any 'behaviour corruption' during the Diary Survey – that is, through any altering of respondent awareness in terms of size or bag limits).*

- CR - catch and release fishing. Some (usually avid) anglers routinely release their fish - regardless of the size, species and so on. Others might practice catch and release fishing for certain species only or on a particular day/outing. In all such cases, the respondent will invariably say so, and where this is the <u>main</u> reason for release, it over-rides all other codes.

- OT - Other ... this code is to be applied <u>without further specifying</u> in two cases only:

  - for poor table quality or inedible/poisonous species – when combined with the species code, the 'story' here will invariably be evident (e.g. toadfish/pufferfish); and

  - for berried female lobsters, crabs or yabbies (i.e. with eggs). For QLD, this code applies to all female crabs/yabbies etc. (berried or not).

- <u>All other OT cases are to be further specified</u> in the Comments Section of the Event Sheet, examples and codes for which include:

- >S - over the maximum legal size limit - applies to several species (e.g. dusky flathead in QLD)

- <u>Too big</u> - cases where the larger size of a species are considered poor/unsafe eating quality as distinct from: a) the species as a whole ('standard' code OT); or b) over the

maximum legal size (as above); or c) some other reason (e.g. personal conservation views/large breeding stock etc.).

- <u>Too few</u> - cases where the fisher was not catching enough to make it worth keeping any (or any more)

- <u>Tag & release</u> - where the animal caught was tagged and released by the fisher. This code over-rides CR as it is a different form of catch and release fishing

- <u>Conservation</u> - cases where the respondent (routinely) releases a particular species for personal conservation reasons, as opposed to any legal requirement to do so (e.g. >N)

- <u>Sick</u> - where the animal caught exhibited disease of some kind (e.g. ulcers)

- <u>Damaged</u> - including, for example, fish mutilated by shark, lobsters damaged by octopus and so on.

- <u>Deformed</u> - where the animal caught had some physical deformity (as opposed to sick or damaged, as above)

- <u>Dangerous</u> - where landing/boating the animal caught was considered physically dangerous, for example, a shark (as opposed to poisonous species – 'standard' OT)

Note: additional codes have been suggested and these can be ultimately customised for each jurisdiction. For example, in the recent WA surveys, a specific release code has been employed for cases where the species was unknown to the respondent, who was therefore reluctant to retain/eat it.

(b) Fishing-related expenditure data

Depending on ultimate needs, fishing-related expenditure can be readily collected during the diary phase as per the NRFS – where this information was obtained from diarists and classified to various/detailed expenditure categories (see, for example, the NRFS Event Sheets, which can be provided by ABARES on request).

These costs were recorded as (i) the total amount and (ii) the proportion (%) attributable to recreational fishing; for example where accommodation costs related to four people in a household and only one person fished, then 25 per cent would usually be attributed by the respondent. Note that for the NRFS, vehicle travel costs were estimated by applying an average cost per kilometre travelled (the latter being recorded/provided by diarists). The NRFS also classified expenditure in terms of 'Economic Zones' (as per Q14 of the NRFS Event Sheets and related zone maps).

Importantly, expenditure data collection in the diary phase was heavily focused on variable cost/trip-related items and interviewers routinely 'prompted' respondents in terms of minor/forgettable items such as ice and fishing magazines. On the other hand, more significant/memorable purchases (for example, boats, camping equipment or 'annual' expenses such as boat insurance, registration or fishing club membership fees) were primarily dealt with in the Wash-up Survey (see Section 5.3 below).

Since the NRFS, only one statewide survey has collected expenditure data in this way (the NT Survey 2009–10). However, many expenditure items were amalgamated (three categories for Tackle - capital, maintence or 'terminal' became 'Tackle – all' (see, for example, NT Event Sheet, which can be provided by ABARES on request)). Also, Economic Zone assessment was simplified to 1) within the NT vs. 2) elsewhere. Otherwise, the methodology was very similar to the NRFS.

However, as noted recently, additional data elements may be required for the proposed survey in terms of any 'travel cost' assessment (for example, trip-based referencing), but all additional data would need to be on a 'demand-side' basis (as above), as opposed to 'supply-side' data (for example, employment levels in relation to recreational fishing), which would need to be assessed through different sources/methodologies.

Finally, again depending on ultimate needs, it is proposed that sub-sampling within the diary phase be undertaken for expenditure data collection. For example, it may be that the required precision for such data could enable stratification of all diarist households into (say) 4 groups, where each would provide expenditure data for a different 3 month period within the 12 month diary period. As noted previously, this is potentially important to ultimate response rates and is consistent with our core philosophy of "valuing respondents' time".

5.3 Wash-up survey

As noted in Section 1 above, due to the variety of original (NRFS) and potential awareness/attitudinal questions, no detailed output specifications for the social dimensions component of the survey have been included here. However, the now standard 'Wash-up' Survey has provision for such questioning and further to our recommendations at the recent Social Dimensions workshop, the 'core' national questions should ideally be identified/agreed as part of this project, to enable appropriate jurisdiction-specific questioning to be included (as for the NRFS).

However, this latter questioning does not need to be fully specified at this stage—rather, an agreed amount of 'average interview time' and specification of the kinds of information that can (or can't/shouldn't) be assessed through this survey component. Furthermore, depending on the ultimate recommendations regarding social dimensions data, potential exists for customised 'follow-up' attitudinal/awareness surveys. For example, after a brief review/analysis of data from the Diary Survey and initial Wash-up Surveys, more focused surveys could be conducted with relevant sub-samples of respondents who have agreed to be re-contacted (the vast majority usually). This would ideally occur within 2–3 months after the end of the Diary Survey.

To assist in ultimate output specifications development, the following broad data components might be required for the Wash-up Survey of households that fished in the diary period, and where an absolute maximum average interview time is around 13–15 minutes is recommended. Also, in most recent statewide surveys, an abbreviated version of the Wash-up Survey has been asked of households that did not fish in the diary period (see NSW/ACT example, which can be provided by ABARES on request).

Depending on ultimate data needs, 7 broad data components might be required:

1) Firstly, the need to verify the recreational fishing behaviour of all household members for the diary period (i.e. fished or not). Although this very rarely reveals any errors in the Diary Survey data (and invariably, for example, an unexpected charter trip by a 'non-fishing' son), it is nonetheless an important part of the overall process

2) Additional expenditure data and verification for large-scale/less-obvious/annual items (e.g. boat/trailer insurance)—as discussed in Section 5.2, b) above (see NRFS and 2009/10 NT Wash-up Surveys, which can be provided by ABARES on request)

3) Boat profiling information for all boats owned by the household would be assessed in terms of size; main propulsion method (power, sail, row/paddle); percentage of usage for recreational fishing in previous 12 months; current market value (respondent perception—

an investment/economic assessment); GPS/echo sounder (a measure of fishing power), and so on.

4) 'National' awareness/attitudinal questioning—for all jurisdictions and 'structured' questions (as opposed to open-ended responses in Item 6 below)

5) State/territory-specific awareness/attitudinal questioning—again structured questions

6) 'Open-ended' questioning to enable respondents to 'have their say' on issues of concern to recreational fishing or to provide suggestions. This is especially important, given that during the Diary Survey, interviewers routinely inform respondents wishing to make such comments that respondents will have their chance to do so at the end of the survey. However, in more urgent cases of course, any respondent concerns are dealt with at the time and referred to relevant client staff

7) A final question sequence to assess whether and how respondents would like to receive a copy of the survey results and their availability for re-contact at a later stage.

Examples of questioning for all the above components are contained in various Wash-up Survey questionnaires, examples of which can be provided by ABARES on request.

5.4 Non-intending fisher follow-up survey

As discussed in the introduction to Section 5.2 above, this survey provides an assessment of unexpected fishing activity in the diary period, through a robust and random follow-up sample of non-intending fisher households from the original Screening Survey. The resultant 'drop-ins' provide a counter-balance to the 'drop-outs' from the Diary Survey (those who unexpectedly did not fish) and therefore an overall participation estimate for the diary period. Whilst relatively low levels of unexpected fishing invariably emerge from these follow-up surveys, the large populations and expansion factors involved necessitate quite large sub-samples to reduce the standard error levels for ultimate participation assessment here. In all subsequent statewide surveys, minimum samples of around 20 per cent of households have been drawn to achieve this. Data elements for this follow-up survey are relatively brief and are recommended as follows (however these are not in questionnaire order):

1) Firstly, to establish that the selected household is the same as at the Screening. For example, sometimes disconnected phone numbers are quickly re-allocated

2) Assess any recreational fishing participation in the diary period in the home state or elsewhere

3) If no unexpected fishing (the vast majority of cases), then the interview is terminated after confirming household size

4) If unexpected fishing is reported, then details are assessed for each 'pre-existing' household member aged 5 years or more at Screening—including 'avidity' (recall days fished) and a recent innovation, a dissection of avidity for those who fished both in their home state and elsewhere

5) Also, for fishing households, boat ownership and any usage for fishing in the diary period.

Typically, the low incidence of unexpected fishing activity is also characterised by relatively low avidity levels. By design, this information is used to identify 'aggregate counterparts' (by stratum etc.) among fishers in the Diary Survey sample. This is an integral part of the

analysis/calibration process through the *RecSurvey* package. Importantly, these low levels of activity naturally have minimal 'compounding' impacts on the error levels for total harvest due to the large disproportion attributable to the highly-avid fishers.

Appendix E: Global review of national scale recreational fishing survey methodologies

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Method

Several methods were used to locate information pertaining to broad scale recreational fisheries surveys in both peer-reviewed and grey literature. The primary method was online searches within mainstream search engines (Google) as well as targeted databases, including 'Scopus' and 'Google Scholar'. Search terms included 'recreational fishing survey', 'angler survey' combined with a list of countries of interest. This process was further expanded by reviewing the literature cited in the reference lists of the documents identified in the primary search method.

Where multiple surveys had been conducted within a country, the most recent published implementation of the survey with the greatest geographic scope was reported on. For some countries. multiple survey methods were reported, particularly if they related to a complemented, dual frame, or ancillary design. In the case of Germany, a large-scale freshwater and marine based recreational fishing survey had been conducted. Each of these was reported separately and in the United States two surveys were reported on; one focusing more on general participation and expenditure and the other on the catch and effort from the marine recreational fishery.

The focus was on surveys that were designed to capture information relating to participation rates and demography, fishing effort and harvest estimates. With the exception of a study from the United States, economic and social surveys were not considered unless they were integrated into the former.

To compare and assess survey methodologies, a modified version of the ICES-WGRFS 'Quality Assurance Toolkit' (QAT) (ICES 2014) was applied. The aim of this assessment was to identify survey methodologies that could potentially improve the design of a national survey in Australia in terms of data quality for end-users, cost-effectiveness and future proofing the survey in light of rapid changes in communication mediums, an important component of accessing an appropriate and complete sample frame from which to survey. The assessment criteria and explanations are presented in Table 13.

Table 14 was designed to summarise the survey methods from each country, and where required each component of multi-survey designs. Information was summarised on each survey's target information, geographic scale, temporal scope, temporal frequency, primary method (offsite/onsite/complemented), survey scope, survey exclusions, sample frame, sampling units, strata, identified biases and bias adjustment, and a brief method summary. A summary table for each reviewed national recreational fishing survey is available from ABARES with permission from the Institute for Marine and Antarctic Studies, University of Tasmania.

Table 13 Assessment criteria and rationale used to critique the reviewed surveys

Question ID	Assessment question	Assessment question rationale
A	Is the survey national in scope?	Yes = A survey that is collecting all the information defined in the project objectives at a national level, this may include, participation demographics, effort, catch, expenditure, etc. Partial = At least some of the information listed above is collected at a national level, but some other information may be collected from a smaller spatial scope. No = The survey was not designed to collect data at a national level, often these surveys are designed to collect information from a large region of interest.
B	Are all sectors contributing to the total catch well known and documented?	Yes = All sectors that may be catching fish recreationally are well understood. In most cases this is well known, but some sectors may not be covered in the sampling frame (see question ID D).
C	Is the PSU identified and documented?	Yes = the primary sampling unit (PSU) is either obvious or documented in the survey methodology. No = It is not clear what the PSU was and it is not documented in the referenced report.
D	Does the sampling frame fully cover the target population?	Yes = The sampling frame fully covers all sectors contributing to the total catch. Partial = The sampling frame covers the vast majority of the target population, but there are some exceptions, e.g. non-complete coverage of target population due to missing or non-listed phone numbers. An example is a telephone survey that does not cover people that do not own (or are not listed) in the directories/databases used to select samples. Some surveys use face-to-face sampling in addition to the telephone method to quantify the proportion of people not listed. In this case the response to this question would be 'yes'. No = The sample frame does not fully cover the target population. Unknown = It is not clear in the referenced literature if the target population is fully covered.
E	Are the strata well defined, known in advance, stable and not over-stratified?	Yes = The strata are either well defined in the referenced literature or obvious in the survey methodology. It was also a requirement of this category that the strata were not to numerous (over-stratified), leading to issues with precision. No = It is not clear what the strata were or they were over-stratified.
F	Is sampling probability based?	Yes = Sample selection was randomly stratified from the target population, providing data suitable for expansion to the total population and calculation of precision. No = The sample selection was not randomised.
G	Are there protocols in place and are they being followed to select sub-samples?	Yes = The sampling design and strata were well defined prior to the implementation of the survey and the design protocol was adhered to. No = The sampling design and strata was not considered prior to the survey leading to an ad hoc data set.

H	Are response rates recorded and evaluated?	Yes = The response rates are reported in the referenced literature and the implications of the response rates are discussed. No = The response rates are either not reported or not considered in the referenced literature.
I	Is the recall period appropriate?	Dependent on the information requested. Yes = If the respondent was reporting catch a 1-month recall period was considered acceptable, if they were reporting days (effort) 2-months was considered acceptable, if they were reporting participation (e.g. did you fish) and/or expenditure a 6-month recall was considered acceptable. Partial = 2-month recall for catch, 6-month for effort, 6-month for expenditure, 12-month for participation. No = >2-month recall for catch, >6-month for effort, >6-month for expenditure, >12-month for participation.
J	Is catch, species and size composition verified with an onsite survey?	Yes = a robust onsite survey complemented offsite methods to validate catch, species and size composition. No = No onsite component was considered so that catch reporting is reliant on the respondents recall and ability to identify species (and size if recorded).
K	Is species ID and naming reliable?	Yes = Countries that have few target species and species are well known, or that pooled species data to higher taxa to minimize potential misidentification. Or where catch was determined solely by an onsite survey conducted by trained interviewers. Partial = Surveys that provided respondents with species identification material prior to the commencement of the survey. No = Surveys that did not verify species identification ability of respondents in any way.
L	Is there a clear division between fish kept and released?	Yes = The information reported on catch clearly identifies whether it was landed catch or released (if the survey was reporting harvest it did not necessarily have to report released catch, as long as this was clear in the referenced literature). No = It was not clear if catch reported equated to landed fish or all fish caught.
M	Is the analysis appropriate for design?	Yes = A statistical method was applied appropriate to the survey design. No = The statistical design was inappropriate for the survey design. Unknown = There was insufficient information in the referenced literature to determine if the analysis was appropriate for the survey design.
N	Has there been weighting adjustments made for non-response/avidity bias?	Yes = non-response and avidity bias have been estimated and weighting adjustments made, or the biases are fairly reported as not to be of a magnitude that required adjustment. No = non-response and avidity bias was likely to have occurred and either has not been reported or no adjustments were made.
O	Has estimate precision been calculated and reported?	Yes = The referenced literature reports some form of appropriate precision metric for the expanded estimates. No = There is no reporting of precision estimates in the referenced literature.

Note: The question ID is applied as column headings in Table 14. **PSU** Primary sampling unit.

Table 14 Assessment of reviewed surveys based on criteria outlined in Table 13

Country	Primary method	Response rates	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Australia	Offsite telephone diary with ancillary regional onsite surveys	80% (SC) 89% (EN) 93% (RET)	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Partial	Yes	Yes	Yes	Yes
New Zealand	Offsite f2f-telephone panel survey with ancillary regional onsite access surveys	86% (SC) 91% (EN) 84% (RET)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Partial	Yes	Yes	Yes	Yes
Canada	voluntary mail survey	NR	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Partial	No	No	Yes	Yes	Partial	Yes
United States – Marine Recreational Information Program	Completed survey - random-stratified one off RDD survey; random-stratified intercept at public access points	14% (RDD)	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Partial	Yes	Yes	Yes	Yes	No	Yes
United States - Game	Two phase phone (visit) survey	77% (SC)* 67% (SP)*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes*	No	NA	NA	NA	Yes	No	Yes
Brazil	Voluntary questionnaire on back of license. Information from authorized fishing events	NA	Yes	No	Yes	No	No	No	No	No	No	No	No	No	No	No	No
Denmark	Two-wave mail recall survey; Omnibus survey for Non-license proportion	73% (MR)	Yes	Yes	Yes	Partial	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	Partial	Yes
Finland	recall mail survey, follow up phone survey for Non-respondents to establish the proportion of fishing households among Non-responders	60% (MR) 63% (SR)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	Yes	Yes	Yes
France	Complemented: RDD telephone survey; onsite	NR	Yes	Yes	Yes	No	Yes	Yes	Yes	No	No	Yes	Yes	No	Yes	Yes	Yes

Country	Primary method	Response rates	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
	survey																
Germany (inland and coastal)	complemented-multistage: phone-diary-mail	51% (SC) 59.6% (EN) 58% (RET)	Partial	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Partial	Partial	Partial	Yes	Yes	Partial	Yes
Germany (marine)	Offsite mail diary with ancillary onsite creel	<10% (MR)	Partial	Yes	Yes	No	Yes	No	Yes	Yes	No	Yes	Partial	Yes	Yes	No	Yes
Netherlands	Complemented - RDD offsite; online diary; onsite creel	80% (RDD)	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Partial	Partial	Yes	Yes	Yes	Yes
United Kingdom	Complemented - Offsite (f2f); onsite: roving creel for shore based and roving access point for boats	58% (f2f) 94% (ON)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes