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Developing robust and cost-effective methods for estimating the national recreational catch of Southern Bluefin Tuna in Australia

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Executive Summary

Background

Southern Bluefin Tuna (SBT) is an iconic species both domestically and internationally. In addition to being a high value commercial fishery, its popularity in Australia with recreational anglers has increased over the last decade as indicated via dedicated state-wide SBT surveys, social media and tagging data. The estimated annual expenditure for the recreational fishing of SBT in Australia is likely in excess of $5–7 million (Ezzy et al. 2012).

The most recent assessment of stock status for SBT estimated that it remains in an overfished state, with the spawning stock biomass at 9 per cent of unfished levels. SBT is listed as conservation dependent under the Environment Protection and Biodiversity Conservation (EPBC) Act, endangered under the New South Wales Fisheries Management Act and threatened under the Victorian Flora and Fauna Guarantee Act. The stock is subject to an international rebuilding plan and catch limits (quotas). The Australian Fisheries Management Authority (AFMA) sets Australia's domestic SBT quota at or below Australia's allocation from the Conservation of Southern Bluefin Tuna (CCSBT). Australia reports its annual catch of SBT to the Commission for the CCSBT. In 2014, CCSBT agreed to a common definition of attributable catch, under which members are expected to have a process to account for all sources of mortality, including commercial, discards and recreational catch within their allocation by 2018. Obtaining reliable estimates of SBT catch is also a Wildlife Trade Operation condition for Australia's SBT fishery under the EPBC Act.

Recreational fishing for SBT spans over 6,500 kilometres of Australia's southern coastline from Western Australia to New South Wales. Recreational fishing activity along this coastline is typically dispersed and episodic with fishing grounds only becoming active as SBT migrate along the coastline from the west to the east. In addition the open-ocean and pelagic habitat of SBT means that they typically occur off-shore and are not available to most anglers. Consequently, catch of SBT by recreational anglers is a rare event when compared with the total recreational fishing catch in Australia.

The management of recreational fishing is undertaken by the relevant states, whereas the management of the commercial SBT fishery, engagement with the CCSBT and management of SBT as a conservation dependent species under the EPBC Act are Commonwealth responsibilities.

Aims/objectives

The objectives of this project were to: 1) develop and test methodologies to provide a national estimate of the recreational catch of SBT; and 2) design a cost-effective program to regularly collect, analyse and report on recreational SBT catches and associated fishing activities.

Methodology

To meet these objectives the project reviewed all available recreational catch survey methods and conducted a gap analysis of existing data sources. This included the existing state-based survey methods for Tasmania, Victoria and Western Australia. There are no past or current dedicated surveys of SBT catch undertaken in South Australia and New South Wales. The data collection from charter boat logbook programs and game fishing tournaments in the relevant states was also reviewed.

On-site testing and modelling

Off-site surveys (e.g. phone and diary based) are a practical and cost-effective method for estimating catch of SBT. However, they are reliant on a suitable sampling frame (e.g. fishing licence database). In

situations where a suitable sampling frame is not available for off-site surveys then on-site surveys (i.e. surveying at boat ramps) are the only cost-effective option. On-site sampling frames for SBT have been designed for locations where SBT are resident for several longer periods and effort is concentrated on a small number of locations (e.g. Victoria and Tasmania). However, SBT recreational fishing occurs in locations where fish are resident for only short periods of time (1–2 weeks) (e.g. South Australia) or move through an area rapidly (e.g. New South Wales), resulting in sporadic fishing events. Surveying SBT anglers to estimate recreational catch has not been undertaken in these situations.

An on-site trial of a methodology for surveying regions with short and unpredictable fishing seasons was undertaken, using stratified random access point surveys, across four provinces in South Australia between January and August 2014. The survey methodology was a modification from the on-site designs applied in Victoria. Bootstrap analysis and data simulation modelling were applied to estimate the error associated with catch estimates given different survey intensities at particular locations. This provided an understanding on how well the survey designs were likely to perform in localities where fishing activity is more diffuse and episodic. The survey designs were developed with stakeholder and technical expert consultations through participation in workshops. Expert SBT anglers were interviewed to provide detailed information on when and where fishing for SBT occurred in the regions with more diffuse and episodic fishing.

Charter boat logbook data and voluntary logbook trial

Charter vessel catch is a component of SBT catch that may not be picked up by other survey techniques. To determine if the charter boat catch of SBT could be routinely estimated, a review of charter boat logbook programs across jurisdictions was undertaken. Compulsory charter logbook programs are operated in Western Australia, South Australia and New South Wales. Tasmania has successfully run voluntary charter logbook programs in the past (collecting data on SBT) and it may be possible for these to be undertaken in the future. A voluntary logbook trial was undertaken in Victoria to determine whether such a system would work in the absence of compulsory logbooks. This trial was conducted through the 2014 SBT season.

Game fishing tournaments

Catch estimates from game fishing tournaments may or may not be captured by other survey methods. A review of game fishing tournaments that target or capture SBT was undertaken to estimate the catch of SBT in organised game fishing tournaments.

Results/key findings

On-site testing and modelling

The analyses of the on-site trial conducted in South Australia and subsequent scenario testing indicated that a sampling coverage of around 500 survey days would be required to provide robust estimates of SBT catch in South Australia based on a fishing season duration of 8 months. The analysis indicated that around 330 survey days would be required in New South Wales based on a fishing season duration of 2 months. This sampling coverage was needed to account for the large standard error associated with sampling fishing activities that are diffuse and episodic. The on-site trial in South Australia generated 151 surveys days, during which 1028 interviews were completed.

Charter boat logbook data and voluntary charter boat logbook trial

Charter boat logbook data are available from the jurisdictions that have compulsory systems in place (Western Australia, South Australia and New South Wales). Previous work in Tasmania has shown a voluntary charter boat logbook can be implement successfully in that state. The trial of voluntary logbooks

in Victoria was unsuccessful, suggesting that only appropriately resourced and mandatory logbook programs in each jurisdiction (with the exception of Tasmania) would produce consistent, ongoing and robust data that could contribute to a national estimate of SBT catch. The initial uptake of the trial by charter operators in Victoria was good. However, only two out of seven finished the trial, citing time limitations as the main reason for non-completion.

Game fishing tournaments

The game fishing tournament review identified tournaments that target SBT in South Australia (Port Lincoln and Port MacDonnell) and Tasmania (Pirates Bay, Far South and Coles Bay). Most game fishing tournaments in southern Australia do not target or interact with SBT due to the location or the timing of the tournament. It should be possible to get accurate data from these tournaments for little cost either directly from the organisers or by incorporating tournament days into on-site surveys. Well implemented off-site surveys are also likely to capture tournament effort.

Implications for relevant stakeholders

The recommended approach is likely to provide the most cost-effective method for estimating the national recreational catch of SBT that could be executed in the absence of a nation-wide and SBT-specific off-site sampling frame. To be most effective, surveying would need to be repeated at regular intervals. The frequency of the surveys to estimate the recreational catch of SBT will depend on the year-to-year variation in catch, the number of recreational fishers (and how this changes over time) and the level of precision required for a national estimate. If the inter-annual variability is low, surveys could be undertaken less frequently, such as every five years. If the variability is high, more frequent surveys may be required.

National estimates of recreational catch for SBT are likely to provide useful data for international reporting, stock assessment and resource sharing discussions. Depending on the survey design, it may also provide data on the take of other large game fish species like tuna and billfish that are of interest to Commonwealth and state governments and other stakeholders.

Recommendations

The outcomes of the project provide three primary recommendations:

1. In the short-term, for estimation of SBT recreational catch in Australia, the most cost-effective and robust method is to implement separate surveys in each state jurisdiction. Off-site surveys are the most cost-effective approach in Western Australia, Tasmania and New South Wales, whereas on-site surveys are the best approach for South Australia and Victoria. The estimates derived from these surveys can be combined with charter boat logbook and game fishing tournament data to provide a total estimate of catch in each state. These estimates, when summed, will provide a robust estimate of the total national recreational catch of SBT for Australia. In addition to the current investment by jurisdictions (such as the Western Australian off-site survey and mandatory charter boat logbook programs), this approach is estimated to cost approximately $2.3 million.
2. In the medium-term, efforts directed towards accessing a suitable off-site sampling frame for South Australia (such as the boat registration licence database) is warranted. Access to an appropriate sampling frame for SBT in South Australia would reduce costs of sampling in this state. Similarly the application of adaptive on-site sampling may reduce the overall costs of data collection in South Australia.
3. Over the longer-term, efforts should be directed towards establishing a national off-site sampling frame for SBT recreational catch. If a sampling frame was generated that was specific to SBT it is estimated to reduce the annual costs of surveying the recreational angler catch to approximately $0.4 million (not including establishment costs). If designed appropriately this sampling frame

could also be used for other game fish species that are of interest to Commonwealth and state governments and other stakeholders.

Keywords

Southern Bluefin Tuna; national recreational fishing survey; on-site and off-site survey; data simulation and scenario testing; voluntary charter boat logbook trial.

Chapter 1 Introduction

Background

Southern Bluefin Tuna (SBT) is an iconic and highly valued species internationally and in Australia, both to the commercial fishing industry and the recreational fishing sector. There is a single global stock that spans international waters and the exclusive economic zones (EEZs) of several nations. The global stock is managed under the *Convention for the Conservation of Southern Bluefin Tuna* (1994) that established the Commission for the Conservation of Southern Bluefin Tuna (CCSBT). The SBT stock has been depleted by historic overfishing (Patterson et al. 2014). The 2014 assessment estimated that the spawning stock was 9 per cent of the unexploited biomass level (CCSBT 2014). SBT was listed as conservation dependent under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) in Australia in 2010. It is also listed as endangered under the New South Wales Fisheries Management Act (1994) and threatened under the Victorian Flora and Fauna Guarantee Act (1988). The CCSBT has adopted a management procedure aimed at rebuilding the stock to 20 per cent of unexploited biomass by 2035 with 70 per cent probability (CCSBT 2011). This management procedure is used to recommend the global total allowable catch (TAC), which is then allocated to the members and cooperating non-members.

Although currently at a low biomass level, SBT has continued to support a valuable domestic commercial fishery in Australia. Since the early 1990s most of the Australian commercial catch has been taken by purse-seine and formed the basis of a high-value, sea ranching industry located off Port Lincoln in South Australia. In 2012-13, the gross value of production (GVP) for the SBT aquaculture industry was $153.5 million (AFAS 2014). The Australian Fisheries Management Authority (AFMA) sets annual TACs for the commercial fishery in line with Australia's national harvest allocation from CCSBT.

The management of recreational fishing activities, under a memorandum of understanding between the Commonwealth and the states and territories, lies with the relevant states and territories (DAFF 2004). The retained SBT catch per angler or vessel in each state is limited through possession limits (Table 1). There are currently no constraints on the level of recreational fishing effort.

Table 1. Jurisdictional possession limits for SBT

Jurisdiction	Possession limit per person per trip (number of fish)
New South Wales	1
Victoria	2
Tasmania	2
South Australia	2
Western Australia	3

In recent years, reports suggest that recreational interest and catch of SBT have increased (Rowsell et al. 2008; Tracey et al. 2013). Data from the NSW DPI Game Fish Tagging programme suggests a substantial increase in tagged and released SBT from 2004 to 2010, although the interpretation of this is unclear given changes in fishers tagging behaviour. Recreational SBT fishing activity tends to be spatially and temporally variable within a season and between years. Within the population of recreational fishers in Australia, those that catch SBT make up a small proportion and most general surveys of recreational fishing currently do not provide robust estimates of SBT catch. Ad hoc studies to estimate the catch of SBT in the waters off a particular state within a given year have provided localised catch estimates (Morton and Lyle 2003; Forbes et al. 2009; Green et al. 2012; Tracey et al. 2013).

A survey conducted at Portland, Victoria, which is a key port for recreational SBT anglers, estimated the expenditure of recreational fishing for SBT at $5.6 to $7.6 million in 2011 and $5.64 to $7.58 million in 2012 (Ezzy et al. 2012). No state-wide or national estimates of recreational expenditure for SBT angling are available, but the total annual national expenditure is likely to be well in excess of these estimates.

The recent expansion in recreational SBT catch, in the context of the international management process and an overfished stock (Patterson et al. 2014), requires regular and statistically robust estimates of recreational and charter fishing catch across all Australian jurisdictions.

Need

In 2014, CCSBT agreed to a common definition of attributable catch, under which members are expected to have a process to account for all sources of mortality, including commercial, discards and recreational catch within their allocation by 2018 (CCSBT 2014). It is also a WTO condition for Australia's SBT fishery under the Commonwealth EPBC Act to take account of all sources of mortality as part of management of the species in Australian waters. Information on catch levels and the geographical and seasonal distribution of recreational fishing activities will aid this reporting. Recreational fisheries also contribute significantly to regional economies and all jurisdictions are likely to benefit from a better understanding of catch and effort to allow for sustainable management.

Objectives

The objectives of this project were to:

1) develop and test methodologies to provide a national estimate of the recreational catch of SBT

2) design a cost-effective program to regularly collect, analyse and report on recreational SBT catches and associated fishing activities.

The project was methodological in nature and was not designed to provide a national estimate of SBT catch over the study period.

Approach

Reflecting the dispersed nature of recreational fishing for SBT, this project has been undertaken in collaboration and consultation with the relevant states. The project was guided by a technical advisory committee that involved experts from the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES), AFMA, Fisheries Victoria, FRDC, Game Fishing Association of Australia (GFAA), Victorian and Tasmanian Game Fishing Associations, Institute for Marine and Antarctic Studies (IMAS), New South Wales Department of Primary Industry (NSW DPI), South Australian Research and Development Institute (SARDI), Victorian Game Fishing Association, Department of Fisheries Western Australia and a charter boat operator.

The project was implemented through separate subprojects that focused on key information gaps, with ABARES providing overarching coordination. These subprojects were conducted by Fisheries Victoria, IMAS and ABARES.

This report is structured to provide:

1) a description of the nature of recreational fishing for SBT in Australian waters, which provides the context and key considerations for the development of a methodology to estimate the national catch;

2) an overview of recreational fishing survey methods that have been used to estimate catch and effort and their potential application to SBT fishing;

3) a summary of previous surveys of SBT recreational fishing and other sources of information on components of recreational fishing activity, which contributed to identifying the key methodology gaps;

4) a description of the methods used to address the key gaps, including: testing of on-site survey methods in regions where this approach has not been applied; simulations to inform the level of on-site sampling required; a review of charter boat logbook information and trial of voluntary charter boat logbooks in Victoria; and a survey of game-fishing tournaments;

5) the results of the work to address the key gaps; and

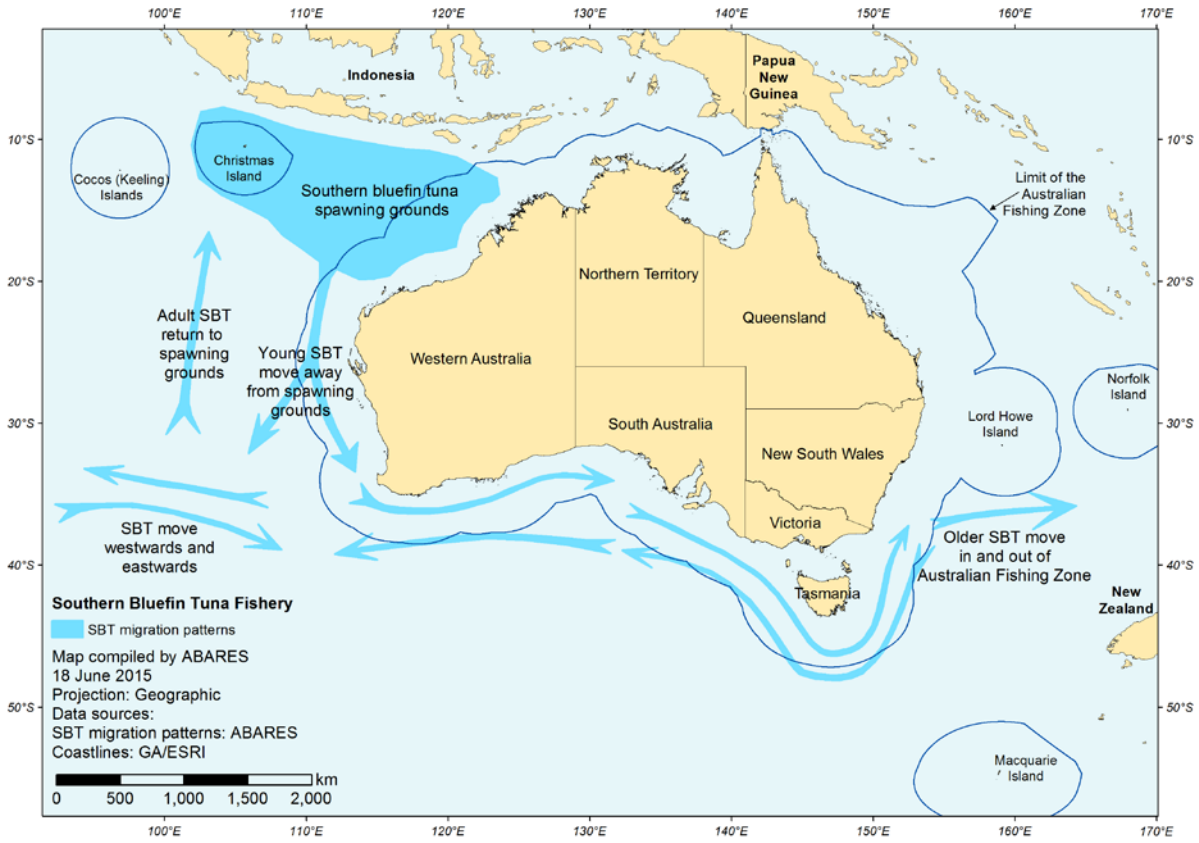
6) a discussion and recommendations on the design options for a cost-effective program to regularly collect, analyse and report on recreational SBT catches and associated fishing activities.

Chapter 2 Recreational fishing for Southern Bluefin Tuna

Southern Bluefin Tuna migration in Australian waters

Southern Bluefin Tuna constitutes a single, highly migratory stock that spawns in the north-east Indian Ocean (off north-western Australia, south of Indonesia) and migrates across the temperate, southern Indian and Atlantic oceans (Grewe et al. 1997; Farley and Davis 1998; Basson et al. 2012). Young fish (1–4 years) move from the spawning ground into the Australian Fishing Zone (AFZ) and southwards along the Western Australian coast (Figure 1). Surface-schooling juveniles are found seasonally in the continental-shelf region of southern Australia, but the proportion of the total juvenile stock that migrates into this area is not known (Basson et al. 2012). Juvenile SBT (2–3 years) migrate through the Great Australian Bight (Everson et al. 2014) and schools of large and small SBT continue to migrate east in waters off South Australia, Victoria and Tasmania, and north to mid New South Wales (Farley et al. 2007; Basson et al. 2012) (Figure 1). The migration pattern of SBT covers the waters off approximately 6500 kilometres of the Australian coastline, from north-west Western Australia to central New South Wales. SBT are also known to migrate across the Indian Ocean to South Africa and across the South Pacific to New Zealand (Basson et al. 2012).

Figure 1 Map showing the migration pattern of SBT to the spawning grounds and around southern Australia



Geographic distribution of recreational fishing activities for Southern Bluefin Tuna

The following description of recreational fishing for SBT in Australia is drawn from various published (e.g. Ward et al. 2012a, Green et al. 2012, Tracey et al. 2013) and unpublished accounts, expert advice and observations during surveys undertaken as part of this project.

Recreational fishing for SBT is a subset of more diverse recreational fishing activities involving a variety of fish species, many of which have a broader seasonal and geographical distribution than SBT. In 2000–01 an estimated 3.36 million Australians had fished recreationally in the past year (Henry and Lyle 2003). Most recreational fishing is shore based or in near shore areas (Henry and Lyle 2003).

Offshore recreational fishing for large, surface-dwelling pelagic species like SBT is referred to as 'game fishing'. Other popular game fish species in Australia include billfish (e.g. Black, Blue and Striped Marlin), other tunas (e.g. Yellowfin Tuna and Albacore) and sharks. Fishing club membership in Australia was estimated at 4.3 per cent in 2000–01 (Henry and Lyle 2003) with game fishers likely to represent a small proportion of club members. SBT is regarded as a 'niche species' for recreational fishing, given the low participation rates, even within game fishing activities.

Recreational fishing for SBT is known to occur off Western Australia, South Australia, Victoria, Tasmania and New South Wales. SBT rarely occur in the waters off Queensland. The abundance of SBT shows large spatial and temporal variation throughout its range (for example, in the Great Australian Bight; Everson et al. 2014) and SBT are not available to anglers all year round. The speed and distance offshore at which SBT migrate and the residence time in each area, largely dictate where and when the species are targeted by anglers. These characteristics appear to be highly variable and related to different oceanographic, temperature and current patterns along the coast each year (Everson et al. 2014).

Western Australia

SBT are caught by recreational anglers throughout the state, although most are caught off the west coast and south coast, with small catches off the north coast and Gascoyne coast (Ryan et al. 2013). Most of the catch is comprised of juvenile fish taken from inshore waters in autumn, though SBT are caught in all seasons. A general off-site, boat angler survey has been conducted every two years in Western Australia since 2012. This survey provides robust information on the catch of SBT from privately owned boats (Ryan et al. 2013).

South Australia

Anglers in South Australia fish for SBT from various ports across the state, with Port MacDonnell and Port Lincoln having the highest angler activity (Figure 2). Fish appear to aggregate off the coast from Port MacDonnell to Victor Harbour, where fish have long residence times providing relatively easy access for anglers. This appears to also be the case for the Great Australian Bight accessed out of Port Lincoln. Elsewhere, fishing appears to be more episodic and geographically diffuse. The fishing season typically runs from December to the end of July. While South Australia conducts general recreational fishing surveys (Jones 2009), they are not of a suitable resolution to accurately estimate SBT catch.

Victoria

Fishing for SBT in Victoria is primarily around the ports of Portland, Port Fairy, Warrnambool and Apollo Bay (Green et al. 2012; Figure 2). Residence times for SBT appear similar to the waters accessed from Port MacDonnell and can last for several months. The fishing season typically runs from February until late July. An on-site survey of the main ports for SBT catch and effort was undertaken covering the 2011 season (Green et al. 2012).

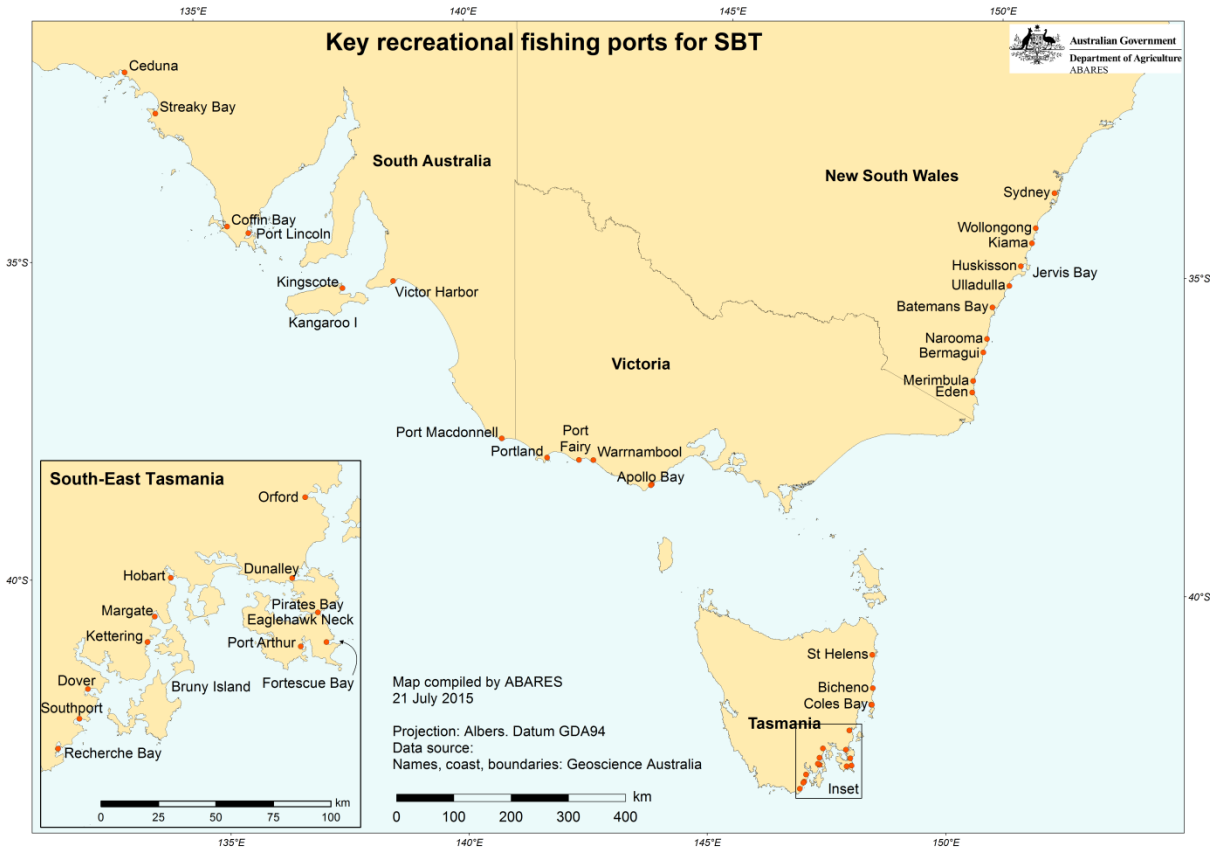
Tasmania

The main fishing for SBT in Tasmania occurs near the coast adjacent to the Tasman Peninsula and is predominantly accessed from Pirates Bay, Fortescue Bay and Port Arthur. Fishing also occurs along the south coast of Tasmania with the main access points at Recherche Bay, Southport, Dover, Kettering and Margate. SBT are also intermittently targeted on the east coast from multiple access points (Forbes et al. 2009; Tracey et al. 2013; Figure 2). The season runs from January to July. Surveys have been undertaken in 2003, 2008 and 2012 to quantify SBT recreational catch and effort in Tasmania, although the methodologies have differed (Morton and Lyle 2003; Forbes et al. 2009; Tracey et al. 2013).

New South Wales

Fishing for SBT in New South Wales is geographically dispersed with key ports at Eden, Bermagui, Batemans Bay, Narooma, Ulladulla, Jervis Bay, Wollongong, Kiama and Sydney (Figure 2). The northern extent to which SBT are available to New South Wales recreational fishers varies between years (Ward et al. 2012b). In years when the SBT distribution extends north towards Sydney, recreational fishers can access a large number of launching locations within the Sydney region. Fishing for SBT in New South Wales is generally much further offshore than other states, often resulting in travel of up to 100 kilometres offshore. The fishing season is much shorter than other states and typically runs from June to the end of July. New South Wales has conducted general recreational fishing surveys (Steffe et al. 2005; Steffe and Murphy 2011; West et al. 2015), but they are not of a suitable resolution to accurately assess SBT catch.

Figure 2 Key fishing ports for SBT around south east Australia



Structure of the recreational SBT sector

Recreational fishing activities for SBT can be separated into three main components:

1) organised game fishing, which includes anglers who are fishing club members participating in competitions or tournaments

2) non-organised recreational fishing, which is comprised of anglers who are not members of a club and do not participate in tournaments

3) charter boats (commercial businesses that charter-out their vessel and crew for recreational fishing) who are engaged by anglers who may be part of the organised or the non-organised component of the game-fishing sector.

In developing and testing the methods to estimate the national recreational catch of SBT, consideration was given to these different components and the potential information sources available.

Fishing platforms

Powered boats are generally required to reach the locations where SBT occur. Recreational anglers who target SBT usually operate from boats of 4 metres in length or larger. Game-fishing boats usually have modern navigation and fish-finding devices, including global positioning systems (GPS), sounders and in some cases radar. Most recreational activity appears to take place on privately-owned boats with a smaller proportion reported from charter boats (Forbes et al. 2009; Green et al. 2012; Tracey et al. 2013).

Changes in technology available to medium size boat owners are likely to have increased the ability of recreational fishers to target SBT. These changes include more reliable outboard motors, more accurate and reliable navigation systems and better safety options on vessels. These changes enable smaller trailer boats (boats that are transported, launched and retrieved each day on trailers) to safely fish further offshore. Across all recreational fishing activities, charter and private boats operate from within a few kilometres of the shore to in excess of 100 kilometres offshore. Near-shore locations can be accessed with relative ease by trailer boats. Charter vessels are often larger boats that can travel greater distances offshore (Trailerboat Fisherman 2010).

While most game-fishing activity takes place from boats, there are locations off south-eastern Australia where it is possible to catch game fish from the shore (e.g. around Jervis Bay, New South Wales). Additionally, there are some game fishers who target game fish from kayaks. However, as most SBT targeting and catch is well offshore, shore based and kayak fishing are unlikely to be significant sources of recreational catch.

Fishing methods

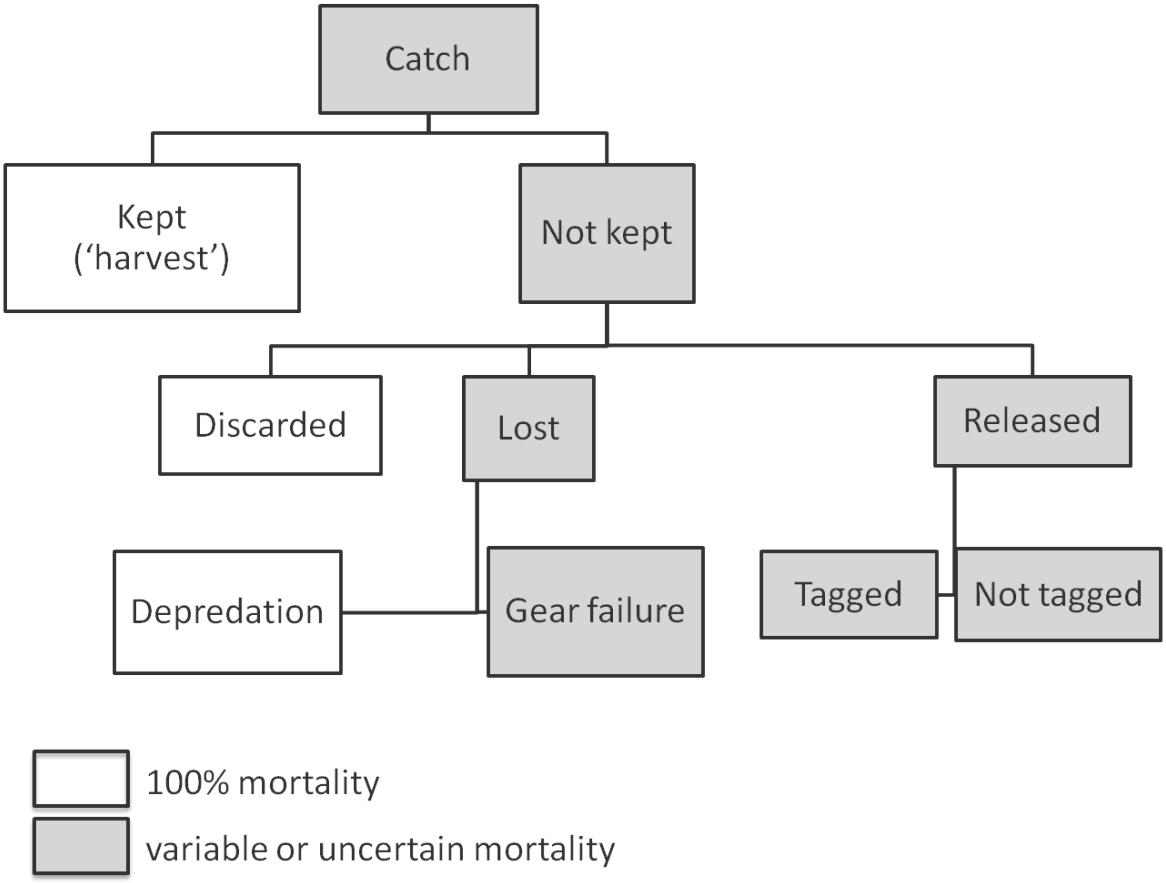
The primary method of targeting SBT involves rod-and-reel, with a lure trolled behind the boat. Lures that mimic the food sources of SBT are trolled around areas that SBT are known to frequent. Bait is also employed at times, which may be alive or dead. Once hooked, SBT are played until they can be brought alongside or into the boat. Technological developments have progressively improved the efficiency of fishing equipment. Combined with improved boat technology these advances are likely to have increased the efficiency or fishing power of game fishers over time.

Southern Bluefin Tuna catch

The SBT are retained as an edible table fish or ‘trophy fish’ by anglers or may be released alive after capture. This report defines catch as those SBT caught by recreational fishers and either retained or released (Figure 3). Harvest is defined as those fish that are retained. Fish may be released (or not retained) because it is tagged and liberated, it is surplus to needs, because the angler is in excess of the bag limit, because the fish is lost before coming to the boat or the fish is eaten (depredation by a seal or shark) (Figure 3). In game fishing there has been a general shift away from landing fish as trophies or for consumption, to tagging and releasing live fish (Pepperell 2010) with many game fishers supporting tag-and-release (Ward et al. 2012b). However, this may not be the case for SBT. Murphy et al. (2002) report a tag and release rate of 88 per cent for game fish captured as part of the New South Wales tournament monitoring program (1993–2000). Dedicated surveys of SBT catch found release rates of 26 per cent in Victoria (Green et al. 2012) and 24 per cent in Tasmania (Tracey et al. 2013).

The fishing mortality associated with recreational fishing will depend on the amount harvested and the survival of fish that are released. The post release survival associated with catch and release of SBT in Australia has been estimated at 81 per cent (95 per cent confidence 74.6 – 89.8 per cent), suggesting a high survival rate of released SBT (Tracey et al. 2015). In Tasmania, the recent study of recreational fishing for SBT estimated seal induced mortality (depredation) of line caught SBT at 32 per cent of the total mortality from recreational fishing activities (Tracey et al. 2013). Seal induced mortality appears to be an issue only in Tasmania.

Figure 3 Classification of recreational catch and the associated mortality



Chapter 3 An overview of recreational fishing survey methods

In general, the dispersed nature of recreational fishing, both spatially and temporally, means that survey approaches are needed to provide a sample of the recreational fishing population. Survey results are then scaled up based on a known population and sample fraction to derive quantitative estimates of catch, effort and other quantities of interest. Recreational fishing surveys for large regional areas are complex and the methods employed are closely linked to the survey objectives (Lyle et al. 2002; Pollock 2003; Jones and Pollock 2012). Given the objective of this study was to identify methods for obtaining regular estimates of the national recreational catch of SBT, the following overview of methods refers to this overarching objective.

In general, recreational fishing survey methods can be on-site (i.e. on the water or at access points), off-site (e.g. phone, mail, diary and computer based) or a combination approach (Jones and Pollock 2012).

On-site methods, such as boat ramp creel surveys, are generally effective at capturing information relating to niche fisheries by targeting areas (such as boat ramps) known to be used by fishers targeting the species. However, the size of the area of interest in this case and the temporal variation means on-site methods are likely to be logistically challenging and costly at the scale required to survey SBT (Jones and Pollock 2012).

Off-site surveys are conducted away from fishing sites and include mail, e-mail, internet and telephone surveys (Jones and Pollock 2012). Generally, off-site surveys are less expensive than large-scale, on-site surveys and information can be obtained from fishers not easily contacted using on-site surveys, such as those fishing from private jetties or returning to moorings.

In order to determine the most appropriate survey techniques for estimating the recreational catch of SBT, the strengths and weaknesses of each survey technique were assessed. Key issues that need to be considered for SBT recreational fishing surveys include:

- that it is a low participation sector (a niche species) compared to other recreational fishing activities, so a comparatively rare event;
- the fishing activity can occur over an extensive part of the Australian coastline, some of which has a large number of access points (Figure 1);
- boats accessing the recreational fishery may use public boat ramps, private docks or moorings and the proportion of vessels using these types of access points varies among regions;
- availability of SBT, which influences fishing activity and catch, is seasonal in most regions and varies between years;
- coverage of the different components of recreational fishing activities (i.e. general angling, tournaments, charter boats) needs to be considered and double counting avoided;
- estimates of the number of fish and weight of the catch are required, as well as effort and release rates.

Sampling frame

A fundamental component of all survey methods is an appropriate sampling frame. A sampling frame refers to the population from which a subset (sample) will be screened and interviewed in order to produce comprehensive sampling coverage with the least bias. The sample must be representative of the target population in order to provide statistically robust population estimates. The frame needs to capture all (or the vast majority of) potential respondents. A frame targeted to the fishery or species of interest will improve efficiency, precision and reduce cost. Developing robust and cost-effective sampling is a key priority for designing off-site and on-site surveys (Arlinghaus et al. 2010; Jones and Pollock 2012).

Off-site surveys

Off-site surveys, those conducted away from where fishing occurs, can be implemented through mail, telephone-based or email and web-based processes. They can also use respondent driven approaches. A key issue in determining the effectiveness of off-site surveys, particularly for a low participation activity such as SBT fishing, is the availability of an appropriate sampling frame. Off-site surveys often rely on angler memory for the number of fish retained and their size, which may be affected by recall bias (Tarrant and Manfredo 1993; Jones and Pollock 2012). This potential bias can be reduced with a diary based approach and regular contact (Lyle et al. 2014).

Mail surveys

Mail surveys are one of the cheapest survey methods to implement, but suffer from several disadvantages. Firstly, mail surveys tend to have a low response rate. Secondly, this issue can be exacerbated by avidity bias where the respondents that return the surveys may be particularly keen fishers. Less-avid fishers may feel that their responses are not worth the effort as they may not have caught many fish or spent many days fishing. Furthermore mail surveys are also susceptible to exaggeration, recall bias (e.g. remembering more memorable catches) and species misidentification. There is often little or no scope to identify these biases or train the respondent to reduce the impact of these biases (Jones and Pollock 2012). Mail surveys are more suited to surveys with the objective of collecting information on opinions or preferences rather than catch and effort information, particularly for a niche species.

Telephone-diary surveys

Telephone-diary surveys are an effective method of assessing recreational fishing catch and effort and are considered more appropriate when the survey area is large (Jones and Pollock 2012). Respondents are contacted by phone and a structured interview is administered to record data on fishing activity. The number and frequency of interviews administered depend on the survey objectives and budget. Telephone surveys generally have high response rates (Henry and Lyle 2003; Lyle et al. 2014; Tracey et al. 2013). Computer assisted telephone interview (CATI) technology can be used to potentially improve efficiency and reduce cost.

Historically, the White Pages® directory has been used as a sample frame for telephone-diary surveys. However, its suitability for providing an unbiased representation of the community is now uncertain. This stems from a reduction in the use of landline telephones and a trend of fewer people listing their contact details with this service with the rapid development of mobile phone technology and social media (ACMA 2009). This dynamic has been identified as a significant threat in future-proofing survey methodologies as there is potential for unknown biases to be introduced. Currently the White Pages® continues to be the most accessible source of contact details at a state or national level. However, its appropriateness and the potential for sourcing alternative datasets that provide whole of population contact details need to be considered if the methodology is to continue into the future (Georgeson et al. 2015). Method continuity is important to enable the comparison of survey results across years.

Email and web-based surveys

Email, web and app-based surveys offer potential alternatives to telephone surveys. These methods may address issues such as a reduction in the use of landline telephones. Online methods allow the respondent flexibility to enter data at a time that suits them, which may reduce respondent burden. Self-reporting systems may also reduce survey costs relative to phone methods. Automation of ‘skip patterns’ within the survey questionnaires can be implemented to shorten the response time required depending on the activity of the fisher. Furthermore, there is scope to ‘error proof’ the questionnaire by providing bounds on the responses. Photos can also be included of entered species to reduce species misidentification.

The major disadvantages of these approaches are not having a well-defined sampling frame, avidity bias and potential for erroneous reporting (e.g. some individuals reporting multiple times). Another disadvantage is

that not all people use online services, but into the future with generational change it is likely that this will be a more comprehensive medium for communicating with the population (ACMA 2009). There are, however, significant challenges in identifying a centralised database of email addresses that provides a sampling frame.

Online survey methods have the potential to reduce survey costs if an appropriate sampling frame can be determined and properly implemented. However, if poorly implemented they are likely to produce inaccurate and biased data.

Frequency of respondent contact; one-off, multiple or panel survey

The regularity of respondent contact in off-site surveys depends on the project objectives and the survey budget. In some cases a single phone interview may be sufficient, for example a one-off attitudinal survey. Panel surveys are designed to have a degree of regular contact with the same respondents over a period of time (Kasprzyk et al. 1989; Jones and Pollock 2012). This method has the advantage of providing a more efficient estimate of change over time, as there is no cost to identify new fishers. The respondents can be trained about the data they are providing, ultimately leading to more reliable data. Respondents can also be provided with simple diaries to record fishing events, so that they have information to jog their memory during interviews. The regularity of interviews can be based on the activity of the respondent, with active fishers being contacted more regularly and vice versa. The use of diaries and responsive interview rates can reduce recall bias. A potential disadvantage of panel surveys is the increased respondent burden, as the fisher is participating multiple times over the survey duration. This can negatively affect response rates and potentially lead to response bias, but this can be minimised by the interviewer.

Telephone-diary panel surveys have been used, and found to be effective, for collecting robust recreational fishing catch and effort information in Australia and elsewhere. Examples include the National Recreational and Indigenous Fishing Survey (NRIFS; Henry and Lyle 2003), which was the first (and only) comprehensive study assessing recreational fishing across Australia. The methods implemented in the NRIFS have since been replicated to provide catch and effort estimates at a jurisdictional level in Tasmania (Lyle et al. 2014), Victoria (Ryan et al. 2009), Northern Territory (West et al. 2012), Western Australia (Ryan et al. 2013) and South Australia (Jones 2009). Georgeson et al. (2015) have been developing an approach to implementing national recreational fishing surveys, building on the NRIFS and state-based surveys. In addition, the method was employed successfully in Tasmania, using a boat registration sample frame to provide estimates of SBT, as well as other key species, harvest, effort and release rates from the recreational sector (Tracey et al. 2013).

Respondent driven surveys

Respondent-driven sampling—a modified form of snowball sampling—is a peer-referral sampling method that has been used in epidemiology and social sciences to survey hard-to-reach populations (Heckathorn 1997). It has been proposed that this technique has potential for sampling specialised recreational fisheries (e.g. game fishing) where strong social networks often exist among participants (Griffiths 2011). However, the method is currently being tested and is not ready for wider implementation at this stage. Whether such approaches deliver representative data remains to be determined.

Off-site survey sampling frames

White Pages® directory

The NRIFS (Henry and Lyle 2003) and subsequent state-based recreational fishing surveys have utilised the Australian White Pages® directory. It assumes that all households in Australia, where a recreational fisher resides, had a contact number listed in this directory. While this is a very broad sample frame it was appropriate to the resolution and the objectives of those surveys. However, this framework led to significant imprecision of catch and effort estimates for some target species (‘niche’ species) or fisheries with low participation rates, such as SBT. For example, of the estimated 136 million aquatic animals reported as

harvested during the NRIFS, only 232 000 tuna (all species) and 76 SBT were reported as captured during the survey (0.00005 per cent of 136 million) (Henry and Lyle 2003). Extrapolation of these rare events leads to large relative standard errors that limit the usefulness of these data. This estimate contrasts with more recent dedicated surveys of Victoria (26 600 individual SBT caught by recreational fishers in 2011) (Green et al. 2012) and Tasmania (95% CI: 557 SBT in 2008); (95% CI: 5368 SBT in 2012) (Forbes et al. 2009, Tracey et al. 2013). This suggests that more targeted sampling frames are required to adequately capture low frequency events like recreational fishing for SBT.

Licence or permit frames

Sampling frames based on recreational fishing licences are particularly effective at targeting respondents because the purchase of a licence indicates an intent to participate, and in the case of specific permits, fish within a targeted fishery. Boat registrations and boat drivers' licences also have the potential to provide a more targeted sampling frame, given SBT fishing is almost exclusively boat based.

General recreational fishing licences

General recreational fishing licences provide a framework that is more targeted than a broad sampling frame such as the White Pages® directory. However, in the case of a niche sector such as fishing for SBT, the frequency of SBT anglers is likely to be extremely low among all fishing activities. Hence, reduced precision or elevated sampling costs would need to be considered if a general fishing licence frame was used to survey SBT fishers.

General recreational fishing licences are currently only required in Victoria and New South Wales and in both states some exemptions apply. Exemptions are typically given to people under the age of 18, people fishing in private waters, Aboriginal or Torres Strait Islander people and concession card holders. The impact of the exemptions on the representativeness of a licence database as a sampling frame is not known. The absence of a general recreational fishing licence in other states where SBT are caught means they do not provide a national sampling frame. However, an off-site survey could be developed for New South Wales and Victoria using the recreational fishing licence sampling frame, but the impacts of exceptions on sampling completeness would need to be determined before adoption.

Boat-based fishing licence

Given that recreational fishing for SBT occurs almost exclusively from boats, a boat-based fishing licence can provide a targeted and appropriate sampling frame. Exemptions may also affect the representativeness of this sampling frame and would need to be assessed before utilisation. Currently Western Australia is the only state that applies a boat-based fishing licence. This is used as the sampling frame for Western Australia's regular recreational boat-based fishing surveys (Ryan et al. 2013).

Vessel registration or boat driver licences

An alternative sampling frame could be based on recreational vessel registration databases or boat driver licences. Vessel registrations commonly distinguish between private and charter vessels. Tracey et al. (2013) used the Tasmanian vessel registration database as a sampling frame for an off-site survey targeting recreational game fishing, including SBT. Exemptions to vessel registrations are not likely to be a major factor for SBT fishing as these are generally based on the horsepower of the engine fitted to the boat (Tracey et al. 2013). Small vessels that may be exempt, such as those with less than 5 horsepower, are unlikely to be used to fish for SBT in the open ocean.

Fishing sector or gear specific licence (permit)

Fishing sector or gear-specific licences can also provide robust sampling frames if they encompasses the sector or gear type with which the target species is caught. These frameworks are likely to be most effective if the gear is not broadly used across a range of target species. This sampling frame has been used in phone–diary surveys to assess particular capture methods including passive set-lines (Lyle and Tracey 2012a) and

gill-nets (Lyle and Tracey 2012b) that have permit requirements. There are currently no gear based permit requirements relevant to SBT recreational fishing.

Species-specific fishing licence (permit)

For low participation niche fisheries, the most cost-effective sampling frame would be one associated with a species-specific fishing licence. Currently, there is no specific license or permit requirement for the recreational catch of SBT in any state. Where species-specific licences have been used they enable off-site sampling to be targeted directly to the species of interest and provide comprehensive coverage. This form of sampling frame has been used in off-site phone–diary surveys to assess recreational catch and effort for important niche species. For instance, Tasmania undertakes bi-annual, off-site phone–diary surveys to assess the recreational catch and effort of high value species including southern rock lobster and abalone, which require species-specific recreational fishing licence endorsements (Lyle and Tracey 2014 and reference therein). Recreational fishing for southern rock lobster in Western Australia requires a fishing licence and targeted mail-out surveys are conducted using the license database as the sampling frame (Melville-Smith and Anderton 2000).

A related approach can be taken if there is a recreational fishing tag system for species, where fishers are required to purchase tags and attach these to any fish harvested. Western Australia applies a management tag system for the recreational capture of pink snapper in Shark Bay (Department of Fisheries, Western Australia, 2013). This is complemented by a telephone survey where fishers who have purchased tags are contacted at the end of the season to determine if they used the tags they purchased. This method provides a high degree of confidence in the harvest estimate, assuming there is high compliance with tag use.

The United States provide another example of these types of approaches. Recreational fishers require permits to target highly migratory species (NOAA n.d.). The permit scheme requires all landings and dead discards of Atlantic bluefin tuna caught by recreational fishers to be reported to national or state (in Maryland and North Carolina) reporting services. There are also requirements for anglers to participate in the Large Pelagic Survey (LPS) and the Marine Recreational Information Program (MRIP) should they be contacted. The NOAA HMS permit scheme is reported to provide real time estimates of landings and discards (NOAA n.d.).

Another example is the New South Wales Game Hunting Licence, where hunters are required to purchase a permit to hunt on public land. An online database processes licence payments. There is a requirement to book hunting trips in advance and to report game sighted and taken from the location within a predetermined time. This information is recorded through an online survey portal. It provides New South Wales with real-time data on feral animal sightings and removals from public lands (New South Wales Department of Primary Industries n.d.).

On-site surveys

On-site surveys have been used extensively to assess the catch and effort of recreational fishers in Australia (Green et al. 2012; Tracey et al. 2013) and internationally (Dunlop and Mann 2012; Llompart et al. 2012). On-site angler surveys are typically used to assess catch and effort of a particular area or of a type of fishing activity. They are often labour intensive and depending on the number of locations and temporal coverage required can be costly to undertake and complex to roll out over large areas. One advantage is that they allow for the direct counting and measurement of landed fish that can be used to estimate weights (Jones and Pollock 2012).

Access point surveys

Access point surveys are conducted at defined access points for the fishery; typically, this is at boat ramps, marinas and public jetties. This captures activity at a central point and allows a census or sample of anglers using these areas (Pollock et al. 1994).This approach works well when anglers are concentrated at focal points. This substantially reduces screening costs and typically provides greater coverage of fishing activity. As the number of access points increase or access becomes more diffuse this approach is less applicable. On-

site surveys have been used to estimate SBT catch in Victoria, where there are relatively few access points (Green et al. 2012). A comparison of on-site access point and off-site surveys has been used in Tasmania to sample SBT recreational fishing (Tracey et al. 2013).

A ‘bus route survey’ (Robson and Jones 1989) is a modified access point survey for covering larger areas with fewer interviewers. A bus route survey follows a particular route and surveys anglers at multiple access points along the route, rather than limiting the survey to a single access point. A bus route style survey was combined with standard access point survey to sample locations in Victoria for SBT fishing (Green et al. 2012).

Roving creel survey

Roving creel surveys are an on-site survey method used when recreational fishing effort is more diffuse. Roving surveys can be conducted by car, boat or on foot and involve sampling along a predetermined route. Roving surveys have unique properties in that anglers are often intercepted before the completion of their fishing trip. This affects the probability of the angler being intercepted compared to access point surveys (including bus route surveys). Roving creel surveys are not likely to be effective for assessing offshore or game fishing activities.

On-site survey sampling design

Like off-site surveys, on-site surveys rely on having an appropriate sampling frame. A spatio-temporal sample frame is used for on-site surveys. The frame uses periods of time available for fishing and all access points for the fishery. Decisions need to be made regarding the time period the sampling will be conducted over (e.g. fishing season, calendar year) and what sampling units are appropriate (e.g. entire day or part day, boat or individual angler). Sampling times and locations are randomly determined and surveys are conducted according to probabilistic based sampling requirements. This allows for robust estimates of catch and effort with limited sampling bias. The random sample design can be weighted by known strata to increase precision.

Given the large spatial and temporal differences in availability and access to SBT around Australia any on-site surveys of recreational catch will need to be at an appropriate scale to accommodate this variation. It is likely that the most useful implementation scale is at the state level, with stratification of access points within states. Providing on-site surveys are based on probability based sampling it will be possible to derive a national estimate based on summing the estimates from each jurisdiction.

Chapter 4 Previous recreational fishing surveys for Southern Bluefin Tuna & key gaps

Since the National Recreational and Indigenous Fishing Survey (Henry and Lyle 2003), several states and the Northern Territory have conducted regional or statewide surveys to meet their information needs and obligations under their legislation and policy. These are reviewed in Georgeson et al. (2015). These general surveys aim to provide an overview of recreational catch and effort across the states and robust data for key species. The broad nature of these surveys leads to imprecise estimates for niche species, such as SBT. While SBT catch may be recorded, it is often reported as part of general 'tuna', which also includes other tuna species.

Western Australia

Western Australia undertakes an off-site, boat-based angler survey every two years. These are conducted using a Recreational Fishing from Boat Licence as a sampling frame. The survey includes three complementary components: (i) off-site phone surveys (12 month phone dairy survey, wash-up survey and non intending fisher and benchmark surveys); (ii) on-site boat-ramp surveys (including a validation survey); and (iii) a remote camera survey (Ryan et al. 2013). As a result of this comprehensive sampling strategy these surveys are likely to provide robust estimates of SBT catch. The standard errors that are supplied with the estimates of catch provide a measure of the level of accuracy of the estimates. The most recent estimates of SBT catch in Western Australia had acceptable standard errors for surveys of this type (Ryan et al. 2013).

Tasmania

The first targeted on-site creel survey to assess game fishing catch in Tasmania, with a particular focus on SBT, was conducted in 2003 (Morton and Lyle 2003). This survey was limited to the one boat ramp at Pirates Bay on the Tasman Peninsula (Figure 2), which at the time was the main access point to the areas traditionally fished by anglers targeting SBT on the Tasman Peninsula. This survey was supplemented with information from angler diaries distributed amongst fishers affiliated with registered game fishing clubs and voluntary charter boat logbooks.

No SBT were caught during the on-site survey over the survey's two-month duration. However, catches prior to the survey were reported and some information on catch was provided via angler diaries and charter boat logbooks. A minimum estimate of approximately 2.5 tonnes of SBT was reported for the 2003 season. Interviews with fishers during the creel survey enabled inferences to be made about SBT catches in the 2002 season, which appeared to be approximately 10 times greater than catch in 2003. These interviews drew attention to the development of recreational fishing targeting SBT along the south coast of Tasmania with approximately 70 per cent of the catch reported in 2003 taken from this area. Morton and Lyle (2003) identified that any ongoing monitoring of the game fish sector will need to take account of the inherent spatial and temporal variability in the availability of SBT in relation to survey design.

In 2008 a second onsite creel survey was conducted to assess recreational game fishing catch, with a focus on SBT (Forbes et al. 2009). Similar to the 2003 study this survey was focused on the Tasman Peninsula, but with the addition of a survey location for access to the south coast of Tasmania. The survey was constrained to one boat ramp in each region. On the Tasman Peninsula, Pirates Bay boat ramp was again selected as it was identified as having the highest use in the area. It was noted that several other boat ramps in the area were also likely to be used by fishers targeting SBT. Southport boat ramp (Figure 2) was selected as the main access point for fishers launching to target SBT on the south coast. There are, however, several other boat ramps in the area that are intermittently used. A voluntary Charter Boat Logbook program was also initiated to provide information on catches of game fish from this sector. Not all operators agreed to participate.

Given the limitations in survey coverage, only a minimum catch estimate was presented, equating to a total retained SBT catch of 14.0 tonnes (95 per cent confidence interval (CI) = 10.6–17.7 tonnes).

In November 2011 a study was implemented to assess offshore recreational fishing in Tasmania and to provide information on a number of key niche recreational species including SBT (Tracey et al. 2013). The study involved multiple survey methodologies, including an onsite creel survey during March to July 2012 at the Pirates Bay and Southport boat ramps as well as an offsite phone–diary panel survey that ran for 12 months and overlapped with the onsite survey period. By running the two independent survey methods concurrently it was possible to compare methods and results. Charter boat catches of SBT were also monitored during 2012 with all charter operators who target game fish species agreeing to participate in a voluntary logbook program.

The off-site survey was based on a sample frame of registered recreational vessels in Tasmania, as fishers would need a vessel to access the offshore waters where SBT are caught. Marine and Safety Tasmania (MAST) provided access to the vessel registration database with a caveat that, because of privacy laws, the respondents were initially contacted on behalf of MAST to seek approval for the release of their contact information for use in the study.

The off-site survey population was truncated to exclude vessels considered too small for offshore fishing as well as to remove vessels considered out of scope (e.g. yachts and personal water craft). A stratified random sample of vessels was selected with a total of 1431 owners of powered recreational vessels over 4.5 metres in length participating in a screening survey. A third of respondents indicated that they would be at least quite likely to use their boat for game or offshore fishing in the next 12 months. Of these, 92 per cent agreed to participate in the diary survey, with 88 per cent completing the 12-month panel survey component of the study. Almost two-thirds of these respondents subsequently reported some form of game or offshore fishing using their vessel. Catch and effort information reported by respondents was estimated with bootstrapped confidence intervals to represent the offshore fishing activity of all private powered vessels over 4.5 metres using the known proportion of surveyed vessels to the total number of vessel registrations in Tasmania.

Trolling for game fish occurred between December and June, with effort (days fished) peaking in February and April; the February peak corresponded to effort targeted at albacore and the April peak to effort targeting SBT. Trolling activity was reported exclusively off the east, south east and south coasts of Tasmania.

Skipjack tuna were the most commonly caught tuna species by trolling from private recreational vessels during the 2012 game fishing season, with a total 11 955 fish (95 per cent CI: 7616–16 993), of which 68 per cent were released. Albacore were the most commonly retained tuna species, with 8290 albacore kept (95 per cent CI: 6049–10 768) and a further 1406 (14 per cent of total numbers) released. The retained catch of SBT, by number, was the lowest of the three species at 3243 fish, but it was the largest catch by weight (59.9 t). In addition to the harvested (retained) component, a further 1035 SBT were released (24 per cent of total numbers). With the inclusion of SBT recorded as taken by the charter boat sector, the combined estimated harvest of SBT for the recreational sector was 75.8 t for the 2012 game fishing season. In addition 24.9 t of SBT were reported as lost to seals (assuming 100 per cent mortality) prior to landing.

The on-site creel survey, conducted 834 interviews at the two target boat ramps. The estimated number of SBT caught and retained on fishing trips originating from these two boat ramps was 1283 fish; a further 501 were estimated to have been released and 605 lost to seals. The estimated weight of SBT caught and retained on fishing trips originating from the two target boat ramps was 21.4 t. Fish lost to seals during the capture process (not landed) accounted for a further 9.9 t or 32 per cent of combined mortality attributed to recreational fishing activity.

As expected, the creel survey estimate of total catch (21.4 t) was significantly lower than the telephone–diary survey estimate (59.9 t) due to only two main points of access for SBT fishing being surveyed. Trips originating from these two ramps however, accounted for 39 per cent of the total SBT catch reported to the off-site telephone–diary survey.

The comparison of the on-site and off-site surveys results, demonstrates the appropriateness, and subsequently the cost-effectiveness of the off-site approach in Tasmania, given the numerous and diffuse access points. A comparison of the catch estimates from the two independent survey methods for trips originating from Pirates Bay provides validation of the off-site method in estimating catch. Although catch estimates (retained, released and lost to seals) were lower for the diary survey, these differences were not statistically significant (Tracey et al. 2013).

Victoria

On-site surveys were conducted over the period February to July 2011 at four key SBT locations in south western Victoria: Portland, Port Fairy, Warrnambool and Apollo Bay (Green et al. 2012). All ports were stratified into weekend and weekday survey days. The sampling frame was stratified into two weekend days and five weekdays from each week in each month for the survey period. Public holidays were treated as weekend days. Sampling days were randomly apportioned to two of the five weekdays per five day week, with equal probability and without replacement. Sampling days at Portland, Warrnambool and Port Fairy were split into half days. There was a total of 179 on-site survey days.

A two stage stratified random access design was used at Portland, with days used as the primary sampling unit and early and late shifts were secondary sampling units. A modified bus route design was used at Port Fairy and Warrnambool. A stratified random access without secondary sampling was used for Apollo Bay.

Creel clerks measured avidity, home postcode, target species, fishing area, species caught, fishing methods, length of retained SBT, gear used, number of SBT retained or released, age of the angler, reason for release and effort.

The estimated number of fishing trips targeting SBT between March and July was 6184 (± 749 standard error (s.e.)). Portland accounted for 83 per cent of all recreational fishing effort and April was the most popular month with 43 per cent of total effort.

The estimated total retained catch of SBT for March to April was 19 737 fish (± 2796 s.e.), with 90 per cent taken off Portland. The highest SBT catches came in May (8504 fish) and April (7408 fish). Total estimated weight for the retained SBT catch, not including charter vessel catch, was 243 t (± 30.7 t s.e.).

The total number of released SBT was 6942 (± 1483 s.e.), with Portland anglers releasing 25 per cent of the SBT catch and 31 per cent in Port Fairy and Warrnambool. There were no SBT released in Apollo Bay. Most SBT were released (79 per cent) as a result of exceeding bag limits, with 11 per cent excess to needs.

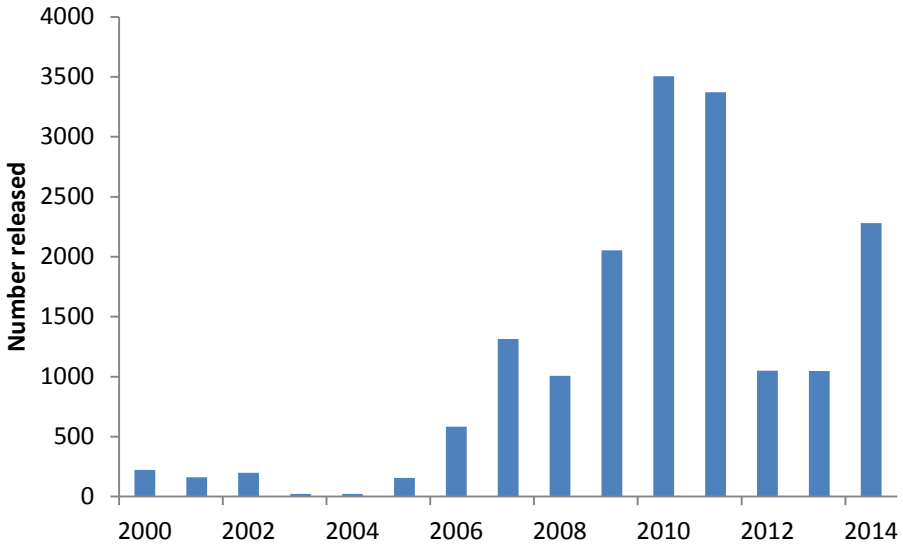
Further bootstrap analysis of the 2011 results (Appendix C) suggested that the survey had very good sampling coverage. Testing various levels of sampling coverage indicated that sampling coverage could be reduced by 20 per cent while maintaining similar estimates and standard errors.

Game fish tagging programs

The NSW DPI Game Fish Tagging Program collects data on game fish tag releases around Australia. We obtained records on the reported SBT tag releases from 2000 to 2014 (Figure 4 & 5). There were 16 990 SBT tag releases for the period, with the number of reported releases increasing from 23 releases in 2004 to a peak of 3503 in 2010 (a 150 fold increase over a six year period) and thereafter decreasing to 2281 in 2014. It is unclear whether these data are indicative of wider trends in recreational targeting of SBT, a move to tag and release fishing for SBT, or changes in availability of SBT or combinations of these factors.

The number of SBT released per state varied considerably, with the highest proportion of releases occurring in South Australia every year between 2000 and 2014 (Figures 6, 7 & 8). Tasmania was the next highest proportion in nine years out of 15 years, followed by Western Australia with eight out of 15 years and then Victoria and New South Wales.

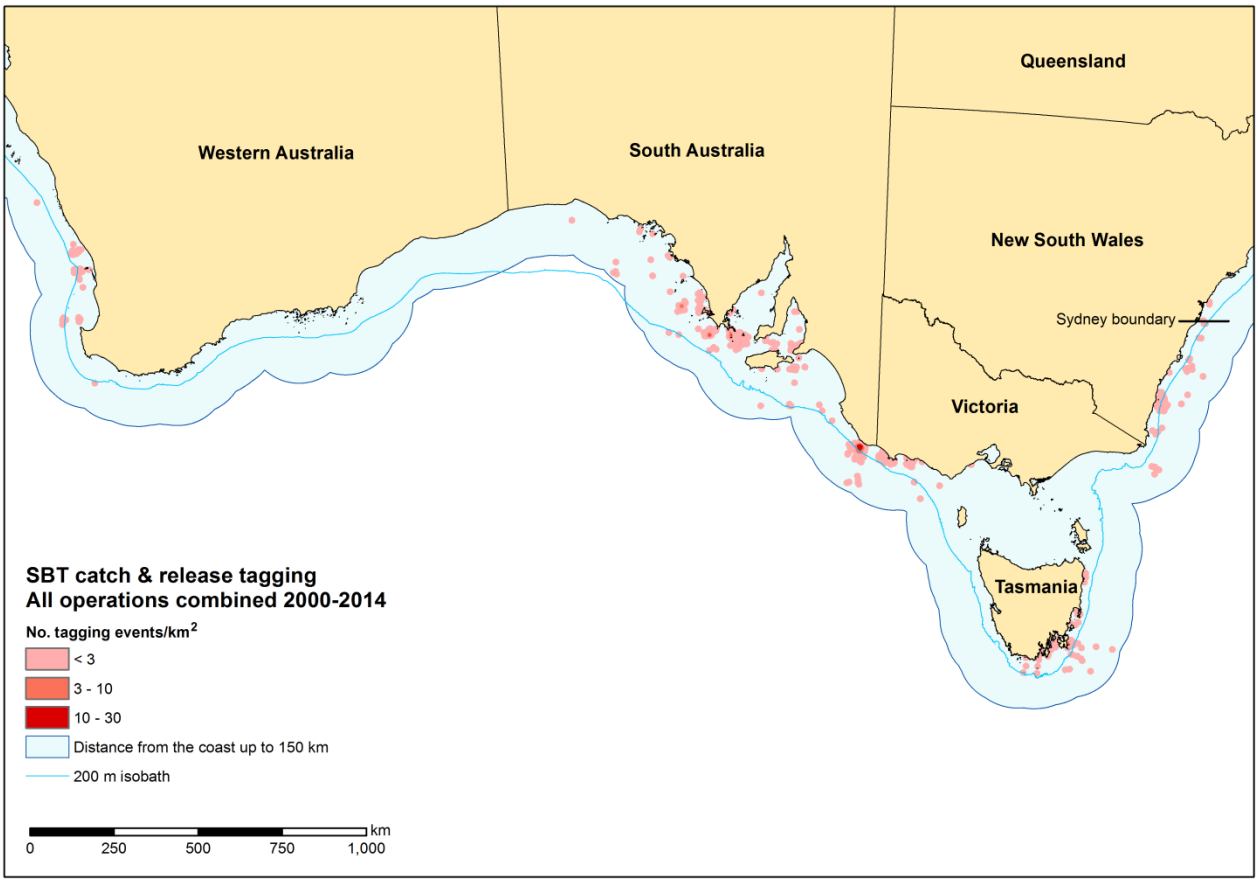
Figure 4 Annual number of SBT reported tagged and released around Australia 2000–14



Source: NSW DPI Game Fish Tagging Program

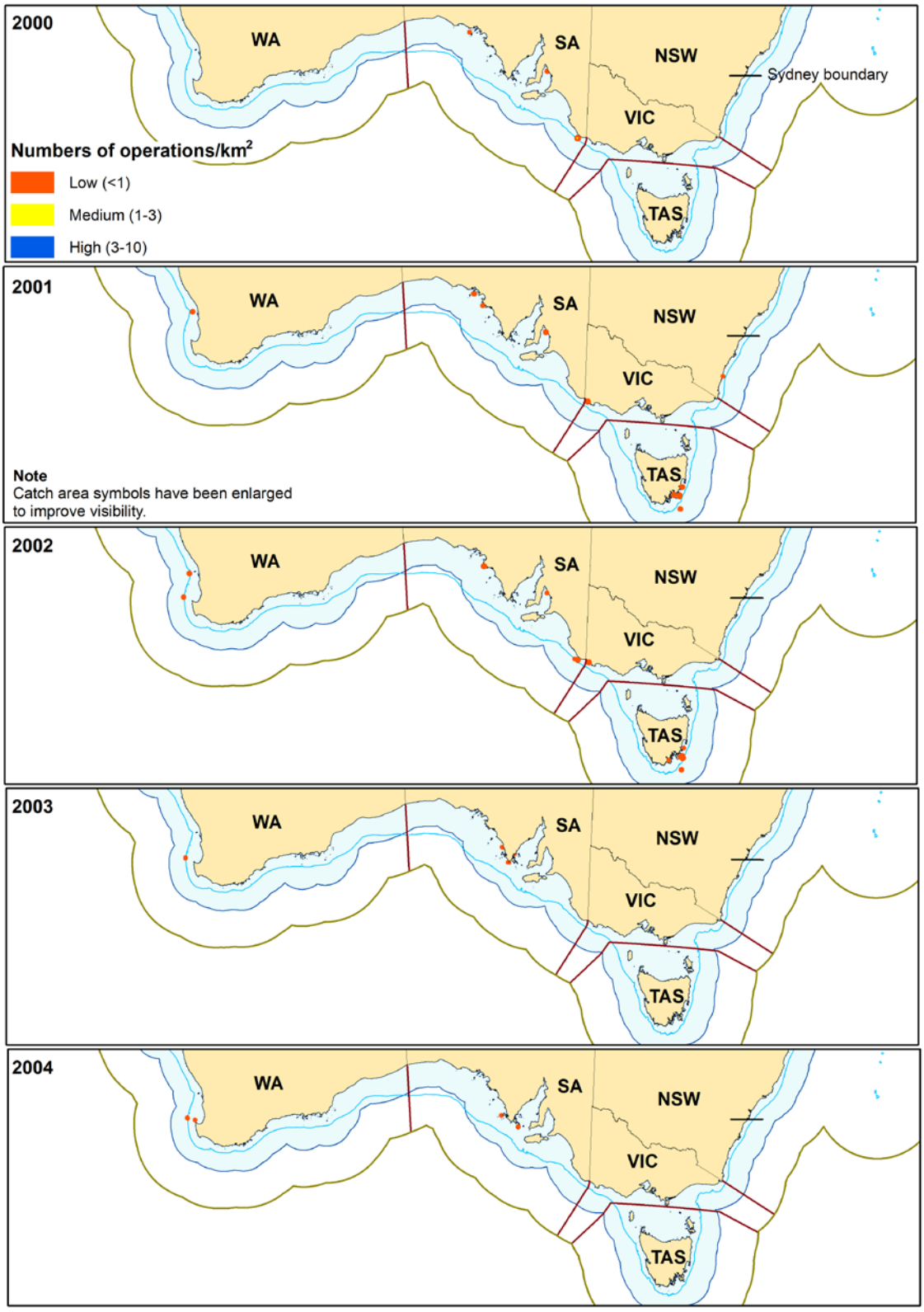
Voluntary tagging programs have the potential to provide information on broad-scale fish movement, growth and longevity and encourage responsible fishing practices amongst anglers. However, existing tag-release data are unlikely to be a useful indicator of SBT catches for a regular catch-estimation program. This is because tagging is influenced by various factors, including angler attitudes and behaviour, the condition of fish, the availability of tags and management measures (e.g. bag limits) in relation to fish size and catch rates. These factors are not well understood for the historic data and due to the complexity it would be difficult to develop a robust index of catch levels based on tag-release data.

Figure 5 Distribution of reported tag releases of SBT in Australia 2000–14



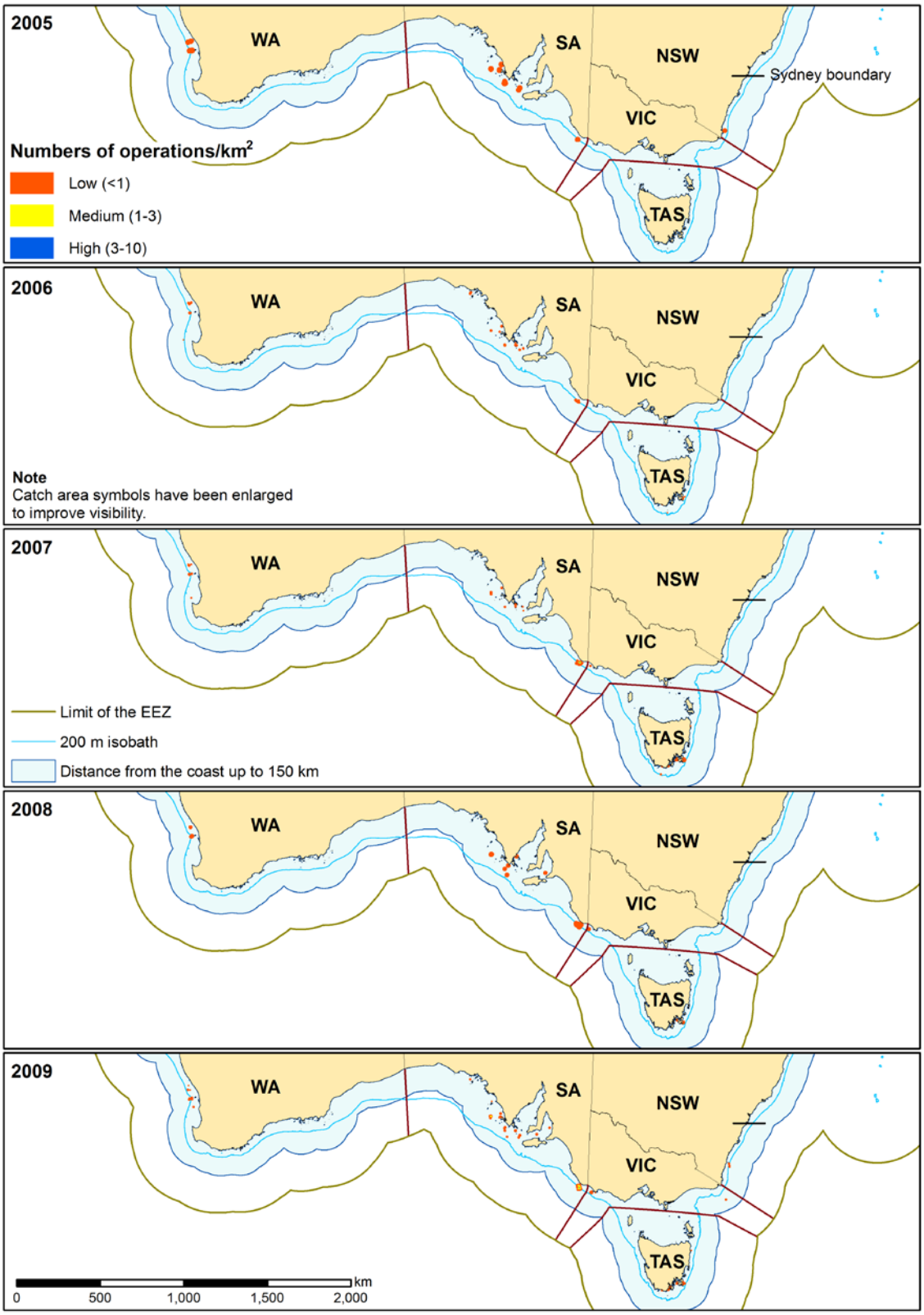
Source: NSW DPI Game Fish Tagging Program

Figure 6 Distribution of reported SBT tag releases from recreational fishing 2000–04



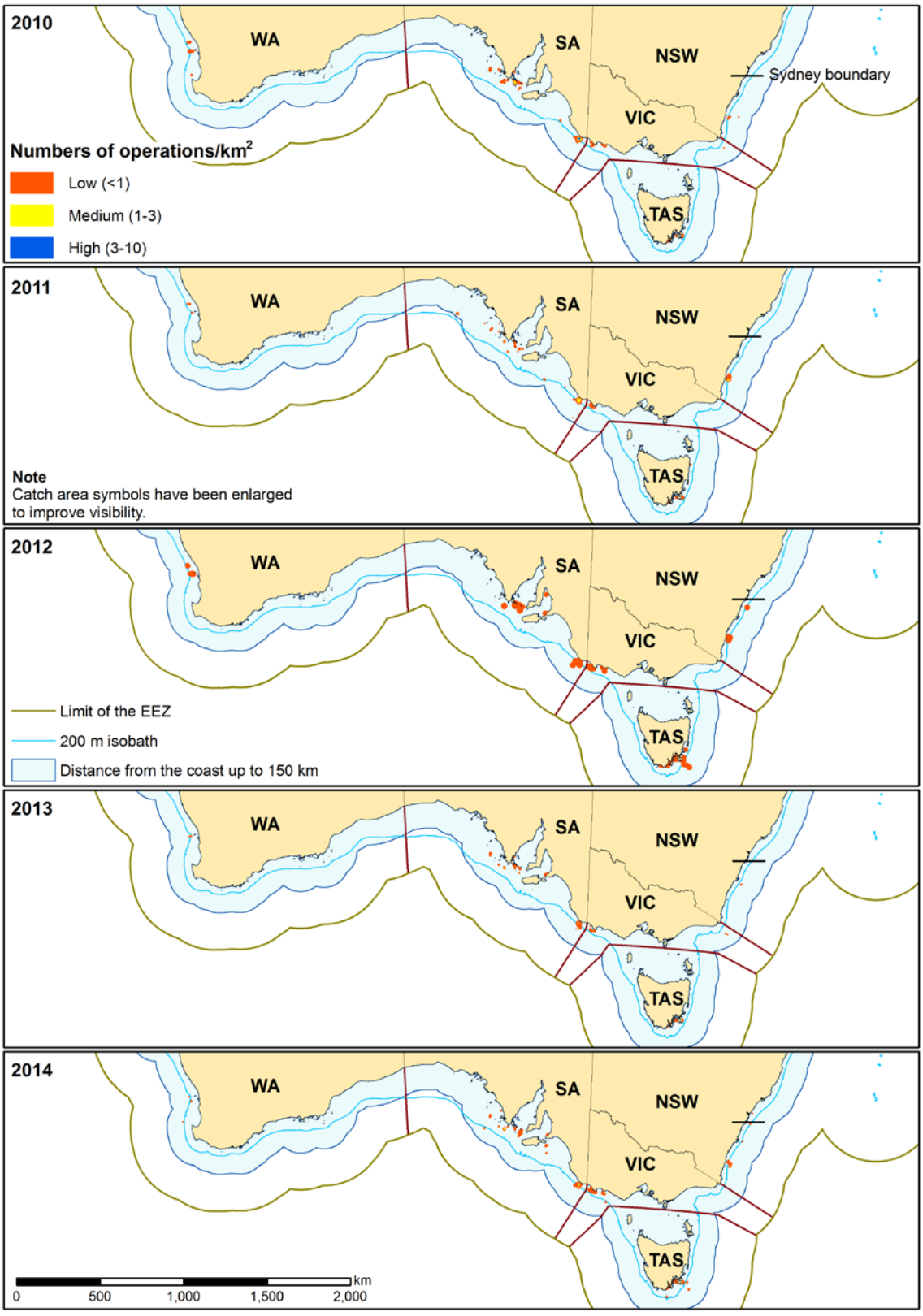
Source: NSW DPI Game Fish Tagging Program

Figure 7 Distribution of reported SBT tag releases from recreational fishing 2005–09



Source: NSW DPI Game Fish Tagging Program

Figure 8 Distribution of reported SBT tag releases from recreational fishing 2010–14



Source: NSW DPI Game Fish Tagging Program

Charter boat logbook programs

Marine and estuarine charter boat operations range from dedicated game-fishing charters to general fishing charters that occasionally target game fish, as well as dive charters and various eco-tourism and sightseeing activities, including whale watching. Charter boats range in size from small trailer boats (commonly used in Victoria) to large cruisers (more common in Queensland).

Charter boat fishing offers recreational fishers an increased probability of success across a range of fishing types and species through the guidance of experienced operators, often using sophisticated fish location technology and a fishing platform that can access fishing grounds not normally available to small boats. Clients include domestic and international tourists, tournament game fishers and general recreational anglers. A charter boat fishing trip may vary from a few hours (enabling a charter fishing operator to conduct multiple charter trips in one day) to several days, where passengers may stay on board the charter boat and fish caught during the trip are refrigerated on board the boat. A new development is 'guided fishing' whereby experienced operators are hired, and guide on privately owned recreational boats (PFIGGA n.d.).

The charter sector caters to many game fishers (Ward et al. 2012a). In some states, licensing is mandatory for boats that accept paying customers. However, jurisdictions vary in the classification of the types of charter operations and information that operators must provide (e.g. fishing versus sightseeing) (DAFF 2000). Charter boat licensing, and compulsory logbook reporting of catch and effort does not currently exist in Victoria or Tasmania.

Some operations move between states and might be double-counted in state logbook and licensing databases. It should also be noted that many charter fishing boats operate on a seasonal or part-time basis, and some businesses may operate more than one vessel (Ward et al. 2012a).

A review of charter operations in South Australia, New South Wales, Tasmania, Victoria and Western Australia (Appendix B) indicates that there are compulsory charter logbook programs in South Australia, New South Wales and Western Australia. A voluntary logbook system has been trialled in Tasmania (Forbes et al. 2009; Tracey et al. 2013) and a voluntary trial was conducted in Victoria as part of this project (Chapter 5).

Game fishing tournaments

Some game fishers are members of fishing clubs (West 1990), which organise fishing tournaments, competitions and other club activities. There are four primary bodies relevant to the organised component of game fishing in Australia:

- Game Fishing Association of Australia (GFAA)
- Australian National Sportfishing Association (ANSA)
- Australian Anglers Association (AAA)
- Fishing Clubs Association (FCA).

Based on a postal survey of eastern Australian fishing clubs in 1988–89, West (1990) estimated that GFAA clubs accounted the highest proportion of club catches, with ANSA clubs the next highest. However club fishers are likely to only represent a small proportion of total recreational SBT catch. It is not known how these ratios for club-based activities may have changed in subsequent years. The AAA and FCA clubs are often smaller scale, tend to be less competitive than GFAA and ANSA clubs and rarely involve game fishing.

In 2014, there were 5317 GFAA and 2044 ANSA members in New South Wales, Victoria, Tasmania, South Australia and Western Australia (Table 2). The clubs affiliated with the GFAA and ANSA organise a variety of tournaments, competitions and informal events that target a broad range of marine game fish species or species groups. However, many of the tournaments are run in the early months of each year, outside the SBT season and are therefore unlikely to encounter SBT.

Table 2 Membership of Game Fishing Association of Australia (GFAA) and Australian National Sportfishing Association (ANSA) affiliated clubs in states where recreational fishing for SBT occurs

State	GFAA Members (2014)	ANSA Members (2014–15)
New South Wales	3174	1135
Victoria	491	404
Tasmania	354	27
South Australia	338	124
Western Australia	960	354
Total	5317	2044

Note: The GFAA Member Database is limited to members who opt to receive the GFAA journal. There may only be one subscription for households with multiple GFAA members.
Source: GFAA Member database (B. Cleary, pers. comm. 2015), ANSA database (J. Garufi, pers. comm. 2015).

The GFAA maintains lists of species for point-scoring in tournaments and for the recognition of records, including SBT (GFAA 2011). The ANSA has a broader range of point-scoring species; fishers involved in ANSA tournaments may target large game fish and also other marine species (e.g. dusky flathead) and freshwater species (ANSA 2011).

The small proportion of fishing club members (and even smaller proportion of game fishers) in the wider angler population presents challenges for obtaining representative data on the game-fisher population and their activities through on-site and off-site surveys. The National Recreational and Indigenous Fishing Survey indicated that while an estimated 19.5 per cent of the Australian population participates in recreational fishing, only 4.3 per cent of those that fish hold club or association memberships and only 10.7 per cent of those members were members of game fishing clubs (Henry and Lyle 2003). Importantly for on-site survey purposes, game fishing club membership rates also vary depending on survey sites and timing (Forbes et al. 2009; Tracey et al. 2013). Surveys of boat ramps in southern Tasmania (outside of tournaments) suggest approximately 12–20 per cent of fishers actively targeting SBT report game fishing club membership, whereas surveys on tournament weekends found 86-90 per cent of game fishers were members of game fishing clubs (Forbes et al. 2009; Tracey et al. 2013). Moreover, the demographics and avidity profiles of game fishing club members likely vary from the wider game fishing community. It is therefore necessary to examine the game fishing community as a whole and not rely on membership databases.

Tournaments

Over 60 GFAA-affiliated tournaments are held each year in eastern Australia, mostly between the New South Wales towns of Eden and Port Stephens and in south-eastern Queensland. These two concentrations of game fishing tournaments align with the major population centres of Sydney and Brisbane, and are in close proximity to the edge of the continental shelf where game fish tend to concentrate. By contrast, there are few game-fishing tournaments around Melbourne because game fish species are rarely encountered in the relatively shallow, cold waters of Bass Strait. The ANSA also support several major fishing tournaments, which target a variety of species, including key game fishing species.

Most tournaments are held over several days at about the same time each year, coinciding with weekends and public holidays. Game-fishing tournaments are currently held in most eastern Australia coastal cities as well as 16 regional centres. Multiple game-fishing tournaments are held each year at several centres (e.g. three tournaments are held each year at Bermagui: the Blue Water Classic, Tag and Release and Annual Yellowfin). However, few of these tournaments feature SBT as a primary target species.

The New South Wales Department of Primary Industries (NSW DPI) has run the Gamefish Tournament Monitoring Program since the early 1990s (Park 2007; Ghosn 2012). The program utilises tournament radio schedules, interviews and boat ramp surveys. All game-fishing tournaments conduct radio schedules that record the location, number of anglers and catch of participating boats at regular intervals during tournament fishing days. The NSW DPI program also involves on-site boat ramp surveys that directly observe catch and collect detail information on fishing practices and gear for particular species of interest.

Participation levels in tournaments range from fewer than ten boats or 40 participants to several hundred boats and over 700 participants. Participation levels vary from year to year, with local weather conditions, abundance of game fish, prizes and tradition being important determining factors. An average of 41 boats participated in game-fishing tournaments monitored by NSW DPI in 2010, with an average of 4.3 persons per boat (Table 3).

Table 3 Summary statistics for game fishing tournaments monitored by the New South Wales Game Fish Tournament Monitoring Program, 2010

Year	Tournament days	Average boats per day	Total boat days	Average persons per boat	Total person days
2010	62	41	2569	4.3	10 977

Note: these data do not cover all game fishing tournaments held in New South Wales in 2010; for example, a Victorian club is known to have held at least one game fishing event in NSW in 2010. Several other game fishing tournaments were cancelled because of bad weather in 2010.
Source: NSW Game Fish Tournament Monitoring Program.

Community based monitoring

In Australia, community based monitoring programs have provided useful qualitative information, including early warning systems in relation to environmental change (Spellerberg 2005). However, there are limitations regarding the interpretation of data obtained through community based monitoring (Stenekes and Sahlqvist 2011). In the context of recreational fishing for SBT, the low-frequency nature of SBT encounters and high levels of inter-annual variation in SBT movements are likely to mean that traditional approaches to community based monitoring are unlikely to provide robust estimates of SBT catch or effort, particularly as they do not utilise appropriate sample frames for probabilistic sampling. However, as a potential indicator of fishing activity at specific locations community monitoring may be a useful tool for guiding on-site survey design.

Many game fishing clubs provide fishing reports and networking possibilities to members and the public through their websites or social media pages. The proliferation of social media outlets has led to fishing clubs shifting away from dedicated web pages towards relying on easily curated pages provided by services, such as Facebook. As such, some dedicated fishing club websites can be poorly maintained or infrequently updated; with more up-to-date information often available through social media.

In addition to formal game fishing clubs, there is a growing knowledge base associated with online discussion boards and fishing blogs. These sites can provide early notification of the seasonal arrival of SBT and anecdotal discussions regarding access to, prevalence and size of fish over time. Furthermore, these sites may contain valuable discussions regarding impending game fishing tournaments, which may in turn be used in the planning of on-site surveys. The value of these sources will depend on how long the discussion boards have been active, how actively users contribute to discussions (potential bias) and the quality of discussions

(for example, it will be difficult to get data on the size of fish caught as reporting bias may be strong). These online outlets provide easy communication and networking possibilities for avid fishers and may play a role in the rapid activation of fishing of effort as word spreads of fishing conditions. Fishing discussion boards vary greatly in their relevance and accessibility in relation to fishing reports. While some boards are easily accessible, some post information behind member logins and pay-walls, limiting access to information potentially relevant to this study.

Key gaps in developing a national estimate of SBT recreational catch

The review of recreational fishing survey approaches, previous surveys and information sources for recreational catch of SBT and discussions at two technical workshops (Ward et al. 2012b; Hall et al. 2013) identified current approaches that could contribute to obtaining a national estimate. These approaches have been shown to work in particular states or regions and will provide robust estimates that could be combined with estimates from other regions. In Western Australia, the regular biennial boat-based angler surveys (Ryan et al. 2013) provide robust estimates of catch and the recent surveys in Victoria (Green et al. 2012) and Tasmania (Forbes et al. 2009; Tracey et al. 2013) demonstrate that appropriate survey options are available for those jurisdictions (Table 4).

The key information gaps or areas that needed further exploration and testing are highlighted in Table 4.

The analyses of key gaps identified that:

1) there are suitable off-site sampling frames for estimating annual recreational catch of SBT in Western Australia, Tasmania, New South Wales and Victoria. These have been cost-effectively used to estimate SBT recreational catch in Western Australia and Tasmania. They have not been used for estimating SBT recreational catch in New South Wales or Victoria.

2) an on-site sampling methodology has been applied in Victoria and this option is currently considered more cost-effective as only four access-points are currently used by recreational fishers targeting SBT.

3) there is a need to develop an on-site sampling methodology for application in South Australia and New South Wales. Recreational anglers in these States utilise a greater number of access-points than Victoria and the timing of the fishery is also unpredictable. This means that the methodology used for on-site sampling in Victoria may not be directly applicable or cost-effective. It is also uncertain whether utilising the New South Wales off-site sampling frame would be more cost-effective than on-site sampling.

4) information from fishing competitions that include SBT as target species has not been collected and a methodology to survey these competitions is required.

5) reporting catch in logbooks from charter vessels operating in Western Australia, New South Wales and South Australia is compulsory. A successful voluntary logbook program has been implemented in Tasmania. Charter Vessel operators in Victoria are not asked to report their catch and a methodology to collect this information is required.

Table 4 Knowledge gap analysis for SBT recreational fishing data and surveys

SBT Recreational Fishing Component	Current methods that provide data on SBT catch	Information gap
Game fishing tournaments	None	No current method that provides direct catch information for all

		tournaments that target or are likely to catch SBT
Charter boats	Compulsory charter boat logbooks (NSW, SA, WA). Successful implementation of a voluntary logbook program for charter boats demonstrated in Tasmania (Tracey et al, 2013).	Level of reporting of SBT in current charter boat logbooks (NSW, SA & WA). No current charter boat logbook program in Victoria
General recreational fishing for SBT		
Western Australia	Boat-based angler survey (conducted bi-annually since 2012)	None
South Australia	State-wide recreational fishing survey (Jones 2009; Giri and Hall 2015) but the associated error with the catch estimate is large.	No on-site or off-site surveys have been undertaken that adequately capture SBT angling. Currently no targeted off-site sampling frame available. Need to design and trial an on-site survey for SBT fishing that takes into account the diffuse and episodic nature of SBT fishing (outside of Port MacDonnell).
Victoria	Successful implementation of on-site surveys to estimate SBT catch (Green et al, 2012). No current commitment to ongoing surveys but the method is reproducible.	Determining the most cost-effective level of sampling effort for future on-site surveys for SBT fishing.
Tasmania	Successful implementation of off-site and on-site surveys to estimate SBT catch (Tracey et al, 2013). No current commitment to ongoing surveys but the method is reproducible.	None
NSW	None	No on-site or off-site surveys have been undertaken that adequately capture SBT angling. Currently no targeted off-site sampling frame available. Need to design and trial an on-site survey for fishing that takes into account the nature of SBT fishing in this state.

Chapter 5 Methods for estimating Australia's annual SBT recreational catch

The following chapter describes: (1) the methodology used to develop an on-site survey suitable for application in diffuse and episodic SBT recreational fisheries such as South Australia and New South Wales. This includes the implementation of a field trial and subsequent modelling to optimise the number of survey days necessary to estimate SBT catch within specified confidence intervals; (2) a trial of a voluntary logbook scheme for charter vessels in Victoria; and (3) protocols for accessing SBT catch information from game fishing competitions.

Development of an on-site survey methodology

A technical workshop (July 2013 (Hall et al. 2013)) reviewed the results of previous angler surveys for SBT to develop a potential methodology for on-site ('access-point') surveys. Since successful surveys had already been implemented in Tasmania and Victoria, the focus of this work were designs appropriate for application in South Australia and New South Wales. SBT in Victoria and Tasmania are typically resident for long periods (several months) and access points to these fish are restricted to relatively few locations. In South Australia and New South Wales SBT have shorter and unpredictable residence times, resulting in a large number of access points and episodic fishing events. This presents substantial design challenges.

The workshop developed a program for testing an on-site methodology suitable for such diffuse and episodic circumstances (Hall et al. 2013). This included determining key sampling locations, developing a stratified sampling design, and designing on-site sampling coverage within each strata.

The on-site survey methodology applied in Victoria was not directly transferable as surveying the large number and geographic extent of potential access points in South Australia and New South Wales was considered cost prohibitive. However dividing each state into regions (i.e. stratification) and then surveying SBT fishing activity at a random sample of access points within each region was considered fiscally feasible. The location and frequency of surveys was based on expert opinion. To aid the process of stratification the workshop participants developed a comprehensive list of ocean access boat ramps for both New South Wales (including Sydney) and South Australia and criteria that classified the ramps as either high, medium or low use.

After consideration of the sampling costs and testing objectives, the technical workshop participants concluded that the test survey should be undertaken in South Australia. NSW was excluded because of the highly transient nature of SBT in that state, combined with a very short fishing season. It was also recognised that in years when SBT move further north than usual and are available off Sydney, surveying would be more costly given the large number of boat ramps around Sydney Harbour. It was thought that these conditions may prove problematic for a trial survey, with the potential to miss substantial amounts of SBT fishing activity. It was also agreed, that as testing was being used to obtain data on sampling from regions where fishing was thought to be diffuse and episodic, sampling at Port Macdonnell in South Australia should be excluded from the Limestone Coast region. The fishing grounds based out of the Port Macdonnell neighbour those of Portland, Victoria and fishing activity is similar (i.e. prolonged and focussed on a single access point).

Expert interviews

Interviews were conducted with experts to characterise SBT angling in South Australia and New South Wales with a priority for information on locations and timing (e.g. season and weekday versus weekend activity) of fishing activity.

In South Australia, the eight expert SBT anglers were based in Ceduna, Port Lincoln, Adelaide (2), Mt Gambier, Port MacDonnell and Warrnambool and fished at least monthly or fortnightly throughout the

season. Some fished weekly during the SBT season (January–February to July). The experts included members of Port MacDonnell offshore angling club, Adelaide game fishing clubs and the Game Fishing Club of South Australia. They were all long-time boat owners with fishing families or partners.

The five expert SBT anglers from New South Wales were based in Sydney (3), Ulladulla and Bermagui. All had extensive experience of New South Wales recreational game fishing, including SBT. They fished regularly during the SBT season (June to July). These experts were either high profile recreational fishers or associated with regional tackle stores. Detailed responses from the experts are given in Appendix D.

The expert SBT anglers were interviewed by telephone or face-to-face and asked a set of questions about their familiarity with, and knowledge of, the SBT sector in their state. A standard structured interview was used to determine:

- their SBT fishing avidity, by assessing their frequency of fishing in their state (annually, monthly, weekly, daily) during the SBT season;
- the origins of their relevant knowledge and level of experience;
- their familiarity with SBT fishing locations in their state (high, medium, low ratings). In South Australia, their experience was categorised geographically as relevant to: Eyre and Western Adelaide and Yorke; Fleurieu and Kangaroo Island; and the Limestone Coast. In New South Wales they were categorized as relevant to: Sydney, South Coast (North of Ulladulla) and South Coast (South of Ulladulla).With the aim of identifying appropriate regions on which to focus SBT surveys in their respective states, the experts were asked (for the regions they knew well):
    - to rate the recreational SBT fishing activity (high, medium, low) and to comment on any specific fishing grounds for SBT, such as named reefs, and the distances offshore within their state;
    - to rate a complete set of coastal boat ramp locations relevant to their state in terms of SBT fishing activity (high, medium or low). Experts were also asked to suggest the highest use boat ramp in each region for SBT fishing activity, and to nominate any relevant boat ramps they may have been omitted from the list. To identify the appropriate time for SBT surveys, the experts were asked to suggest the timing and duration (in months) of the SBT fishing season, including identifying the peak period as well as any trends in fish-size through the season.

To assign selection probabilities between samples of weekdays and weekends and public holidays, the experts were asked to estimate the relative SBT fishing effort activity between weekends and weekdays. To determine the appropriate timing of survey activity at the sampled boat ramps, the experts were asked to estimate the relative SBT fishing activity (returns to the ramp) in morning, afternoon and night periods.

Survey methodology

The survey methodology was developed according to the recommendations of the technical workshop (Hall et al. 2013). As there was no prior empirical data available to inform the choice of survey design, expert opinion and consideration of the locations of reported charter boat catches were the main determinants of location choices. The on-site access point survey design was based on methods developed by Robson (1960) and Robson and Jones (1989). It was consistent with the methodological recommendations in Rowsell et al. (2008) and the methods used to obtain an estimate the total catch and effort of the Victorian recreational SBT sector (Green et al. 2012).

Obtaining SBT catch and effort data for moored vessels is problematic and ultimately was determined as out of scope for this survey method (consistent with the Victorian survey (Green et al. 2012)). Sampling did not include night time fishingor fishing effort by boats originating from outside the zone of interest, for example, from boats launching in Victoria and fishing in South Australian waters.

The selection probabilities and proportional allocation of sampling within strata (‘large’ versus ‘small’ ramps; weekend/public holiday versus weekday for onsite survey testing) was determined based on resourcing and informed by the expert interviews, as were key regions and ramps. An analysis was made of

distances between ramps and regions to determine the number of staff required (two creel clerks required for each survey day) and potential locations for their 'home-bases'.

The trial survey collected catch length data that was converted to weight using the CCSBT weight for length regression (Cochran 1977).

The total catch and effort and their respective variances were calculated by accounting for:

- selection of primary sampling units (PSU) with probability proportional to size (cluster sampling)
- stratification of secondary and tertiary sampling units
- unequal probability of selection without replacement for secondary and tertiary sampling units.

The Horvitz-Thompson estimator (Cochran 1977) was used to account for unequal probability of selection without replacement.

Sampling design for the testing of on-site sampling in South Australia

The temporal scope was daytime hours between 1 January and 2 August 2014, with stratification by weekday/weekend and ramp activity (Table 5). Staff coverage for each region of South Australia is presented in Table 5.

Scope of sampling

The South Australian coast was stratified into sampling regions that reflected where SBT activity was likely to occur, with a focus on sampling regions where fishing activity is expected to be diffuse and episodic (Figure 9).

Figure 9 Map of South Australian coastline showing sampling regions for on-site sampling trial

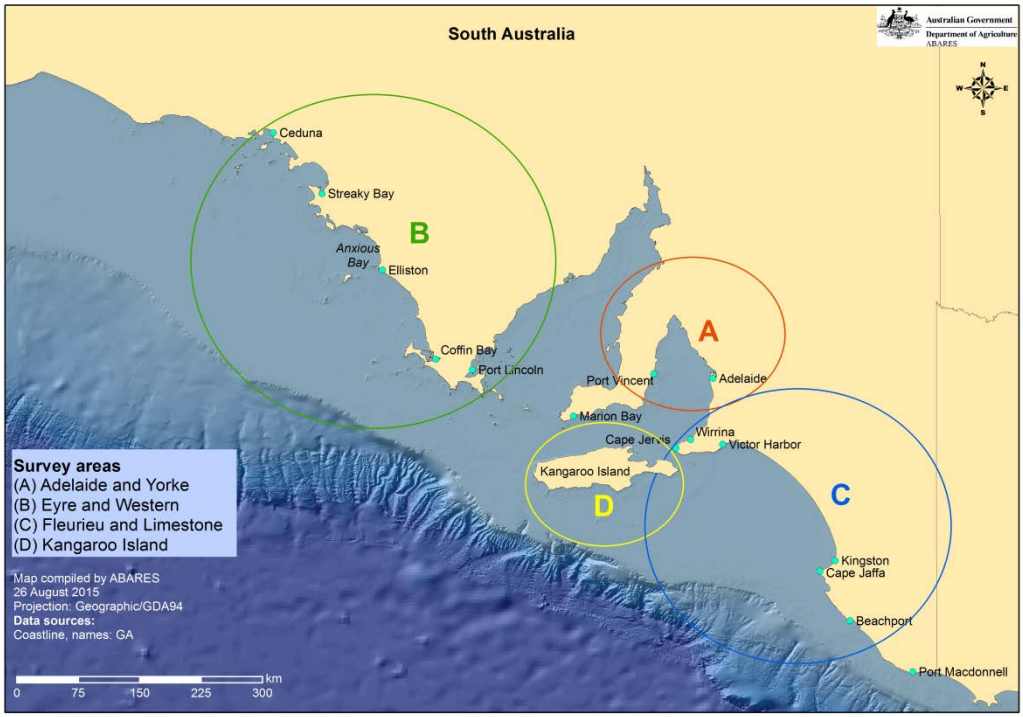


Table 5 On-site sampling stratification and coverage

Temporal scope	Daytime hours: 1 January to 2 August (214 days)
Stratification	Day type: 1 weekends; 2 weekdays
	Ramp type: 1 Large (21); 2 Medium (25)
Staffing	4 –5 pairs of clerks operating in:
	Ceduna to Port Lincoln
	Yorke Peninsula to Wirrina
	Kangaroo Island
	Cape Jervis to Beachport

All large, medium and small boat ramps in South Australia were identified from the South Australian Government database and reviewed by SBT experts to eliminate those considered insignificant for SBT fishers. Small ramps were excluded as they do not offer good access for larger trailer-boats that are typically required for access to the offshore tuna-fishing grounds. The region west of Ceduna was also excluded as there is currently only a small amount of fishing effort for SBT in this region by predominantly large boats (i.e. not trailer boats).

Port MacDonnell was excluded because of its similarity and proximity to Portland. Within the overall geographic scope, the sampling regions were defined with practical consideration of likely travel time between access-points and the local geography.

Multi-stage stratified cluster sampling (MSSCS)

The trial tested an on-site access point survey to estimate the total recreational SBT catch taken from the central coastal region of South Australia by day-time, trailer boat fishers. The design for the survey was an access (effort)-access (harvest) combination and the design constituted a multi-stage stratified cluster sampling (MSSCS) survey as per (Green et al. 2012). This survey used a spatiotemporal sampling frame. The sampling frame consisted of all large and medium sized boat ramps within the central coastal region of South Australia and all days available within the designated sampling period.

The sampling period for this survey consisted of 214 calendar days and 42 boat ramps (Table 6). Cluster sampling involves selecting members of a target population in groups or clusters. With a large geographical area to cover with a limited group of interviewers (8 or 10), boat ramps were categorised into four geographical regions or four clusters.

Table 6 Number of boat ramps per region and selection probability

Region	No. of ramps	Selection probability
(A) Adelaide and Yorke	8	0.19 (8/42)
(B) Eyre and Western	19	0.045 (19/42)
(C) Fleurieu and Limestone	10	0.24 (10/42)
(D) Kangaroo Island	5	0.12 (5/42)
Total	42	

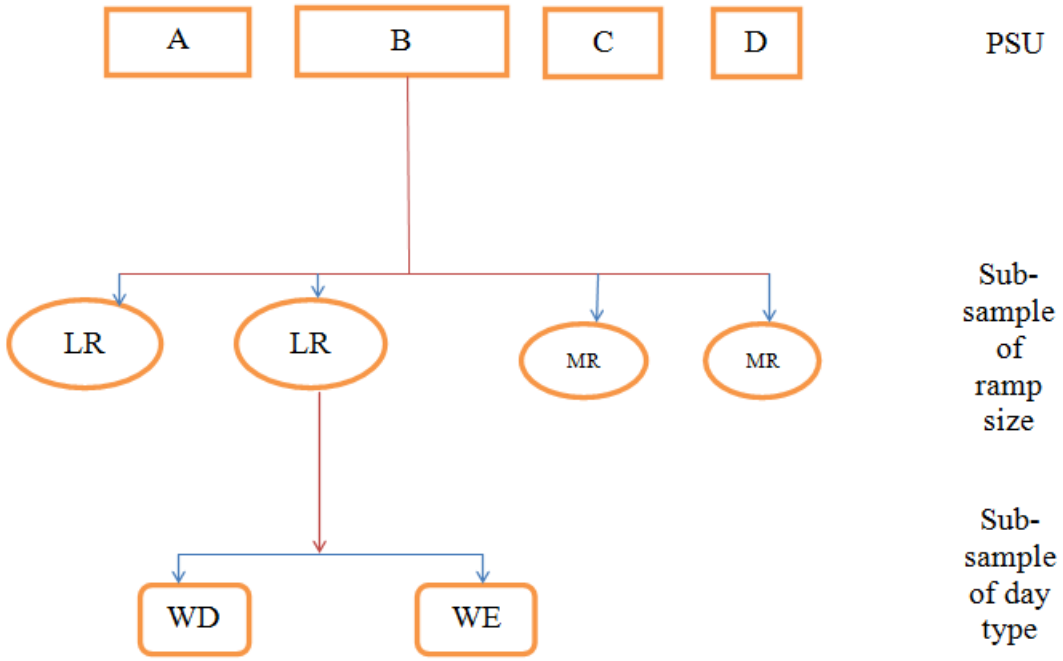
Regions A–D was treated as primary sampling units and all were sampled in the survey. Within regions, boat ramps were stratified as large boat ramps or medium boat ramps with selection probabilities of 0.8 for larger ramps and 0.2 for medium ramps. For all boat ramps, sampling days were stratified into weekdays and weekends, with selection probabilities of 0.3 and 0.7 respectively. Table 6 lists sub-sample and selection probabilities. Figure 10 provides an overview of the sampling design.

The design consisting of a total of 151 sampling days. For each sub-sample, the number of sampling days was allocated by generating a random number range (Table 7) and then selecting 151 numbers randomly without replacements from that range (Table 8). For each sub-sample, a selected numbers of days were counted (ni), and that many ramps in that sub-sample were selected without replacement. Sampling dates were then allocated to these ramps without replacement from the temporal sampling frame.

Table 7 Strata combinations with selection probabilities

Sub-sample (ramp size and day type)	Probability of Selection	Cumulative Probability	Random number range
A-Medium Ramp-Week Days	0.19*0.2*0.3 = 0.0114	0.0114	0000-0114
A-Medium Ramp-Week Ends	0.19*0.2*0.7= 0.0266	0.0380	0115-0380
A-Large Ramp-Week Days	0.19*0.8*0.3 = 0.0456	0.0836	0381-0836
A-Large Ramp-Week Ends	0.19*0.8*0.7= 0.1064	0.1900	0837-1900
B-Small Ramp-Week Days	0.45*0.2*0.3 = 0.027	0.2170	1901-2170
B-Small Ramp-Week Ends	0.45*0.2*0.7= 0.063	0.2800	2171-2800
B-Large Ramp-Week Days	0.45*0.8*0.3 = 0.108	0.3880	2801-3880
B-Large Ramp-Week Ends	0.45*0.8*0.7= 0.252	0.6400	3881-6400
C-Medium Ramp-Week Days	0.24*0.2*0.3 = 0.0144	0.6544	6401-6544
C-Medium Ramp-Week Ends	0.24*0.2*0.7= 0.0336	0.6880	6545-6880
C-Large Ramp-Week Days	0.24*0.8*0.3 = 0.0576	0.7456	6881-7456
C-Large Ramp-Week Ends	0.24*0.8*0.7= 0.1344	0.8800	7457-8800
D-Medium Ramp-Week Days	0.12*0.2*0.3 = 0.0072	0.8872	8801-8872
D-Medium Ramp-Week Ends	0.12*0.2*0.7= 0.0168	0.9040	8873-9040
D-Large Ramp-Week Days	0.12*0.8*0.3 = 0.0288	0.9328	9041-9328
D-Large Ramp-Week Ends	0.12*0.8*0.7 = 0.0672	1.0000	9329-10000

Figure 10 Overview of sampling design for primary sampling units for regions



Note: Adelaide and Yorke Peninsular (AY), Eyre and western coast (EW), Fleurieu and Limestone coast (FL) and Kangaroo Island (KI); for sub-sampling units of ramp size - large ramps (LR) and medium ramps (MR); and for sub-sampling units of daytype — weekdays (WD) and weekends/public holidays (WE).

Within each cluster, two-stage stratified random sampling was undertaken and within cluster calculations, the following formulae were used:

The population mean for the stratified population is:

$$\bar{Y} = \sum_{h=1}^{L} W_h \bar{y}_h$$

The estimate used in stratified sampling is $\bar{y}_{st}$:

$$\bar{y}_{st} = \sum_{h=1}^{L} W_h \bar{y}_h$$

and the variance without finite population correction factors is:

$$\mathrm{Var}(\bar{y}_{st}) = \sum_{h=1}^{L} W_h^2 \frac{s_h^2}{n_h}$$

where

L = number of strata

Nh = total number of units in stratum h (h = 1, …,L)

$N = \sum_{h=1}^{L} N_h$, total population size

nh = number of units in stratum h

$W_h = \frac{N_h}{N}$ stratum weight

yhi = the value obtained in ith unit of for each stratum h

$\bar{y}_h = \left[\sum_{i=1}^{n_h} y_{hi}\right]/n_h$ is the sample mean for stratum h

s_h^2 = variance of stratum h.

For calculations between clusters, the Horvitz–Thompson estimator of population totals was used, as the sampling was done by probability proportional to a measure of size of a cluster (sampling with unequal probability):

$$\hat{Y}_{HT} = \sum_{i=1}^{n} y_i/\pi_i$$

where $y_i$is the ith unit to be included in the sample and π_i is the probability of the inclusion of the ith unit to be in the sample. The variance of the unbiased the unbiased estimator $\hat{Y}_{HT}$ is:

$$\mathrm{Var}\left(\hat{Y}_{HT}\right) = \sum_{i=1}^{N} \frac{(1-\pi_i)}{\pi_i} y_i^2 + 2\sum_{i=1}^{N}\sum_{j>i}^{N} \left[\frac{\left(\pi_{ij} - \pi_i\pi_j\right)}{\pi_i\pi_j}\right] y_i y_j$$

where π_{ij} is the joint probability that units i and j both are in the sample. The unbiased estimate of which can be given as:

$$v\left(\hat{Y}_{HT}\right) = \sum_{i=1}^{n} \frac{(1-\pi_i)}{{\pi_i}^2} y_i^2 + 2\sum_{i=1}^{n}\sum_{j>i}^{n} \left[\frac{1}{\pi_i\pi_j} - \frac{1}{\pi_{ij}}\right] y_i y_j$$

As per Cochran (1977).

Let p_i be the probability of selecting cluster i in a single extraction. For simplicity, it is assumed that the clusters are drawn with replacement, then the probability, $1 - \pi_i$ of not including cluster i in the sample of size n can be calculated as the probability of not selecting the cluster i in any of the n extractions, that is:

$$1 - \pi_i = (1 - p_i)^n$$

$$\pi_i = 1 - (1 - p_i)^n$$

Also, the probability of extracting either cluster i or cluster j in a single extraction is $p_i + p_j$and so the probability of neither extracting cluster i nor cluster j, will be $1 - (p_i + p_j)$. Then the probability of extracting neither i nor j in a single extraction is $[1 - (p_i + p_j)]^n$. Therefore the probability of extracting either cluster i or cluster j in n extractions is $1 - [1 - (p_i + p_j)]^n$. Alternatively, same probability can be expressed as probability of including i, plus the probability of selecting j, minus the probability of including both i and j, which is $\pi_i + \pi_j - \pi_{ij}$. Thus

$$\pi_i + \pi_j - \pi_{ij} = 1 - [1 - (p_i + p_j)]^n$$

$$\pi_{ij} = \pi_i + \pi_j - [1 - [1 - p_i - p_j]^n$$

Table 8 Sampling coverage in each region

		Sampling days	Variance	
Region	**Ramp size**	**Weekday**	**Weekend/public holiday**	
Adelaide and Yorke	Large	8	14	
	Medium	1	6	
Eyre and Western	Large	17	37	
	Medium	5	9	
Fleurieu and Limestone	Large	6	24	
	Medium	3	3	
Kangaroo Island	Large	4	10	
	Medium	2	2	
Totals		**46**	**105**	**151**

Fisheries Victoria were concurrently conducting a state-wide telephone–online diary survey of South Australian recreational fishing during 2013–14 (which commenced prior to the on-site survey in December 2013). This telephone–online diary survey used methods similar to a state-wide survey undertaken in 2007–08. Angler reports of targeting or catching SBT during the telephone–online survey were also assessed as part of this project.

Testing of on-site methodology through simulation

To estimate the error associated with the proposed methodology a simulation study was undertaken using the data collected from the on-site trial. We used the information derived from the on-site survey trial in South Australia and the data from the on-site survey for Victoria. Simulation was applied in preference to bootstrapping (random sampling of actual data, with replacement) because the data from the on-site survey trial was sparse. Although a total of 155 ramp days were sampled during the on-site trial (representing a sample coverage of 2.2%), SBT were only recorded on four of the sampled days, and twice for one ramp. Eighty per cent of the observed catch occurred on one day. The incorporation of additional effects in the simulated data is also possible allowing the impact of these to be explored.

The first step in the simulation process was the computer generation of a population of data that represented the SBT recreational fishing catch and effort. This data set was then sampled according to the survey design and analysis was performed as it would be for real data, where samples from the simulated population are taken, and upscaled (by 1/survey-coverage) to estimate population metrics.

The most contentious part of simulating a survey would ordinarily be the simulated data itself, however this was less important in this study because the confidence interval of the estimated catch was the parameter of interest. The confidence interval of each survey scenario is expressed as a proportion of the mean of the simulated catch (taken from the actual population of simulated data).

Constructing recreational catch data

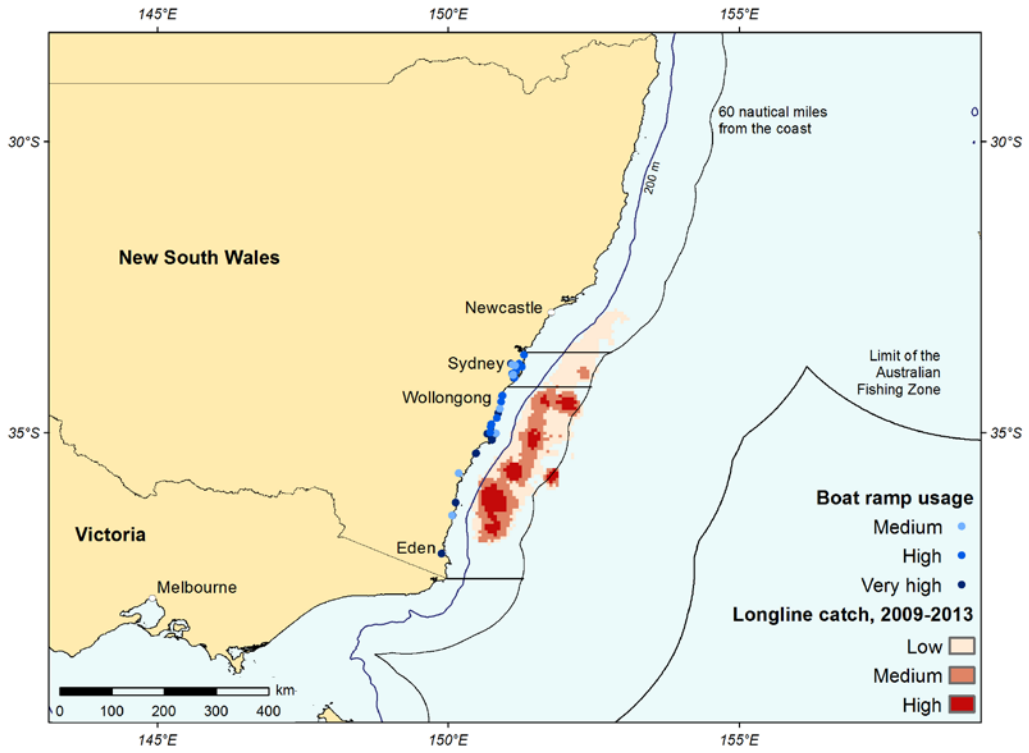
For both South Australia and New South Wales, boat access points (ramp stratum) were classified on the basis of boat volume and grouped into coastal regions. Coastal regions were assigned a relative catch volume, based on expert opinion (SA) or local commercial catch data (NSW). In South Australia, an additional week-end/week-day stratum was used, and boat volumes were assigned to each in proportion to findings from the Victorian survey (Green et al. 2012). The product of each stratum value at each ramp was summed across ramps and scaled to one to give the proportion of state level catch at each ramp. Fish availability was then accounted for as an availability window for South Australia (7 or 14 days per ramp), or as the result of simulated fish movement in New South Wales. Fish availability over time (assigned to specific dates) was combined with ramp catch proportion, and scaled to the total catch (based on either the SA on-site survey estimate or a nominal value in line with the Victorian survey), to provide expected catch per ramp per given day, within each state survey.

The simulation of the New South Wales recreational catch benefitted from better information on the movement of fish along the New South Wales coast than the South Australian coast. New South Wales experts thought there were only 21 boat ramps (south of Sydney) that needed be included in their state's survey, with the period over which SBT are caught being shorter than for South Australia, from the start of June to the end of July. The experts also thought that SBT take from 14 to 21 days to move from Eden to just south of Sydney, where they may persist for some time. Data was simulated for New South Wales SBT recreational catch, based on the movement of SBT off the New South Wales coast and commercial catch data of SBT. Locations around Sydney and further north were excluded due to the difficulty in on-site sampling the many launching sites present.

Simulating the movement of SBT along the New South Wales coast

During their passage up the New South Wales coast, SBT are only available to anglers when they are within about 100 km of a launching ramp; and when beyond this distance they are unavailable from that ramp. The region off the New South Wales coast where SBT can be found was ascertained from records of commercial catches by the Commonwealth Eastern Tuna and Billfish Fishery over a five year period (from 2009 to 2013 inclusive) (Figure 11). These data were used to generate a map of smoothed SBT catch densities, with densities calculated to grid squares of ~0.053 units of latitude/longitude (~ 5.9 x 5.9 km). This density data was then used to determine where SBT might be caught by recreational anglers off the New South Wales coast, and also where they may swim up the coast.

Figure 11 Commercial longline catch 2009–13 and boundaries for the New South Wales simulations



The path taken by SBT as they traversed the New South Wales coast was simulated as a stochastic process. SBT positions (as grid centres across the commercial catch density map) were calculated daily as a south-> north step, in combination with possible east <–> west steps. Each days movement was calculated as the number (random) of grid squares traversed in each direction across the grid of fishing densities.

The number of northerly grid squares that could be traversed in a day was either an integer from 1 to 4 (for 21 days to traverse the New South Wales coast), or an integer from 3 to 6 to traverse the same distance in 14 days. Probabilities were assigned to each possible number of grid points that could be traversed and the actual movement made in a day was the outcome of a random draw from multinomial distributions. The concurrent east–west movement made with each northerly step was determined from five components. These were; (1) the number of east-west steps with non-zero commercial fishing density, (2) no more than 3 steps in either direction, (3) a bias for fish to generally move in a north to north east direction (parallel to the New South Wales coast), (4) a weighting to more likely move fewer than more squares in either direction, and (5) a weighting for catch density over the possible grid points that could be moved. The overall product of these five east-west components was made multinomial probabilities, by scaling their overall sum to 1.

In this way, the movement of SBT up the New South Wales coast was confined to grid points with a non-zero commercial catch density, and was calculated as a series of latitudes and longitudes for the centres of the grid points the fish moved to each day. Multinomial probabilities for the possible number of northerly steps made by SBT each day, were calibrated to ensure SBT took on average either 21 or 14 days to traverse the New South Wales coast (from the southernmost starting point to cross latitude –34.21oS, which is south of the southerly most boat ramp in Sydney) (Table 9).

Table 9 Catch probabilities for strata in the South Australian stratified recreational catch survey

Strata	Ramp	Ramp class	Probability
Jervis-Bellambi	Bellambi (Beach)	H	0.36
Jervis-Bellambi	Bellambi - alternate ramp beach	H	0.36
Jervis-Bellambi	Port Kembla Boat Harbour (Darcy Rd)	H	0.36
Jervis-Bellambi	Shellharbour (Bass Point Ocean Ramp)	M	0.36
Jervis-Bellambi	Kiama Harbour	VH	0.36
Jervis-Bellambi	Boat Harbour, Gerringong	H	0.36
Jervis-Bellambi	Shoalhaven Heads - River Rd Ramp Shoalhaven River	H	0.36
Jervis-Bellambi	Shoalhaven Heads - Wharf Rd Ramp Shoalhaven River	VH	0.36
Jervis-Bellambi	Greenwell Point - West St Crookhaven River	H	0.36
Jervis-Bellambi	Watt St Callala Bay Jervis Bay	H	0.36
Jervis-Bellambi	Warrain Cres Currarong	M	0.36
Jervis-Bellambi	Woollamia Regional Ramp	VH	0.36
Jervis-Bellambi	Murray Beach Jervis Bay	VH	0.36
Batemans-Ulladulla	Ulladulla - North Harbour	VH	0.27
Batemans-Ulladulla	Ulladulla - South Harbour	VH	0.27
Batemans-Ulladulla	North Bridge, Batemans Bay	M	0.27
Batemans-Ulladulla	South Bridge, Batemans Bay	VH	0.27
Bermagui-Narooma	Apex Park, Narooma	VH	0.32
Bermagui-Narooma	Bridge, Bermagui	M	0.32
Bermagui-Narooma	Boat Harbour, Bermagui	VH	0.32
Eden	Quarantine Bay, Eden	VH	0.05

Having calculated daily positions for SBT swimming up the New South Wales coast, the distance from the fish to each boat ramp along the coast was calculated. If this distance was less than 100 km, fish were deemed available to that boat ramp, and were unavailable otherwise (would not be caught from that ramp). This calculation was made for every day from 1 June to July 14. For each boat ramp, there were then a number of days that fish were available to anglers. To account for fish needing to be 'discovered' before being generally available to anglers, the number of days fish were to be available was reduced by 1 for each

ramp. Discovery is thought to be quick as a result of communication between anglers via social media and direct radio communication when on the water.

The probability of catch at ramps was then multiplied by fish availability (0 or 1) across the survey time frame (dates) to obtain probability of catch at every day in the frame, which was then multiplied by total expected catch across the state, to obtain an expected number of catch per day per ramp. The expected number of catch of SBT per day per ramp was then made stochastic using random draws from poisson distributions parameterised by the expected number of catch at a given ramp on a given day. This generated a synthetic data set for New South Wales for one season.

Simulating recreation catch surveys

Given synthetic data for New South Wales (and correspondingly for South Australia), survey findings could be simulated as described above. The distribution of survey estimates of recreation catch was estimated by taking 100 samples from each data set generated. To account for variation in the movement of fish in different seasons, 100 sets of different seasons were also generated, and predicted catch for each survey and each season were pooled to obtain an overall confidence interval as a proportion of predicted catch (such that proportions are largely independent of expected catch). This approach implies that all of the effect of season on uncertainty in recreational catch is because of stochastic movement of fish off the coast. This is unlikely to be true, as the proportion of the recreation catch caught of the various segments of the New South Wales coast is known to vary across years. As well, the stochastic movement of fish off the New South Wales coast may be more variable than that built into the existing model for fish movement. Taking account of the effect of season on the uncertainty of predicted catch was not similarly possible for South Australia, because so little is known of the movement of fish along the South Australian coast.

Assumptions

A number of assumptions have been made in the simulation of the SBT recreational surveys, which can be expected to influence findings, including:

- it is assumed important ramps have not been missed or under-sampled in surveys.
- sampling intensity within each survey strata is assumed to be balanced such that coverage is constant across the survey. This is easy to program in a computer simulation, but will be harder to achieve in practice in a real survey. The effect of coverage varying between strata will be to vary the scale-up of survey results, which will increase uncertainty in predicted catch, and so increase its confidence interval (as a proportion of predicted catch).
- it is assumed that predicted catch per se will have only a modest effect on uncertainty of the simulated catch, when expressed as a proportion of predicted catch. This should be correct to a large degree.
- for New South Wales, it is assumed that interviewers will be able to identify and target boats intending to pursue SBT on boat ramps, on the basis of the boat queue and onboard gear on each. This is necessary, as only a very small proportion of boats launching from ramps will be attempting to catch SBT, and the volume of boat launches may preclude all being interviewed.

Cost-effective sampling and acceptable levels of error

Sampling error occurs when a sample of a population used to estimate a particular attribute is not representative of the total population. Survey design necessitates a trade-off between the amount of sampling coverage with its associated level of bias and precision and the cost of sampling. Increasing sample size typically reduces bias and increases precision, but comes at a higher cost (Pollock et al. 1994). The variation in the attribute we wish to measure and the frequency at which it occurs will determine the sample size required to minimise bias and increase precision. Low frequency or more variable attributes require larger sample sizes (Dixon et al. 2005). For SBT, recreational fishing can be episodic and diffuse, which requires high sampling coverage. A well designed survey based around randomised sampling should limit sampling

bias. In determining the risk associated with different levels of accuracy we should first consider what the consequences are if we arrive at an incorrect conclusion (Burgman 2005). For estimating the national recreational catch of SBT we chose to set a limit of ±30 percent error. This was based on the costs of the survey (especially the on-site survey) versus the risk of an inaccurate catch estimate. However, multiple estimates through time will be required to determine year-to-year variation in SBT catch.

State charter boat logbook information

A survey of state-based logbook programs was implemented to determine what jurisdictions had charter logbook programs and whether the data that is routinely collected adequately captured SBT fishing activity. Jurisdictions were contacted and asked for access to information on any charter boat logbook systems and whether SBT were captured in these systems.

Voluntary charter logbook trial

There is currently no compulsory logbook program for charter boat operators in Victoria and so a trial of voluntary logbooks was conducted. Trial logbooks were designed for the Portland SBT charter boat sector based on a review of the existing charter boat logbook programs in other states and in consultation with staff from the Catch and Effort Data Collection unit of Fisheries Victoria, Fisheries Victoria Compliance Officers and several charter boat industry leaders.

The objective of the trial was to test the feasibility of a simplified form, which would enable ease of data recording and data entry (hence a similarity with commercial catch and effort logbook design). Data elements included port of departure, time of departure, number of fishing clients, fishing area/location, target species (SBT, tuna or other), total number of fished lines, total fishing time, total number of SBT retained, size of retained SBT, number of other species caught, total number of SBT released, release reason, time of trip completion. Accompanying documents included instructions for completion, a fishing area zone map, a port code list and an optional fish length and weight data sheet.

Department of Environment and Primary Industry Fisheries Victoria Regulation and Compliance fisheries officers based at Portland were able to identify 14 SBT charter operators, including both local and seasonal operators. Contact details were obtained from websites.

Strong collaborative links previously forged with several industry leaders were used to garner support for the project, and a draft design was taken to an industry meeting in Portland on 9 April 2014, which also enabled explanation of the aims, benefits and consequences of the project. A few edits were made, and a revised design was printed and distributed to the charter boat industry. Logbooks were distributed either directly by fisheries officers; via email to 11 operators on 15 April or were available for collection by the charter operators from the local fisheries office in Portland. Six charter operators undertook to voluntarily participate in the logbook trial.

The trial ran through the main tuna season off Portland, commencing in mid-April 2014. Participants were contacted to request the return of log sheets at the end of June 2014, and subsequently. The trial data were analysed to determine the charter catch and applicability of using these data as a low-cost indicator of SBT fishing activity between years of on-site surveys. The data were also analysed to determine the applicability for monitoring recreational fishing activity for SBT to determine when on-site surveys should commence.

Game fishing tournaments

A survey of game fishing tournaments was undertaken from April to November 2013 with support from the GFAA, and state GFAs. The survey aimed to determine which game fishing tournaments targeted or caught SBT and what data were collected by tournament organisers. The GFAA provided a list of all sanctioned game fishing tournaments and contact details for the organisers. Contact was made with the executive of state level GFAs and organisers of individual tournaments. No contact was made with individual competitors as tournament organisers keep a record of captures.

ANSA was also contacted, but they advised that there were no tournaments organised by their affiliated clubs that caught SBT. No contact was made with the Australian Anglers Association or the Fishing Clubs Association based on earlier work that indicated a very low level of tuna targeting and catch by these fishers.

Tournaments organised in areas that are likely to encounter SBT in Tasmania, Victoria, South Australia and New South Wales were selected for survey. Clubs north of Sydney were excluded from the surveys as a result of being outside the normal range of SBT.

Surveys were completed by tournament organisers in order to identify which tournaments encounter SBT on a regular basis, and whether SBT are captured as part of active targeting or as incidental encounters. Organisers of GFAA-sanctioned tournaments were also asked whether private tournaments were run in their region. In conjunction with internet searching and advice from GFA representatives, two privately run tournaments that have potential to encounter SBT were identified and surveyed.

Direct survey of GFAA members

A direct phone survey of GFAA members was investigated to determine if it could be used as an estimator of SBT catch by GFAA members. However the trial was rejected due to the confidential nature of GFAA membership data. On-line surveys of GFAA members would likely lead to substantial avidity bias.

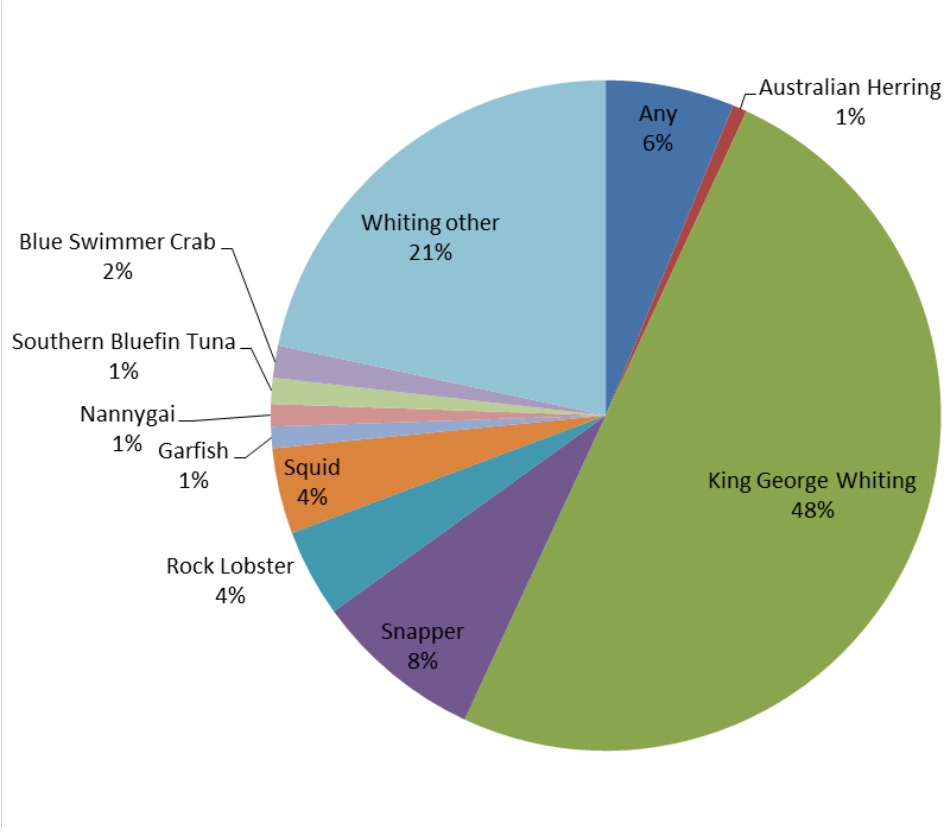
Chapter 6 Results

South Australian On-site survey trial

Between 1 January and 2 August 2014, 151 interview days were completed by field staff. Of these, interviews were obtained on 82 days out of 120 at large ramps and 14 days out of 31 at medium ramps. Because of the random nature of the surveys, there were survey days when no anglers utilised the ramps (either as a result of bad weather or other reasons).

The survey results clearly demonstrate the episodic nature of the SBT fishery in South Australia. In addition they demonstrate that the vast majority of fishers are targeting other species. In total, 1028 completed boat trips were recorded and 937 fishing parties and 8 non-fishing groups were interviewed, comprising 2123 individual fishers. Thirty-eight parties that had completed a fishing trip (4 per cent of interviews) fully declined to be interviewed, and 21 parties (1.2 per cent) provided partial interviews (declined catch measurements). Interviewed anglers were targeting a variety of species, both inshore and offshore (Figure 12), where proportion of anglers that were targeting SBT was very low, at 1.2 per cent.

Figure 12 Percentage of fishing parties targeting key species (n=937)



In total, 17 fishing parties comprising of 45 individual anglers were targeting SBT and 16 (94 per cent of those targeting SBT) fishing parties were successful in catching SBT. Over the entire survey period, about 1.2 per cent of interviewed anglers were targeting SBT. Out of these 45 individuals who targeted SBT, 42 were male.

All of the anglers that were interviewed that were successful in catching SBT were from South Australia. Postcode analysis (of the skippers of each party) indicated that the skipper interviewed at Coffin Bay lived locally (four anglers). At Marion Bay, three of the skippers interviewed lived locally, five were from Adelaide and suburbs, one was from Port Pirie, one was from Port Hughes and one was from Booleroo (28 individuals interviewed at Marion Bay).

A total of 87 SBT were caught, 21 of which were released and 3 of the released SBT were tagged prior to release.

The average number of SBT caught per angler per trip ranged from 0.6–9.0 and effort ranged from 1.75–33.75 hours per person. Catch per unit effort ranged from 0.03–0.53 SBT per fisher per hour. Twenty-two of the harvested SBT were measured by the creel clerks. The minimum length (total length) of the measured SBT was 81 cm, and the maximum length was 104 cm.

Estimated catch and effort

The sample of 155 days was not sufficient to estimate the recreational catch of SBT for South Australia (excluding Port MacDonnell) within the specified error of 30%. The estimated total retained catch of SBT during the survey period was 1808 (± 690 S.E.) fish and the total estimated weight was 29 (± 12 S.E.) tonnes (Table 10). An estimated 1021 (± 230 S.E.) SBT were released during this period.

Between 1 January and 2 August 2014, an estimated total of 61 989 (± 9834 S.E.) boat trips were completed, of which 441 (± 157 S.E.) were targeting SBT. In all boat trips, 142 901 (± 23 882 S.E.) individual anglers were fishing, of which 1162 (± 436 S.E.) were targeting SBT. Even though the relative errors (standard error/total estimate) in the onsite survey were smaller than the errors for the 2013–14 state-wide angler diary survey estimates for SBT (Giri and Hall 2015), they were still relatively high. This was mainly because of very few anglers (2 per cent) targeting SBT during the on-site survey period. The estimates from the survey should be regarded with caution, given the high relative errors.

Table 10 Total estimates of SBT catches, releases and fishing effort for the survey period (1 January and 2 August 2014) based on South Australian (excluding fishing from Port MacDonnell) trial on-site survey

Fishing parameters	Estimated total	Standard error	Relative error
SBT fishing trips	441	157	0.36
Number of SBT anglers	1 162	436	0.38
SBT kept	1 808	690	0.38
SBT released	1 021	230	0.23
Harvest weight of SBT (tonnes)	29	12	0.41
Completed fishing trips	61 989	9 834	0.16
Number of anglers	142 901	23 882	0.17

Simulation results

The results of the simulation study are contained in the histograms of the distributions of predicted number of SBT caught and retained (Figures 13 & 14).

The simulation of the Victorian survey returned equivalent results to the actual Victorian survey. The general finding from the simulation studies showed that for a fixed cost, a boat ramp survey to estimate a state's SBT recreational catch, would be most accurate in Victoria, and least accurate in South Australia (Table 11; Figures 13 & 14). Increasing the scale of the South Australian or New South Wales survey, and therefore its cost, would return a more accurate estimate of the recreational catch of SBT. However, even tripling the scale of the survey in South Australia or New South Wales did not result in an equivalent level uncertainty in the estimated catch between either of those states and Victoria (Table 11).

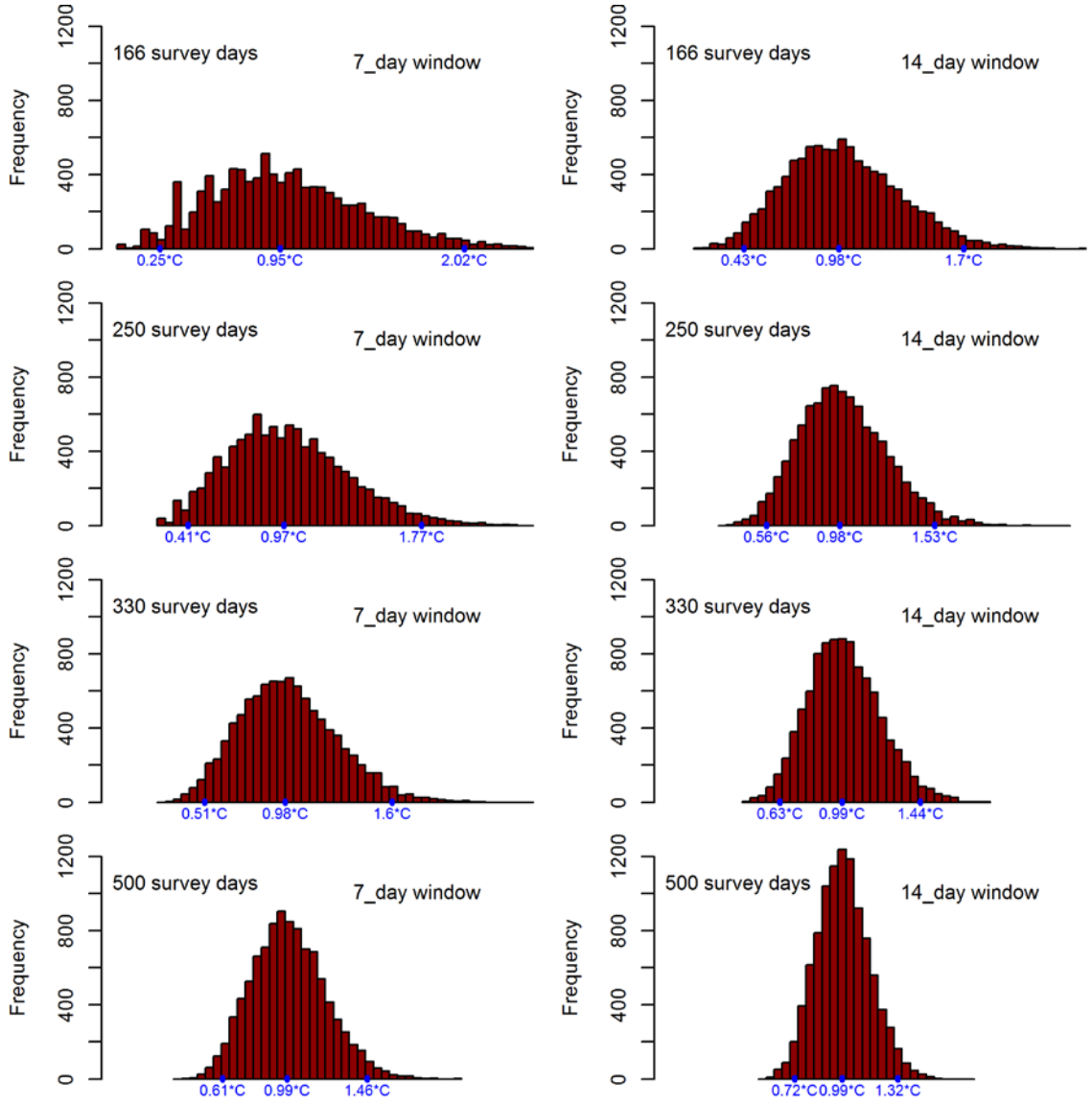
The simulation also investigated the effect of the window in time that SBT could be caught at each boat ramp, on accuracy of estimated catch for South Australia. When SBT are available for a longer time (doubling the window from 7 to 14 days) the uncertainty is reduced (Table 11). Similarly, the New South Wales survey estimates of recreational catch have less error when SBT were assumed to take 21 days to traverse the southern New South Wales coast, than when they took 14. This is because catch is observed over a longer period, and therefore the overall catch is predicted with a smaller scale-up factor than when catch is observed over a smaller number of days.

Table 11 The predicted error (the 95 per cent confidence interval expressed as a proportion of catch) in estimated catch of SBT based on simulations of on-site surveys in South Australia and New South Wales

South Australia	**7-day window % (C.V.)**	**14-day window % (C.V.)**
Days sampled		
166	25 - 202 (46.11)	43 - 168 (33.02)
250	41 - 177 (35.2)	55 - 152 (25.13)
330	51 - 160 (28.59)	63 - 143 (20.58)
500	61 - 146 (21.6)	72 - 131 (15.29)
New South Wales	**14-day transit**	**21-day transit**
Days sampled		
166	37 - 180 (34.07)	55 - 151 (24.67)
250	67 - 138 (25.67)	66 - 140 (18.99)
330	71 - 131 (21.34)	72 - 133 (15.56)
500	80 - 122 (15.01)	80 - 124 (10.98)
Victoria	**Survey period**	
Days sampled		
162	86 - 114 (14.21)	

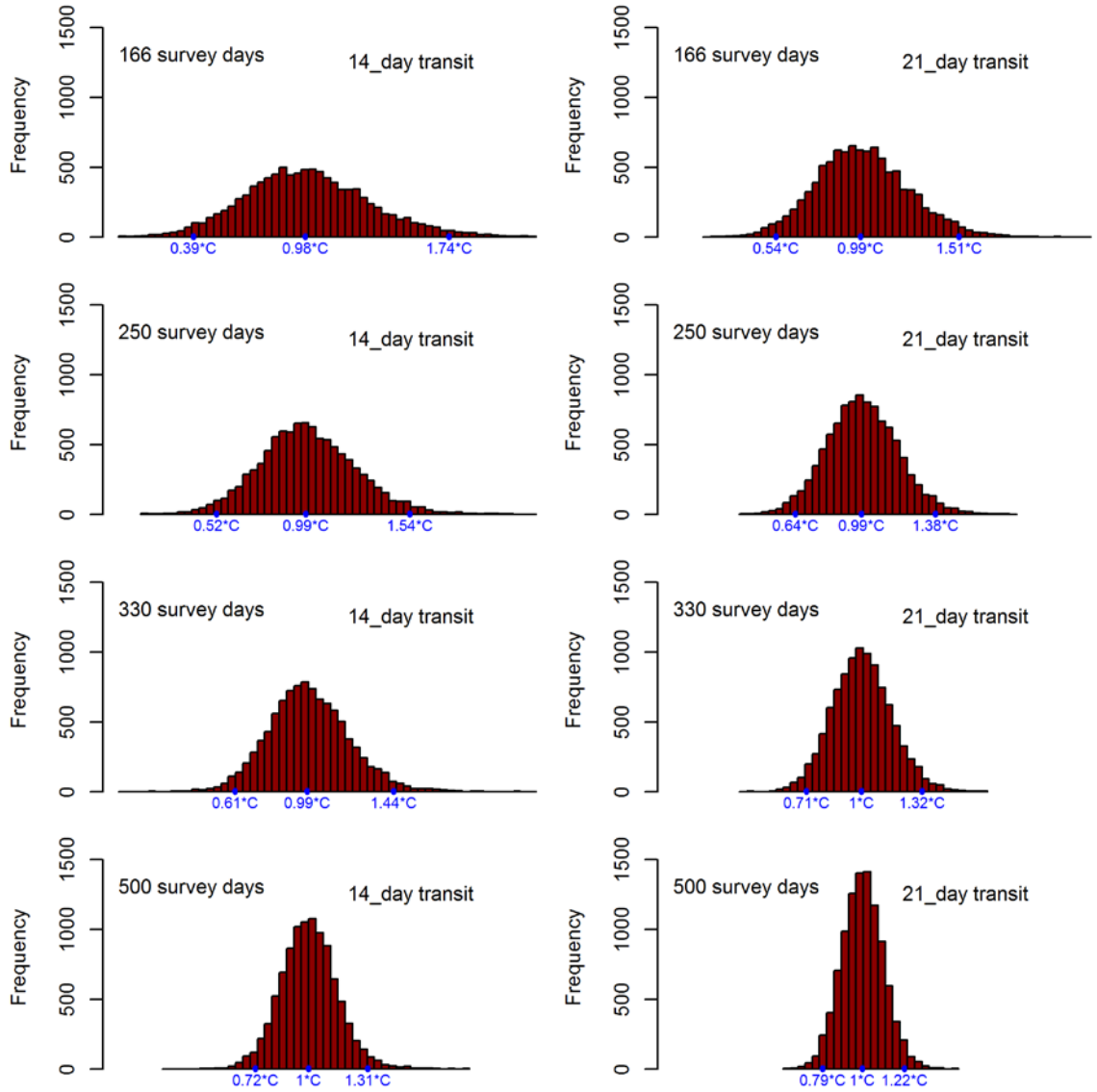
Note: C.V. = coefficient of variation

Figure 13 Uncertainty of estimated catch of SBT (for number of fish caught) based on simulated survey data for South Australia (166, 250, 330 and 500 survey days) and a 7 or 14 day window during which SBT are available to catch from an access point



Numbers along each x-axis provide uncertainty in the survey estimate of number of fish caught (C), for example where for the top left plot, 0.95*C is the median survey estimate and 0.25*C is the lower 95% confidence bound and 2.02*C is the upper confidence bound. That is, 95% of the time, surveys would estimate the number of fish caught to be between 0.25 and 2.02 of the true value.

Figure 14 Uncertainty of estimated catch of SBT (for number of fish caught) from simulated surveys conducted in southern New South Wales (166, 250, 330 and 500 survey days)



Numbers along each x-axis provide uncertainty in the survey estimate of number of fish caught (C), for example where for the top left plot, 0.95*C is the median survey estimate and 0.25*C is the lower 95% confidence bound and 2.02*C is the upper confidence bound. That is, 95% of the time, surveys would estimate the number of fish caught to be between 0.25 and 2.02 of the true value.

State charter boat logbook information

The logbook information provided by charter boat operators to state Fisheries Agencies is treated in the strictest confidence. That is, it is not provided to any other government or industry group any in a form that may identify any boat or person. The catch by charter vessel operators is likely to be at a level that warrants inclusion in an annual catch estimate for SBT for Australia. Assuming that catch by charter vessel operators has been relatively constant over the recent period and the catch of Victorian operators is similar to SA then the total annual charter boat catch is likely to exceed 4 000 individual SBT.

Western Australia

The Western Australia Fisheries annual State of the Fisheries Report (Fletcher and Santoro 2014) includes detailed information about the number of licensed fishing tour operators operating in the State and their annual catch. Charter catches of SBT peaked in 2010 with 144 retained and 16 released from 10 operators. Charter catches have been decreasing in recent years, with 12 SBT retained and 4 released from 5 operators in 2014. This is the lowest catch since 2008.

South Australia

South Australia has a mandatory charter logbook program in place. There were 105 charter boat licence holders in 2013–14 financial year with 74 active in the sector. Charter catches have been increasing year-on-year since 2007–08 (554 retained) with a peak of 1824 SBT retained in the 2013–14 financial year. There is no information on numbers released or estimated weights.

Tasmania

From the 2012 voluntary charter logbook program (Tracey et al. 2013), 8 operators out of 10 who targeted SBT participated fully, and 2 operators participated partially.

A total of 1090 SBT were caught from charter operations in 2012 (937 harvested and 153 released), seven of which were greater than 90kg in weight (caught late March-late June). The estimated total harvested weight of SBT for 2012 was 17.75 t. In 2012 the release rate for the charter sector was estimated to be 15 per cent, although if catches from the south coast are excluded, the effective rate for the main area of the charter sector (Tasman Peninsula) was 12 per cent.

New South Wales

A mandatory charter logbook system is in place in New South Wales. In 2015 there 276 charter licences in New South Wales, with 172 that could interact with SBT based on their endorsement class (e.g. game fishing, deep sea). A total of 157 SBT (118 retained and 39 released) were recorded in charter logbooks in New South Wales between December 2011 and June 2014.

Victoria

There is currently no charter logbook system in place in Victoria.

Charter boat logbook trial (Victoria)

A trial of voluntary charter boat logbooks was conducted in Victoria. While a good level of acceptance of the project and cooperation of about half of the operators was obtained, the actual reporting highlighted several problems in implementation with a voluntary program in this state. The burden for voluntary completion was identified as a key area of difficulty for this program. Operators were not always skippers, and the task of daily completion often fell to time-limited deckhands.

Communications were maintained throughout the trial, offering encouragement and validation and it was not until the end of the trial that participation rates became apparent as operators advised of the status of their logbooks, and provided constructive comments as to reasons for incomplete data (responses in Appendix C).

A smartphone application might be an easier option for instantaneous reporting, similar to the Victorian mandatory reporting of commercial sea urchin trips.

The two operators reported a total of 424 SBT caught, with 305 (72 per cent) retained and 119 (28 per cent) released by 241 fishing clients. On 40 per cent of fishing trips, the charter boats achieved bag limits for each of their fishing clients (two SBT per person per day). There was not any statistical difference in the mean number of SBT caught each day between the two operators ($F=0.01$, P-value=0.91, 1,46) each catching around nine SBT each day (Figures 15 & 16). The mean catches for May was 9.9, June (8.0) and July (4.8) SBT per day, however, the difference between the mean monthly catches were not statistically significant ($F=1.41$, P-value=0.25, 2, 45).

Figure 15 Histogram of the number of SBT caught (daily) reported by operator 1 who completed the logbook trial

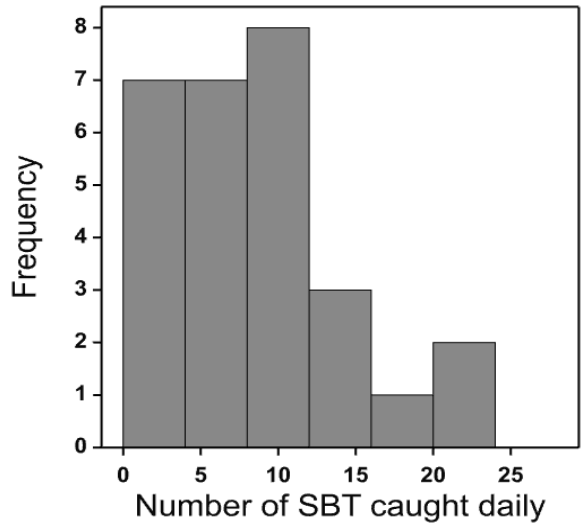
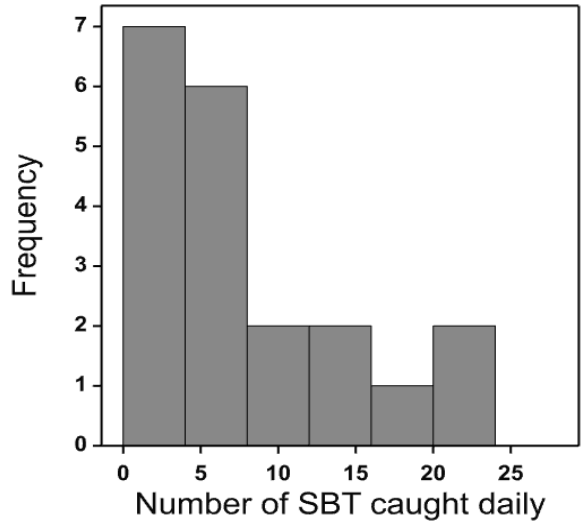


Figure 16 Histogram of the number of SBT caught (daily) reported by operator 2 who completed the logbook trial



Game fishing tournament survey

There was generally a positive response to the survey, with most of the contacted tournament organisers responsive to the voluntary survey.

In total 20 questionnaires were completed, identifying 12 tournaments that have the potential to encounter SBT (Appendix A). Most organisers reported zero catches of SBT in tournaments, often as a result of the timing of events being outside of SBT season. Further, with the exception of a few ports (eg. Bermagui (NSW), Port Lincoln (SA), or Eaglehawk Neck (Tasmania)), SBT are inaccessible for many tournament participants because of the long travel distances required to reach the offshore fishing grounds and the associated costs of running private boats to get there. Of the tournaments surveyed there tended to be a focus on tag and release, or catch and release, with little retention of fish reported. Some tournaments have disincentives for the retention of fish by precluding those weighed from scoring points. The potential retention of fish can also be influenced by other tournament regulations, such as line weight requirements,

that influence the size of the fish caught. The catch by tournament operators is likely to be at a level that warrants inclusion in an annual catch estimate for SBT for Australia

Key tournaments

The tournaments organised in southern Tasmania (Eaglehawk Neck) and out of South Australia (Port Lincoln and Port MacDonnell) were identified as being key events for SBT fishing (Table 12; Figure 17). The events have high relative participation rates and are often organised specifically to target SBT. Tournaments based out of Bermagui, Merimbula and Batemans Bay may be important for SBT in New South Wales. When organised in mid-May to late-July, these tournaments have the potential for encountering SBT.

The largest tournaments are the Riviera Port Lincoln Tuna Classic, Sport and Tuna Fishing Competition in South Australia and the Tom Jenkins Memorial Bluefin Championship in Tasmania. The Riviera Port Lincoln Tuna Classic reported the highest numbers of SBT caught and released, with 897 SBT caught in 2013. The Sport and Tuna Fishing Competition held out of Port MacDonnell caught 230 SBT in 2013. These three tournaments caught nearly 1500 SBT in 2013. Some other tournaments did catch SBT but at a low lower level (Table 12). The Tom Jenkins Memorial Bluefin Championship tagged approximately 20 SBT in 2013 (down from 72 in 2012) and 12 were weighed (retained). The organisers of the Tuna Club of Tasmania indicated that the season-long point scoring competition may be valuable to the survey with tuna tagged over many weeks. The Tuna Club of Tasmania reported that in 2013 a single fisher tagged 28 SBT in a single day.

Tournaments by jurisdiction

South Australia

There was one privately organised tournament of note identified in South Australia. The Riviera Port Lincoln Tuna Classic (6–7 April) registered 155 competitors and 20 boats. Over the two days in 2013, 897 SBT were caught and released, while just three were retained and weighed. The event organiser stated that this was an exceptional catch, with tournaments in previous years reporting catches of 400 to 500 SBT, with similar participation rates. The organiser further stated that there were very few SBT retained and weighed by competitors.

The Sport and Tuna Fishing Competition (4–11 May) is hosted by the Port MacDonnell Offshore Angling Club in Port MacDonnell, South Australia (Table 12). In 2013, 145 anglers and 43 boats tagged 230 SBT over the course of the event. The tournament organiser commented that 2013 was a reasonably low catch year compared to previous years.

Victoria

There were no Victorian GFA tournaments that target or encounter SBT (Table 12). The Eden Kingfish Classic, organised by a Victorian based web community ‘Mr Fisho’ (now affiliated with La Trobe Valley Game Fishing Club), involved many anglers that actively target SBT outside of tournaments. Despite being organised by a Victorian based collective, the tournament is held in Eden (New South Wales). However, the Eden Kingfish Classic is held out of the usual SBT season, towards the end of March, and therefore does not encounter any SBT.

Tasmania

Tasmanian game fishing tournaments reported encountering SBT with relative ease of access from Tasmanian ports.

The Tuna Club of Tasmania organises a series of tournaments, many with the potential to encounter SBT (Table 12). The Tom Jenkins Memorial Bluefin Contest (25–27 April, 2013) has the largest participation rate of the Tasmanian tournaments. There were 64 boats (three to four fishers in each boat) entered in the 2013 event. Over the three days, 12 SBT were weighed, and 20 were tagged and released. The victor of the 2013

tournament weighed in with an 88.9 kg SBT. The organiser of the event expressed that the 2013 tournament had a low catch levels.

The Light Line Contest (23–24 February) is also held by the Tuna Club of Tasmania. In 2013, it was held a month later than it is traditionally held. With 15 boats registered (averaging 3.5 fishers in each boat), the competitors weighed nine SBT over the weekend, with zero tagged and released.

The Coles Bay Classic (24–25 March 2013) run by the Southern Game Fishing Club of Tasmania targets largely Yellowfin Tuna and Marlin, with approximately 300 game fish tagged in two days of fishing. In 2013, there were 60 participants registered and 15 boats. Despite the large number of game fish tagged and released, only ten SBT were tagged, and six were kept and weighed during the 2013 tournament.

The Far South Classic (11–12 May 2013) is also organised by the Southern GFC of Tasmania, but in 2013 just one SBT was weighed, and none were tagged and released despite participation rates of 120 participants and 30 boats. In 2012, there were 5 SBT weighed and 10 tagged and released. Weather can play a significant limiting factor in this tournament (Sean Tracey 2015).

The St. Helens Game Fishing Club hosts a number of tournaments, including the St Helen's Game Fishing Classic (Easter, 9–10 March, 2013) which occasionally encounters SBT while targeting Yellowfin Tuna. There was no SBT encountered in 2013. The club does not target SBT in its own tournaments. The Game Fishing Club of Northern Tasmania does not coordinate any tournaments that target SBT directly, with members participating in tournaments organised by other game fishing clubs in Tasmania.

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New South Wales and Australian Capital Territory

The New South Wales Game Fishing Association (NSWGFA) indicated that there is very little active targeting of SBT in NSWGFA tournaments as most are held outside of the SBT season (Table 12). The New South Wales tournament season typically runs from September to May, while the SBT season in New South Wales is usually June to July. However, several tournaments encounter SBT intermittently in New South Wales.

The Batemans Bay GFC Annual Yellowfin Tournament (8–9 June, 2013) has the potential to be an important tournament for SBT. The event targets Yellowfin Tuna, but SBT are often encountered as tag and release species. The event is held at the start of SBT season and has a reasonably high level of attendance, with 28 boats registered in the 2013 tournament. The event coordinator has been involved in the club for 13 years, while the Yellowfin Tournament has been running for 27 years, and has extensive records dating back in that time. While very few SBT were encountered in the tournaments of 2012 and 2013, SBT were tagged and released in the 2011 event. The historic information from this tournament may provide an indication of the fluctuating availability of SBT to recreational fishers on the south coast of New South Wales.

The Canberra Yellowfin Tournament (18–20 May, 2013) is one of the largest tuna tournaments in New South Wales. Held just before the traditional SBT season, the tournament has the potential to encounter early season SBT. The event takes place out of Bermagui (New South Wales) and despite high participation rates (260 participants, 75 vessels) in 2013 there were no SBT encountered.

The Merimbula Broadbill and SBT Tournament is held over two weekends in late June. With ten registered boats competing over the two weekends (with three to four competitors in each boat), just one SBT was weighed in 2013 and none tagged and released. Given the timing of the tournament, the Merimbula Broadbill and SBT Tournament may become an important source of information in future years.

Other than those tournaments mentioned above, it is unlikely SBT will be encountered in significant numbers in other New South Wales events.

Table 12 Tournaments surveyed in Tasmania. New South Wales, Victoria and South Australia that have potential to encounter SBT, either through direct targeting or incidentally

	Tournament name/club	Location	2013 dates	SBT encounters
Tasmania	Combination Rally Tuna club of Tas.	Eaglehawk Neck	12 January 9 February	Yes
	Light Line Contest Tuna club of Tas.	Eaglehawk Neck	23–24 February	Yes
	St Helens Classic St Helens GFC	St Helens	9–10 March	No
	Coles Bay Classic Southern Gamefish Club	Coles Bay	24–25 March	Yes
	Easter Tournament St Helens GFC	St Helens	30–31 March	Occasionally
	Far South Classic Southern Gamefish Club	South Port	11–12 May	Yes
	Tom Jenkins Bluefin Tuna Contest Tuna club of Tas.	Pirates Bay	25–27 April	Yes
SA	Riviera Port Lincoln Tuna Classic Private tournament	Port Lincoln	6–7 April	Yes
	Port Lincoln Blue Water Classic Game Fishing Club of SA	Port Lincoln	13–20 April	Yes
	Sport &Tuna Fishing Competition Port MacDonnell Offshore Angling Club	Port MacDonnell	4–11 May	Yes
Victoria	All Victorian Game Fishing Tournament South Gippsland GFC	Port Welshpool	19–20 January	No
	Victorian Game Fishing Championships South Gippsland GFC	San Remo	2–3 February	No
	Victorian Game Fishing Classic Victorian GFC	Phillip Island	16–17 February	No
NSW	Batemans Bay Tollgate Islands Classic Batemans Bay GFC	Batemans Bay	18–20 January	No
	Botany Bay Shootout Botany Bay GFC	Botany Bay	25 January	No

Tournament name/club	Location	2013 dates	SBT encounters
Bill Heywood Memorial Tournament Botany Bay GFC	Botany Bay	25–28 January	No
Bermagui Bluewater Classic Bermagui Big Game Angling Club	Bermagui	26–28 January	No
Shellharbour GFC Tournament Shellharbour GFC	Shellharbour	9–10 February	No
Alliance Tag and Release Tournament Interclub competition	Bermagui	9–3 March	No
Eden Kingfish Classic Mr Fisho	Eden	23–24 March	No
Eden Invitational Eden Sport and GFC	Eden	5–7 April	No
Kiama Blowhole Big Fish Classic Kiama GFC	Kiama	5–7 April	No
Annual Yellowfin Tuna Tournament Canberra GFC	Bermagui	18–20 May	Yes
Annual Yellowfin Competition Batemans Bay GFC	Batemans Bay	8–9 June	Yes
Merimbula Broadbill Tournament Merimbula Big Game and Lakes Angling Club	Merimbula	21–23 & 28–30 June	Yes

Figure 17 Location of game fishing tournaments that target or reported catch SBT in south eastern Australia

Source: Geoscience Australia and ABARES

Chapter 7 Discussion

On-site surveys

Surveys to estimate the recreational catch of SBT have been conducted in Victoria (Green et al. 2012) and Tasmania (Forbes et al. 2009; Tracey et al. 2013). However, there have been no targeted surveys of SBT catch in South Australia or New South Wales. The geographic spread and episodic nature of SBT fishing in both these states presented substantial design challenges. It was with these challenges in mind that the design of the South Australian on-site survey trial was developed. The purpose of the trial was to design and test a methodology that would be cost-effective and provide on-going robust estimates of SBT catch, as well as estimates of error associated with sampling coverage. These data also provided the basis for designing an on-site sampling strategy for New South Wales in addition to South Australia.

In South Australia, expert advice indicated that recreational fishing is not limited to a small number of hot-spots, but is geographically diffuse across the state's coastline. The exception to this is Port MacDonnell, which shares fishing grounds with Victoria. Expert advice also indicated that recreational fishing activity in some areas of South Australia was episodic because of the availability of SBT or because local weather conditions limited access. Expert opinion indicated a similar situation in New South Wales, though anglers there tend to travel greater distances offshore to target SBT compared to the distances travelled by anglers in other jurisdictions.

The technical workshop (Hall et al. 2013) focussed on designing and testing an on-site methodology to sample diffuse, episodic fishing effort. The methods for sampling hot-spots of activity like Port MacDonnell have been established in Victoria (Green et al. 2012) and Tasmania (Tracey et al. 2013). As the fishing season is longer in South Australia and the catch, by number, is likely higher than in New South Wales, it was considered the best location for testing. It was expected that lessons learnt in South Australia would be applicable for sampling in New South Wales.

The sampling of rare, geographically diffuse and episodic events typically requires high sampling coverage or an adaptive sampling strategy (Dixon et al. 2005; Guisan et al. 2006). Temporally adaptive sampling was discussed extensively at the technical workshop as it has the potential to decrease cost and increase accuracy (Hall et al. 2013). The approach that showed the greatest potential for SBT recreational catch surveys was where sampling effort in an area is triggered by a spike in fishing activity above a predetermined threshold. This would require continual background monitoring of activity at known locations. This could be the number of large boat trailers at a boat ramp or number of SBT frames at cleaning tables. Alternatively, activity on dedicated fishing websites and social media could be used to guide survey effort. Temporally adaptive sampling was not pursued in the South Australian trial as the resources to deploy sampling effort (interview teams) to geographically disparate locations quickly were insufficient for this task.

Probability-based, on-site sampling guided by expert opinion on sampling key locations and periods was the most appropriate strategy for the South Australian trial. The key limitation encountered was the amount of sampling coverage that could be deployed in each sampling strata. During the 151 sampling days covered by the trial in South Australia, only 45 anglers targeting SBT were intercepted, spanning five sampling days. No SBT anglers were encountered on any other survey day, suggesting that the sampling coverage in the trial was too low to adequately capture the spatially diffuse and temporally episodic nature of recreational SBT fishing in South Australia.

The estimates generated from the South Australian trial had larger associated errors than the estimates obtained in the Victoria and Tasmanian surveys (Green et al. 2012; Tracey et al. 2013). The proportion of fishers targeting SBT during the South Australian on-site survey trial was much smaller (1.2 per cent) than in Victoria survey (Green et al. 2012). During the 2011 Victorian survey period, 60 per cent of fishers targeted SBT at Portland, 27 per cent of fishers targeted SBT at Port Fairy and Warrnambool and 15 per cent of fishers targeted SBT at Apollo Bay (Green et al. 2012).

The simulation of the on-site survey trial and the bootstrap analyses of the Victorian survey (Appendix B, Green et al. 2012) examined the effect of varying coverage levels of sampling days (proportions of weekdays and weekends sampled) on the precision of catch estimates. To understand how the episodic nature of SBT fishing influences sampling coverage in South Australia, two scenarios were tested: a 7 and a 14 day window of SBT availability. The scenario testing indicated that there was a greater level of error associated with the smaller availability window given the same level of survey days. This is because of the lower probability of detecting SBT fishing activity when the availability of SBT occurred for a shorter length of time. Larger sampling coverage (more days per strata) would be required if shorter windows of activity are more common than longer windows. More empirical data needs to be collected to better understand the true duration of SBT availability windows within each strata and its relationship to recreational fishing activity.

The simulated data indicate that there would be very little confidence in the current estimate of SBT catch in South Australia for the year surveyed. Increasing the number of survey days to 250, 330 and 500 showed a progressive decrease in error. Spread over an eight month fishing season (across the sampling sites), 500 survey days is likely to produce the optimum sampling coverage for South Australia assuming the fishery continues to operate in the manner observed in 2014. If the duration of the fishing season increases or more access-points are used then the number of days required for sampling would increase. The dynamic nature of the recreational fishery over the last few years suggests that such a scenario is plausible.

The results from the simulation studies are constrained by the fact the data come from a single season of sampling (2014) in South Australia. Given this and the fact the trial did not oversample the fishing activity, it would be prudent to sample at a higher rate for one or two surveys to build a more detailed empirical understanding of how variability and sampling coverage affect the precision of estimates. This would allow for bootstrap analysis to determine the optimum number of sampling days for future surveys. Surveying should also be designed to commence earlier in the season to ensure complete coverage of the SBT fishing season.

While the project did not test on-site surveys in New South Wales, the surveys of expert SBT fishers provided key information on sampling locations, high and medium use boat ramps and the duration of the fishing season. This information, in conjunction with spatial catch information of SBT from the Commonwealth Eastern Tuna and Billfish Fishery, was used to synthesize a dataset to allow the exploration of on-site sample sizes and coverage (as was used for South Australia).

A key influencing factor in designing on-site surveys for NSW is the ‘transit time’ for SBT, which is the time it takes SBT to move from the Victorian border to below Sydney through New South Wales. Expert opinion suggested that the transit time of SBT moving northwards off New South Wales has a large effect on SBT availability and catch rates per strata. The impact of this on survey design was explored using two scenarios, 14- and 21-day transit times. The simulation results suggest that there is greater error associated with faster transit times as SBT do not occur in one location long enough to attract much, if any, fishing activity. More empirical data on the movements and residency of SBT off New South Wales would improve the capacity to optimise a design for this jurisdiction.

The simulated data for New South Wales indicated that optimum sampling would occur at 330 survey days across the access-points. The fishing season is shorter in New South Wales than it is in other states, with most activity in June and July. This would allow for a high level of sampling saturation along the New South Wales coast at key points. Given the lack of empirical data for New South Wales, it would be prudent to initially sample at a higher rate to build a more detailed understanding of sample coverage and precision, which would allow for bootstrap analysis to determine optimum sampling days.

Charter boat logbook trial

Charter boat logbook data, if adequately collected, could provide a robust source of data for this component of the recreational fishing activity. It could be added to estimates of catch derived from on-site or off-site surveys to produce a total catch estimate for each jurisdiction. However, on-site and off-site survey designs

would need to ensure that catch taken from a charter boats was not double counted. Logbook data are likely to provide an estimate of the charter boat harvest of SBT in the jurisdictions that have compulsory systems in place (Western Australia, South Australia and New South Wales). In addition, the previous work in Tasmania has shown a voluntary logbook can be implemented successfully in that state (Tracey et al. 2013).

The trial of a voluntary logbook program in Victoria suggests that such an approach is unlikely to provide the data required in the current situation. Even given the initial support from operators, the added time-burden suggests that a voluntary approach was unlikely to be successful in this form. The trial did result in some suggestions for how limited SBT catch data might be obtained from charter boat operators, such as by simple catch recorders, or electronic devices including smart phone apps. There was the suggestion that basic clicker counters may be the most cost-effective option. Returning from each charter SBT fishing trip, the skipper could 'click' to record SBT numbers on each of their 'catch', 'release' and 'kept' clicker counters. Regular reporting of these data (e.g. 'phoned-in' on a monthly basis) would aid compliance and validation of data. However, this would not provide weight information, needed for estimates of harvested weight. This may not be critical if the charter boat catch is a small component of overall recreational catch.

If charter boats are trailer-boats and operate out of the key ports covered by on-site surveys, then they are likely to be surveyed as part of any SBT on-site surveys at these locations. This appears to be the situation in Victoria (Green et al. 2012), where Victorian charter boat catch of SBT is likely to captured if on-site surveys are employed.

The reliance on compulsory charter boat logbook data would be strengthened if further work was undertaken to verify the accuracy of these data. The project had initial discussions on the potential value of charter boat data as a lower-cost indicator of SBT recreational fishing activity. However, the potential for this requires more in-depth analysis and comparisons with other survey approaches through time.

There was also consideration of whether charter boat logbook data could provide a means of monitoring recreational fishing activity for SBT to determine when targeted on-site surveys should commence. However, this is unlikely to be possible due to the reporting constraints and time lag in data entry. In those states where logbook data provision is compulsory, the data are generally required to be submitted within one month of fishing. Allowing time for data entry and reporting means that real time monitoring to trigger adaptive on-site sampling is unlikely to be feasible.

Game fishing tournaments

Game fishing tournaments are known internationally to be a potentially important source of data (Salz et al. 2009). The key tournaments that encounter SBT through either direct targeting or incidental catch have been identified. Most tournaments are held outside of the SBT season. Tournament organisers suggested that there have not been more tournaments targeting SBT due to the inconsistency of the SBT season in some locations. In some years, SBT school further offshore, which makes them difficult to target for many anglers. Many of the tournament organisers suggested that this was the case for the 2013 season. However, other complex and variable factors, such as weather and the behaviour of the fishing fleet, also influence the number of SBT interactions.

In Tasmania and Port Lincoln (South Australia), where SBT are more accessible and the SBT season coincides with better fishing conditions, tournaments are organised specifically for SBT. To ensure effective surveys in the future, it is important to keep abreast of tournament schedules and any emergence of new tournaments as they may result in a large amount of effort being activated in a short period of time.

An ongoing program of data collection directly from tournament organisers could be instituted as a cost-effective method for collecting SBT catch data from these concentrated fishing activities. However, competitions could also be nested within on-site surveys. If collected, this tournament data could be added to estimates of catch derived from on-site or off-site surveys to produce a total catch estimate for each jurisdiction. However, on-site and off-site survey designs would need to exclude game fishing competitions

so double counting did not occur. Exclusion of these tournaments makes sense logistically, as it is likely to be more cost-effective to collect the information from organisers rather than to sample tournaments directly.

Approach for obtaining a national catch estimate

The information collected and approaches trialled in this project underpin the recommended options for future data collection. In some jurisdictions there is a single recommended approach, given previous surveys and trials. In other jurisdictions, there may be alternative approaches, which have different advantages and constraints. The overarching aim for these suggested approaches is to provide a robust, repeatable and cost-effective estimate of the recreational catch of SBT in Australia.

Indicative cost estimates have been provided for the options presented below where there is no sampling process currently in place. Therefore, the current Western Australian off-site survey and the compulsory state charter boat logbook programs are excluded from the cost estimates. If surveys are to be implemented, accurate costings should be undertaken as part of that implementation. As a comparison, the data collection and monitoring costs associated with the Commonwealth SBT Fishery, which covers the commercial sector, are currently around $745,000 annually (based on a three year average, T. Timmiss, pers. comm. 2015). The cost of the data collection and monitoring of the commercial fishery is covered by the Australian government and the commercial industry through cost recovery arrangements.

Off-site surveys

Phone diary based surveys

Off-site surveys, using phone diary based methods, have been shown to work for sampling low frequency events like recreational fishing for SBT where a targeted sampling frame is available (Tracey et al. 2013; Ryan et al. 2013). Using this method requires a more specific sampling frame than the White Pages®, which is commonly used for state or national recreational fishing surveys (Henry and Lyle 2003; Taylor et al. 2012). A boat-based fishing licence is used as a sampling frame in Western Australia, while in Tasmania a boat registration frame is used. Both these sampling frames appear to provide adequate coverage to cost-effectively screen for SBT anglers. Access to similar databases in other jurisdictions would allow much more cost-effective sampling than traditional on-site surveys. New South Wales and Victorian fishing licence databases should be able to provide the targeted sampling frames for these jurisdictions. However, it should be noted that in Victoria it has not been mandatory to provide a phone number when purchasing a recreational fishing licence. This is currently being rectified and may not be an impediment to future surveys. There are also a number of licence exemptions in both states. The potential impact of these exemptions on the robustness of the catch estimate would need consideration.

A comparison of on-site and off-site surveys in Tasmania (Tracey et al. 2013) reported larger catches of SBT through off-site sampling, with the authors concluding that the on-site survey was missing SBT catches because of limitations in coverage. Off-site surveys are likely to be the most cost-effective option for SBT in Tasmania. As the current boat-based survey in Western Australia appears to adequately sample SBT catch in that state (although this has not been validated) and is cost neutral, it is currently the best option.

The cost of implementing an off-site phone based diary survey of the recreational fishing licence databases in New South Wales and Victoria is estimated to be approximately $1.2 million. These could be combined with an offsite phone based diary survey based on the Tasmanian boat registration sampling frame for an estimated additional cost of about $0.25 million including some on-site validation. These costs could be further reduced if an SBT specific sampling frame could be developed which would remove the costs associated with sampling anglers that did not target SBT.

Off-site surveys are likely to be more cost-effective in jurisdictions with diffuse access points. The off-site surveys also have the advantage that if SBT in these states move outside of the typical sampling locations (such as moving adjacent to Sydney where sampling would be very difficult and expensive) the data is still able to be collected. Off-site surveys would capture any tournament or charter boat fishing undertaken. If the sampling frame is appropriate they would also sample moored vessels which the on-site method ignores.

The implementation of an off-site survey program for SBT could also consider coverage of other gamefish species, such as other tuna (e.g. Yellowfin Tuna, Albacore) and billfish (e.g. Striped Marlin, Broadbill Swordfish). Several of these species are important to Commonwealth and state governments, international fisheries and other stakeholders. Depending on the sampling frame, it may be cost-effective to survey for these species as a group.

Other databases, such as boat registration or boat licences, that would be useful for screening in South Australia are not currently accessible. This lack of access limits options for off-site surveys, especially for this state, which does not have a recreational fishing licence. As a result, an off-site sampling frame is not currently available for South Australia. If access to the boat registration or boat licence databases became available, an off-site survey could be implemented in each jurisdiction.

Validation of off-site surveys

Validation of off-site surveys could be used, at least initially, to provide reliable data on SBT size, which would translate to better harvest weight estimates. These on-site surveys would provide more precise length measures of retained SBT, which would increase the precision of harvest weight estimates, using accepted species specific length-weight relationship parameters for conversion. These on-site surveys could be undertaken at a number of locations, as the size of SBT appears to differ substantially between states, ports and even throughout the season. This would need to be taken into account in designing such a survey. It should be noted that these on-site validation surveys would not provide any increase in the precision of size or number estimates of released SBT or mortality rates of those releases. On-site validation has been costed as part of the Tasmanian off-site survey.

Licence and permit frames for off-site survey

One longer-term option for establishing a suitable off-site sampling frame for SBT is a national recreational fishing permit/licence system for SBT. This would provide a targeted and efficient sampling frame for off-site surveys. Permit and licence systems have been used to manage recreational catch and effort for particular recreational fisheries both in Australia and internationally. Where these systems exist, they can provide the contact details for anglers that are necessary for the off-site surveys to monitor the catch and effort.

A related approach is the use of harvest tags, where anglers are required to purchase tags in order to land a particular species. In order to obtain tags fishers would need to provide contact details to a central agency which could provide the sampling frame. This type of access tag system is used for snapper in Western Australia (Department of Fisheries Western Australia 2013) and Atlantic bluefin tuna in the United States (NOAA n.d.).

Conducting an off-site SBT survey based on a permit or tag based sampling frame would be relatively straightforward and in the longer-term probably most cost effective. Most of the expense in conducting off-site surveys is the initial screening phase. For rare events, like fishing for SBT, many thousands of households would need to be screened to find a single fisher. With a permit-derived or tag-based sampling frame presumably all people who purchase a permit will have the intention of fishing for SBT in the coming 12 months. Therefore, screening calls are likely to have predominantly positive hit rates, substantially lowering the cost of the survey. For example, if a national SBT recreational fishing permit was in place, the estimated cost of conducting an off-site (phone–diary based) is approximately $0.4 million. This cost estimate does not include the costs associated with establishing and maintaining a permit or tag-based system. An issue for adoption of such an approach for SBT is the mix of jurisdictional responsibilities; recreational fishing is a state administered responsibility whereas the management of SBT as a conservation dependent species under the EPBC Act, the management of the commercial fishery and engagement with the CCSBT are Commonwealth responsibilities.

On-site surveys

On-site (access point) surveys for SBT have successfully been undertaken in Victoria (Green et al. 2012). The key characteristic in Victoria, is the limited number of access points where SBT fishers concentrate. A similar situation is evident in Port MacDonnell in South Australia.

The results from the trial of on-site surveys in South Australia (excluding Port MacDonnell and Ceduna), demonstrated that this approach can be used but it will require a large number of sampling days. Over time, as survey data is available, it may be possible to refine the sampling design. Similarly, on-site surveys are possible for the south coast of New South Wales.

On-site surveys are likely to be the only option in jurisdictions where a targeted sampling frame is not available for off-site surveys. As demonstrated in Victoria, they also provide robust catch data and direct measurements of harvest weights. However, especially at a national scale, on-site surveys will be large, complex and expensive. Some access points used to target SBT are not close to population centres and geographically diffuse, making sampling challenging.

Proposed approach

Currently, the most cost-effective method to obtain a national estimate of recreation catch of SBT will be to use the most appropriate method in each jurisdiction. If these are implemented within the same time period (a calendar year, or fishing season), it will be possible to combine the jurisdictional estimates to generate a national estimate. The work undertaken in this project, clearly demonstrates there is not a single method that is applicable to all jurisdictions. In most jurisdictions there is a single method that is currently most applicable and most cost-effective. However, in New South Wales, it is less straightforward.

Game fishing tournaments

Though game fishing tournaments are likely to represent a minor part of the total SBT catch, it is still a component of the recreational fishery that should be accounted for and the data are relatively cost-effective to obtain with the cooperation of tournament operators. This project provides a list of the key tournaments and coordinating a survey of these tournaments at the same time as other surveys in each jurisdiction is recommended. The tournament catch from each jurisdiction could be added to the catch estimates from other techniques to provide a total catch estimate. Care would need to be taken to ensure on-site or off-site surveys do not include tournament participation. If this was not the case then potential double-counting would need to be factored into the analyses.

Western Australia

The off-site survey of boat based anglers in Western Australia, currently implemented by Western Australia Department of Fisheries (Ryan et al. 2013), offers adequate coverage to capture SBT recreational fishing catch. The survey provides regional estimates of retained and released SBT with acceptable standard errors. The surveys are conducted every two years and the SBT catch estimates from these surveys are reasonably robust and accessible. As long as these surveys are maintained, the data accessible and the nature of SBT fishing does not change, there is no need to conduct additional surveys of fishing from private boats in Western Australia.

The compulsory charter boat logbooks provide data on the SBT catch from this component of the sector. The estimate of total catch for Western Australia would be derived from the combination of these two data sources.

South Australia

On-site surveys are currently the only feasible option for South Australia. This is due to the lack of an accessible, targeted sampling frame for off-site surveys. If such a sampling frame becomes available, such as a boat licence database, it is likely to be more cost-effective to conduct off-site sampling.

On-site surveys of Port MacDonnell would require approximately 80 sampling days (based on sampling in Portland, Victoria; Green et al. 2012). For the remaining area of South Australia, the analyses undertaken in this project suggest a minimum of 330 on-site survey days, with surveys commencing in December and finishing in August. Because of the diffuse and episodic nature of fishing events and the large spatial scale of fishing over an eight month fishing season, it is recommended to initially deploy a higher number of sampling days. Modelling indicated a sample of 500 on-site days produced an error estimate of about 30 per cent (95 per cent CI) for a 14 day window of SBT fishing activity.

A sampling coverage of 500 days is likely to offer the best compromise between sampling cost and associated error. The estimated cost of a survey for South Australia (implemented in the same manner as undertaken in the trial) at a sampling coverage of 500 onsite sampling days is approximately $0.8 million. Lowering the number of sampling days to 330 would reduce the cost to approximately $0.52 million but at a substantial increase in estimated error to 40 per cent (95 per cent CI – 14 day window). The total estimated cost of a survey for South Australia at a sampling coverage of 580 days (including 80 days for Port MacDonnell) is approximately $0.92 million. The minimum number of sampling days required may decrease following further surveys and analyses to determine optimum sampling over seasons.

The effective implementation of an adaptive sampling approach would have the potential to reduce the costs of on-site sampling. Moving to such an approach may be best achieved through a commercial tendering process whereby the methods proposed by potential service providers to overcome the logistical issues that currently limit the application of this survey technique can be evaluated.

The compulsory charter boat logbooks provide data on the SBT catch from this component of the sector. There are key game fishing tournaments in South Australia. These two data sources would contribute to the estimate of total SBT catch for South Australia. Care would need to be taken to ensure the on-site surveys do not include tournament participation or charter boats. If this was not the case then potential double-counting would need to be factored into the analyses.

Victoria

A successful on-site survey has been conducted in Victoria (Green et al. 2012), surveying 162 days. Further analysis of the data demonstrated that the survey days could be reduced without significantly reducing the robustness of the catch estimate (0.02 relative error). Further reductions in sampling days could be made to half the survey days while maintaining error at less than 10 per cent (0.08 relative error). However, the year in which the Victorian survey was conducted (2011) was considered a ‘bumper year’. In future years SBT may not be as plentiful or may move to new areas outside the existing sampling locations. For this reason, reducing sampling effort below 130 days is likely to be a higher risk option. The cost of a survey for Victoria with a sampling coverage of 130 days is approximately $0.2 million. It is recommended to follow the methodology detailed by Green et al. (2012).

An alternative approach would be to use the Victorian angling licence database as a sampling frame for off-site surveys. This would allow for sampling coverage across Victoria. It could also provide information on changes in the spread or movement of effort over time, like the opening up of new fishing locations that are not currently captured in on-site surveys. However, the cost is likely to be considerably higher than an on-site survey in this state, estimated at about $0.64 million. The total cost of on-site surveys in Victoria is relatively low because of the limited number of access points and so this remains the more cost-effective approach.

There is currently no compulsory charter boat logbook program or key game fishing tournaments in Victoria to provide data on the SBT catch from these components of the recreational fishing sector. Therefore, the estimate of total catch for Victoria would be derived from the on-site survey alone and the coverage of the charter boat component would need to be considered in the survey design.

Tasmania

The 2011–12 survey of Tasmania indicated that off-site surveys captured a greater proportion of SBT than on-site surveys. The availability of an appropriate off-site sampling frame and the numerous diffuse access points, makes off-site surveys the preferred approach. An on-site validation component is added to verify SBT lengths for conversion to weight. The cost of an off-site survey with on-site validation for Tasmania is approximately $0.25 million. It is recommended to follow the methodology detailed by Tracey et al. (2013).

There is currently no compulsory charter boat logbook program in Tasmania, however a voluntary logbook system was successfully trialled in 2011–12. The cost of conducting a similar voluntary logbook system would be approximately $0.03 million if undertaken at the same time as the off-site survey. There are key game fishing tournaments in Tasmania. The estimate for total catch in Tasmania would be derived from the combination of these three data sources, with care taken to ensure there was no double-counting of fishing activities.

New South Wales

On-site surveys are only likely to be feasible for the south coast of New South Wales. In years when the SBT move further north, this approach is likely to under-estimate the catch.

The work undertaken in this project suggests that on-site surveys require an initial sample size of 330 on-site survey days for the south coast of New South Wales, with surveys commencing in June and finishing in July. The cost of a survey for New South Wales at a sampling coverage of 330 onsite sampling days is estimated to be about $0.52 million. Higher sampling rates (500 days) reduced the estimated error to 20 per cent (95 per cent CI – 21 day) and 30 per cent (95 per cent CI – 14 day), but at a much higher cost ($0.8 million). The minimum number of sampling days may decrease in the future after further surveys and analysis to determine optimum sampling levels. The effective implementation of an adaptive sampling approach (as described in the above options for South Australia) would have the potential to reduce the costs of on-site sampling.

An alternative approach in New South Wales would be off-site surveys using the recreational fishing licence database as a sampling frame. There are likely to be more advantages to conducting an off-site survey in New South Wales than Victoria, as fishing effort is more dispersed and episodic and if SBT move off Sydney on-site sampling will miss this fishing activity. The cost of an off-site survey in New South Wales is more expensive than an on-site survey (about $0.64 million) but would achieve a better coverage if SBT move offshore of Sydney or further north.

The compulsory charter boat logbooks provide data on the SBT catch from this component of the sector, and there are no key game fishing tournaments in New South Wales. Therefore, the total estimate of catch for New South Wales would be derived from combining the off-site survey and charter boat data.

Chapter 8 Conclusion

It is clear that there are challenges in estimating the national catch of SBT given that it has a wide distribution and occurs episodically and diffusely around much of the coastline. Despite being a popular part of the recreational fishing sector in some locations, fishing for SBT is still a relatively rare event. The sampling of rare events typically requires large sample sizes. Our results indicate that, without the availability of an appropriate nation-wide off-site sampling frame, high levels of sampling coverage for both on-site and off-site sampling is required to obtain robust estimates catch of recreationally caught SBT. As responsibility for recreational fisheries management sits with the state jurisdictions, establishing a SBT specific and nation-wide sampling frame for off-site surveying for SBT will require collaboration across jurisdictions and engagement with stakeholders. In the absence of a nation-wide off-site sampling frame our results indicate that no single survey approach will currently work in every jurisdiction. A tailored survey design for each jurisdiction is currently required to accommodate the circumstances of each State. The on-site testing and data simulation and modelling in this study enhanced our ability to optimise survey coverage for each state. However, further fine tuning is likely to be required as the surveys are implemented and as the recreational sector changes and evolves.

Chapter 9 Implications

Estimating SBT recreational fishing catch, given the currently available sampling frames, will be resource intensive. The recommended approach outlined above and summarised in the Recommendations, is the most cost-effective method currently available while still providing robust estimates. It is estimated this will cost an additional $2.3 million on top of the existing resources that are already allocated to processes that will contribute to estimating the national SBT recreational catch. A single year estimate is unlikely to be representative of the longer-term trend and take into account the apparent annual variation. Therefore a multi-year commitment to establishing a time series is likely to be required.

There are potential opportunities to reduce the resourcing requirements in the medium-term, for example if access to an off-site survey sampling frame could be obtained for South Australia, the overall survey costs could be reduced, also testing and implementation of adaptive sampling approaches to on site surveys may enable cost reductions where on site surveys are required. Over the longer-term, efforts should be directed towards establishing a national off-site sampling frame for SBT recreational catch that could substantially reduce the annual costs of surveying the recreational angler catch.

Chapter 10 Recommendations

Recommended approach

Given the current situation, particularly the lack of an appropriate nation-wide off-site national sampling frame, the most appropriate approach to obtaining a robust national estimate of recreational catch of SBT is to use specific surveys techniques best suited to each jurisdiction and combine these with data from charter logbook programs and game fishing tournaments to estimate the national catch (Table 13).

The recommended approach in Western Australia is to use the catch estimate from the biennial boat based angling off-site survey and combine it with the estimate from the compulsory charter boat logbook program. In South Australia, the preferred option is to conduct an on-site survey and combine it with data from the compulsory charter logbook program and game fishing tournaments. In Victoria, on-site surveys are recommended, if these do not cover the charter boat operations, further development of a logbook program for this sector is required. Off-site surveys are most appropriate in Tasmania and should be combined with data from a voluntary charter logbook program and key game fishing tournaments. Off-site surveys are recommended for New South Wales (using the recreational fishing licence database) and should be combined with the data from the compulsory charter boat logbooks. In all cases, consideration needs to be given to ensuring there is no double-counting between the general surveys and information from charter boat logbooks or tournaments.

Estimating the nation SBT recreational fishing catch, given the currently available sampling frames, will be resource intensive. The recommended approach summarised here is the most cost-effective method currently available while still providing robust estimates. It is estimated this will cost an additional $2.3 million on top of the existing resources that are already allocated to processes that will contribute to estimating the national SBT recreational catch. A single year estimate is unlikely to be representative of the longer-term trend and take into account the apparent annual variation. Therefore a multi-year commitment to establishing a time series is likely to be required.

Table 13 Recommended approach for surveying jurisdictions to obtain a national estimate of SBT catch, given the currently available sampling frames.

Jurisdiction	Survey type	Charter boat logbook data	Cost
Western Australia	Off-site boat based licence	Yes	Nil
South Australia	On-site	Yes	$0.92 million
Victoria	On-site	No	$0.2 million
Tasmania	Off-site using boat registration frame	Voluntary and would need to be funded	$0.28 million
NSW	Off-site using recreational fishing licence frame	Yes	$0.64 million

In the medium term, potential opportunities to reduce the resourcing requirements should be investigated, for example if access to off-site survey sampling frame could be obtained for South Australia, the overall survey costs could be reduced. Similarly the application of adaptive on-site sampling may reduce the overall costs of data collection in South Australia. Moving to such an approach may be best achieved through a commercial tendering process whereby the methods proposed by potential service providers to overcome the logistical issues that currently limit the application of adaptive sampling can be evaluated.

Over the longer term, efforts should be directed towards establishing a national off-site sampling frame for SBT recreational catch that could substantially reduce the annual costs of surveying the recreational angler

catch. If designed appropriately this sampling frame could potentially also be used for other game fish species targeted by recreational anglers. Given the current mix of jurisdictional responsibilities establishing a nation-wide, SBT specific frame for off-site surveying for SBT will require a collaboration across jurisdictions and engagement with stakeholders.

Future options

Off-site sampling frame for South Australia

There is currently no off-site sampling frame for South Australia, which necessitates the implementation of a large and costly on-site survey. In South Australia there are databases that would allow for more streamlined sampling frames to be developed including recreational boating licence and registration databases. As part of this project we have investigated gaining access to these databases, which was initially denied due to confidentiality reasons. However access to the boat registration database in Tasmania was granted for the 2011–12 off-site survey. It also appears possible to gain access to the New South Wales and Victorian recreational fishing licence databases. Access to an off-site sampling frame for South Australia is likely to substantially reduce the cost of surveys in that jurisdiction.

Adaptive sampling for on-site surveys is intuitively appealing as sampling days when SBT are not available to recreational fishers are not sampled and surveying time can be optimised to those days when they are available. However the logistics of organising sampling to coincide with SBT catch on a location by location basis has proven to be difficult when the duration of that SBT are available for capture may only be a few days. The most effective way to test the feasibility of this approach maybe via a commercial tendering process whereby the methods proposed by alternate service providers to overcome these logistical issues can be evaluated.

Further development

National off-site sampling frame

Over the longer term there are likely to be benefits in establishing a national off-site sampling frame for SBT recreational catch. A license or permit based system is one option that would allow a targeted national sampling frame to be developed. Internet and smart phone based surveys are a second option and have become popular due to convenience, speed and cost. However, if they are used for recreational fishing surveys without a randomised sampling frame they typically provide data that is biased towards avid anglers, which inflates catch estimates. If properly implemented, using appropriate sampling frames and data checks, these technologies have the potential to substantially increase sampling efficiency and reduce costs while providing useful output to anglers. An issue for such an approach is the current mix of jurisdictional responsibilities. In order to establish a SBT specific national off-site sampling frame for SBT, collaboration across jurisdictions and engagement with stakeholders will be required.

Chapter 11 Extension and Adoption

The project has provided regular updates to stakeholders including the advisory committee, which includes representatives from game fishing associations, the charter boat industry, technical experts and the jurisdictions, the Australian Fisheries Management Authority Recreational Angling Forum, Southern Bluefin Tuna Management Advisory Group, Department of Agriculture and Water Resources, Game Fishing Association Australia, Australian Recreational Fishing Foundation and Recfishing Research. We have also provided interviews with the Fisheries Research and Development Corporation's Fish magazine and Australian Broadcasting Corporation regional radio stations.

Chapter 12 Project materials developed

NA

Appendices

Appendix A: Charter boat logbooks

South Australia

South Australian recreational charter boat fishery operators have been required to be licensed since 2005. A boat is considered to be used for charter boat fishing even if recreational fishing activities are not the sole or primary purpose for which the boat is being used. For example, a dive charter operator or a shark–whale viewing charter operator requires a Charter Boat Fishery licence if passengers participate in recreational fishing or take fish during the charter trip. A charter boat fishing trip may involve passengers leaving the boat to undertake shore based fishing. In these cases, all fish harvested are considered to be taken pursuant to the charter boat fishing trip. A boat ferrying passengers to or from a shore-based fishing destination, provided that no fishing is undertaken while passengers are on board the boat or in association with that boat trip, does not require a Charter Boat Fishery licence (PIRSA 2011). A depth limit of 60 m applies for charter boat fishing activities and, although classified as a commercial fishery, a charter operator cannot take fish for trade or sale (Tsolos 2013).

A management plan is in place, with the current 'Management Plan for the South Australian Charter Boat Fishery' applying for 10 years from 1 August 2011. The fishery is limited entry, although licences may be transferred, and the fishery is also managed by gear restrictions, vessel numbers per licence holder, and minimum legal size, bag and boat limits for various fish species, and also a multi-day charter limit for overnight charter trips.

Licence holders complete a compulsory logbook for each trip, in which they report the start and end time of each fishing trip, the port of operation, the number of clients and their corresponding postcode, the fishing region sub-block (Marine Fishing Area) and details of the catch. Reporting of catch by species changed in June 2007, with the introduction of a new logbook, so only the number of each species harvested is consistent over the full time series. Logbook returns, including 'nil' returns, are submitted on a monthly basis (within 15 days of the end of the month) to SARDI Aquatic Sciences. Data are entered into the South Australian Charter Boat Fishery database.

In each financial year from 2009–10 to 2011–12, there were 109 licence holders in the Charter Boat Fishery. Of these, 77 licences were active, and operated from 83 vessels in 2009–10, 81 vessels in 2010–11 and 80 vessels in 2011–12 (Tsolos 2013). Thirty-seven ports along the South Australian coastline were utilised from 2009–10 to 2011–12, with the main regions fished being Gulf St Vincent–Kangaroo Island and Spencer Gulf–Coffin Bay. Key fishing locations included Coffin Bay, Port Lincoln, Whyalla, Port Hughes, Marion Bay, Port Adelaide and Cape Jervis. The main attraction for visiting clients was inshore and offshore fishing, with snapper, King George whiting, bight redfish and SBT the main targets (Tsolos 2013).

New South Wales

The main sites for game-fishing charter operators in New South Wales are Tweed Heads, Macleay – Southwest Rocks, Port Stephens, Broken Bay, Sydney Harbour, Botany Bay, Port Hacking, Wollongong, Kiama, Nowra, Ulladulla, Batemans Bay, Narooma, Bermagui and Merimbula. A total of 42 ports or sites within New South Wales were used by charter operators for access to the coastal fishery during 1997–98 (Steffe et al. 1999). Thirty-three of these ports or sites were nominated by these charter fishing boat operators as their main ports of operation. Charter boats are known to travel between ports to service various tournaments, with boats known to travel from as far afield as Cairns. In 1997–98, 42 per cent of the fleet indicated that they had used one or more ports of operation throughout the year (DAFF 2000).

During 1997–98, 211 operators were identified managing 249 charter fishing boats (Steffe et al. 1999); in 2010 there were 160 registered charter boats.

Since May 1997 there has been extensive consultation with charter fishing boat operators about how best to incorporate the marine and estuarine charter fishing sector into New South Wales Fisheries' management arrangements. Consultation included various rounds of port meetings with charter operators along the New South Wales coast, distribution of a comprehensive discussion paper to all identified operators and several

meetings of the Charter Fishing Boat Industry Review Group (CBIRG), which was established in 2000 to oversee the development of management arrangements for this sector. The Marine and Estuarine Recreational Charter Management Advisory Committee was established in 2002 to facilitate consultation with the marine and estuarine charter fishing boat sector. Committee membership, meeting and reporting requirements are outlined in the terms of reference.

New South Wales has had a charter boat logbook program since 2000 (NSW Charter Vessel Monitoring Program). In 2011, many operators reported difficulties with the requirement to record the number and size of all fish retained while charter fishing, and this requirement was known to add to non-compliance. Following discussions with the Charter Boat Industry Review Group it was agreed that a representative sample of fish caught would satisfy research objectives. Therefore, if all fish retained could not be measured, operators were requested to measure a random sample of the total catch (i.e. not sorted by size prior to measuring) to ensure there was no bias with the data. It was then decided that reporting of length measurements be excluded from logbook reporting requirements, with support for implementation of alternative methods to collect fish length data. Funding was to be sought from the Recreational and Charter Fishing Trusts.

In 2010, 80 per cent of registered charter boats indicated game fishing as at least one of their fishing activities. The most frequently retained game fish species (by number) in 2000 to 2010 were Dolphinfish, Australian Bonito, Skipjack Tuna, Yellowfin Tuna and Mackerel Tuna. The total retained catch of game fish peaked in 2001 and has declined since then, largely attributed to reduced logbook reporting by charter boat operators, particularly for released game fish, the departure of several major operators from the industry and, after 2006, the discontinuation of the dedicated game fishing logbook.

Catches of SBT have been reported by game fishers off southern New South Wales in recent years, with several charter boats involved in those activities. In 2004 SBT was listed as an endangered species in Schedule 4 of the New South Wales Fisheries Management Act 1994. Under section 221IG of the Act, the Minister for Primary Industries made a series of Interim Orders authorising continued recreational fishing of SBT. Interim Orders may be used to permit the continuation of an existing activity if considered necessary to reduce social or economic impacts during the assessment of a proposed Ministerial Order (Commercial landings of SBT in New South Wales state waters are not permitted). A draft Ministerial Order and a supporting Species Impact Statement was put to public consultation in April 2014. The proposed Ministerial Order will permit the continued recreational harvest of SBT in New South Wales and adjacent Commonwealth waters, reducing the personal bag limit from seven to one SBT, and introducing a daily boat limit of two SBT and a charter boat limit of six SBT, removing size restrictions for SBT. The proposed order will be applicable to all recreational anglers and boats fishing in New South Wales and adjacent Commonwealth waters, regardless of their state of residence.

To facilitate efficient management of the marine and estuarine recreational charter fishing boat sector, four endorsement categories of charter fishing have been identified and the category relevant to SBT is ‘game fishing’, which includes any recreational charter fishing activity that involves taking fish, catching and releasing fish, or attempting to take fish, other than protected species, in ocean waters (as defined in the regulation) as listed in Schedules 2 and 3 and according to bag and size limits. Recreational fishers under this category can take an incidental catch of one individual fish per boat trip from Schedules 1 and 4. The intention of this schedule is to include large game fish species, such as billfishes, large species of tunas, including SBT, and large species of sharks that are targeted by charter boats that specialise in game fishing.

Tasmania

Charter boats are not licensed in Tasmania and there are only small numbers of operators. In February 2012, 25 charter boat operators were identified throughout Tasmania, including Flinders Island (Tracey et al. 2013). Game fishing for SBT occurs between March and July, with peak catches and effort in April. Most charter fishing occurs in the south east of Tasmania adjacent to the Tasman Peninsula, with the vast majority of charter trips originating from Pirates Bay, and low numbers from Southport and Hobart.

A charter boat logbook for Tasmanian operators was designed in the early 2000s by the Sea Charter Boat Operators of Tasmania. Voluntary logbooks had been completed by some operators, but data were incomplete. The logbook has been completed in conjunction with surveys focused on estimating the charter boat catch of SBT (Morton and Lyle 2003; Forbes et al. 2009) and most recently during 2012 to assess

offshore recreational and game fishing with the aim of generating a total catch estimate for the SBT catches of by the charter boat sector. For the 2012 study, charter operators were asked to focus on the reporting of SBT catches (including zero catch days). The decision to focus on game fishing was taken to promote a high rate of returns by not burdening operators with details about all captures. Ten operators based in the south east of Tasmania were engaged in charters where SBT were targeted or caught during 2012 (Tracey et al. 2013).

The logbooks record information relating to fishing trips including the date, general fishing area, fishery type, time spent fishing, amount of gear used and the number or weight of fish retained and released. The logbooks also allow operators to record interactions with wildlife. Fishing effort is reported in two ways. The first uses specific effort information from a given trip including the number of fishing lines trolled and the total soak time (hours). The second is a count of the number of days game fishing occurred in areas where SBT are likely to be caught. While data is collected on the number of clients on-board, this is not used as a means to determine fishing effort. Not all individuals will be in possession of a line because fishing is undertaken using trolled lines rather than individual lines. Daily catch is reported as the number of fish caught (kept and released) on a day. Zero catch days when game fishing occurred in areas where SBT could have been caught are also logged by skippers to provide complete data for of estimating catch-per-unit-effort.

Victoria

Charter boats are not licensed in Victoria and there is no charter boat logbook program in place. Game-fishing activities directed at SBT occur off Victoria's west coast from ports including Portland, Warrnambool and Port Fairy. Those activities include substantial numbers of trailer charter boats. Game-fishing charter boats are not known to be active off eastern Victoria, although Lakes Entrance and Mallacoota may hold potential if boat ramps are upgraded or if the game fishery for swordfish expands. Southern Bluefin Tuna are listed as threatened species under the *Victorian Flora and Fauna Guarantee Act 1988*; but recreational fishing is permitted under an exemption.

Western Australia

A specific management framework for the aquatic tour industry (including fee-for-service fishing charters and aquatic eco-tours) was introduced in late 1988, including the requirement for a Fishing Tour Operators Licence (FTOL) for charter operators ‘conducting extractive fishing tours for a commercial purpose’, with a benchmark date of 12 September 1997. The benchmark date was designed to cap fishing tour activity at 1997 levels until the relative impact of fishing tours on fish stocks and fish habitat could be assessed (Department of Fisheries, Western Australia 2012).

The requirement to hold a FTOL (or an Aquatic Eco-Tourism Operators Licence, AETOL) came into effect on 1 July 2001. Within 12 months nearly 250 FTOLs had been granted. In 2004–05 existing AETOL holders were provided the opportunity to transition to a new Restricted Fishing Tour Operators Licence (RFTOL) if they wished to be able to fish for the purpose of providing an immediate meal during the course of the tour. The number of licensed aquatic tour operators peaked in 2007–08 with approximately 270 FTOLs, 35 RFTOLs and 7 AETOLs operating in one or more of four management zones—Pilbara and Kimberly Zone (~3050 FTOL fishing tour days, ~900 non-extractive fishing tour days), Gascoyne Zone (~2250 FTOL fishing tour days, ~1150 non-extractive fishing tour days), West Coast Zone (~3750 FTOL fishing tour days, ~1600 non-extractive fishing tour days) and South Coast Zone (~600 FTOL fishing tour days, ~250 non-extractive fishing tour days). Numbers have declined since then as a result of operators leaving the industry.

After a decade of monitoring, as at 3 September 2012 (the beginning of the 2012–13 licensing year) there were 211 FTOLs, 26 RTOLs and 6 AETOLs valid in Western Australia (Department of Fisheries, Western Australia 2012). As part of their licence obligations, charter fishing operators provide monthly logbook records of all the fish their clients catch to the Western Australian Recreational Fishing Surveys and Statistics Branch.

Logbook trial

Trial logbooks were designed for the Portland SBT charter boat fishery based on the review of existing charter boat logbook programs, in consultation with staff from the Catch and Effort Data Collection unit of Fisheries Victoria, Fisheries Victoria Compliance Officers and several Charter Boat Industry leaders.

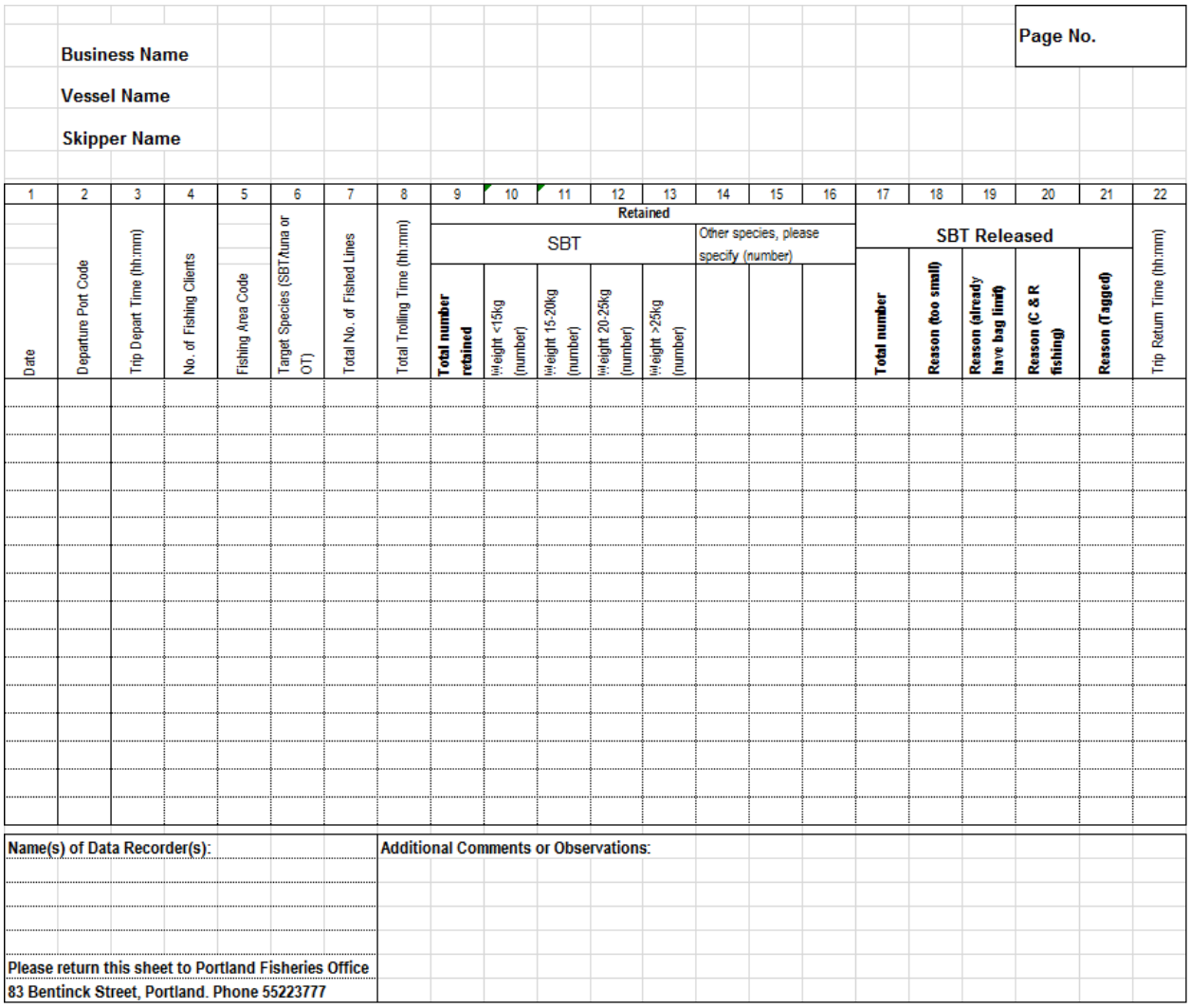
Management objectives included the requirements of a simplified form (Figure 18), which would enable ease of data recording and data entry (hence a similarity with commercial catch and effort logbook design).

Data elements required were as such determined: trip date; port of departure; time of departure; number of fishing clients; fishing area/location; target species (SBT/tuna/other); total number of fished lines; total fishing time; total number of SBT retained; size of retained SBT; number of other species caught; total number of SBT released; release reason; time of trip completion. Accompanying documents included instructions for completion, a fishing area zone map, a port code listing and an optional fish length and weight data sheet.

Department of Environment and Primary Industry Fisheries Victoria Regulation and Compliance Fisheries Officers based at Portland were able to identify a list of 14 SBT charter operators, including both local and seasonal operators. Contact details were obtained from websites.

Strong collaborative links previously forged with several industry leaders were used to garner support for the project, and a draft design was taken to an Industry meeting in Portland on April 9th, which also enabled explanation of the aims, benefits and consequences of the project. A few edits were made, and a revised design was printed and distributed to the Charter boat industry thereafter. Logbooks were distributed either directly by Fisheries Officers; via email to 11 operators on 15 April; or were available for collection by the Charter operators from the local Fisheries Office in Portland.

Figure 18 SBT survey form for Victorian charter boat voluntary trial



Page No.

Business Name

Vessel Name

Skipper Name

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
								Retained													
								SBT					Other species, please specify (number)			SBT Released					
Date	Departure Port Code	Trip Depart Time (hh:mm)	No. of Fishing Clients	Fishing Area Code	Target Species (SBT,tuna or OT)	Total No. of Fished Lines	Total Trolling Time (hh:mm)	**Total number retained**	Weight <15kg (number)	Weight 15-20kg (number)	Weight 20-25kg (number)	Weight >25kg (number)				**Total number**	**Reason (too small)**	**Reason (already have bag limit)**	**Reason (C & R fishing)**	**Reason (Tagged)**	Trip Return Time (hh:mm)

Name(s) of Data Recorder(s):	Additional Comments or Observations:
Please return this sheet to Portland Fisheries Office	
83 Bentinck Street, Portland. Phone 55223777	

INSTRUCTIONS

<u>PLEASE NOTE:</u> In order to collect important <u>effort</u> data, all columns must be completed whenever fishing activity is undertaken. This includes when no fish are caught or retained.

1 Date: Write the day of the month.

2 Departure Port Code: Write the port code for the port from which the vessel departed.

Refer to the attached port code list e.g. Portland is 300.

3 Trip Depart Time (hh:mm): Show the time as 4 digits, 24 hour clock time e.g. 0500 = 5am,

1700 = 5pm.

4 No. of Fishing Clients: Number of people fishing.

5	**Fishing Area Code:**	Write the area code for the area in which you fished. If, on any trip, you fished in more than one area, complete a separate line for each area. Refer to the attached map for area codes.
6	**Target Species:**	Write SBT if Southern Bluefin Tuna were the target species, tuna if tuna generally were the target species, or OT if other species were the target.
7	**Total No. of Fished Lines:**	Write the total number of lines fished.
8	**Total Trolling Time (Fishing Time) (hh:mm):**	Write the total time the gear was in the water. (Exclude time spent travelling to fishing grounds when no fishing was undertaken) Show the time as 4 digits, e.g. 0500 = 5 hours, 0530 = 5 hours 30 minutes.
9	**Number of retained SBT:**	Write the total number of SBT kept.
10-13	**Weight of retained SBT:**	Guesstimate the weight category of retained SBT and record numbers
14-16	**Other species:**	Specify the names and numbers of other species caught and retained by the clients. If there are not enough columns, record the species retained in highest numbers.
17	**Number of SBT released:**	Specify the number of SBT released by the clients.
18-21	**Reason(s) for release of SBT:**	Specify the number of SBT released for each reason(s).
22	**Trip Return Time (hh:mm):**	Show the time as 4 digits, 24 hour clock time e.g. 0500 = 5 am, 1700 = 5pm.
	Name(s) of Recorder(s):	Provide the names of all crew fishing with you during the recorded fishing activity.
	Additional Comments:	Provide any comments relevant to your fishing activity.

Approximately 6 charter operators undertook to voluntarily participate in the logbook trial

The trial ran through the main tuna 'season' off Portland, commencing in mid-April 2014. Participants were contacted to request the return of datasheets at the end of June 2014, and subsequently.

The trial data was analysed to determine the applicability of using these data as a low-cost indicator between years of on-site surveys. The data was also analysed to determine the applicability of using these data as a

means of monitoring recreational fishing activity for SBT to determine when on-site surveys should commence.

Operator responses

While a good level of acceptance of the project and cooperation of approximately half of the operators was obtained the actual reporting identified several problems in implementation.

The key area of difficulty was in minimising the burden for voluntary completion. Operators were not always skippers, and the task of daily completion fell to time-limited deckhands.

Communications were maintained throughout the trial, offering ‘encouragement‘ and ‘validation’ and it was not until the end of the trial that participation rates became apparent as operators advised of their incompletion of the logbook, and constructive comments as to their reasons why.

Operator 1

Didn’t fill out the forms at the time, although he did intend to, as it became 'yet another task' on top of mandatory returns for his commercial rock lobster fishing operation. Informed that personal electronic records of charter operations were kept, and offered to transcribe data for the project, after the rock lobster fishing season ended (15th Sept). Acknowledged that he might be able to modify his spreadsheets (remove financial data) and send the data in that way.

Operator 2

Travels to Portland for the SBT season. During that time his boat is in Portland and he travels back and forwards from his home location. Maintains a diary of charter bookings; didn’t fill out the log sheets as he went, but intended to transcribe info from his diary onto the log sheets.

Note: met with operator at home location to pick up datasheets, and additionally obtained historical information from 2013 season.

Operator 3

Didn’t obtain the forms until after the trial had started and determined that incomplete data wouldn’t be useful. Offered that the catch this year would be down on last year as there was a limited number of fishing days due to weather.

Operator 4

Did request of his skipper that the forms (on board) be completed, but workload and time commitments prevented completion.

Operator 5

Did have copies of the forms on the boat, but they didn't get completed. Intended to transcribe from private diary data, but didn’t.

Operator 6

Good intentions, unfulfilled. Portland based. Offered that he too kept a diary of bookings which could potentially be transcribed.

Operator 7

Very familiar with local conditions and fishing, as he also commercially fishes for rock lobster.

Did fill out forms for a few days, then just recorded as usual in his fishing diary, some of the same data is recorded in charter logbooks for maritime board. Most days did bag, it was a ‘consistent’ season, but fish early in season were a bit larger at 25kg, then later they were around 17kg, and quite late in the season they were up over 20kg again. The timing of this year's season was the same, but local areas where the fish were

found were different; Easter April storms usually push SBT in closer, but these storms didn't arrive until much later, in June/July. They could still be caught in close around the weeks of a full moon (at 40m depth). Food sources were less plentiful, krill and plankton on an upwelling at 200m. Thermocline at 10m depth there. Came in to 140m depth. Good numbers. Good bait schools, but fewer than in previous years. An early upwelling at the start of the season, flushed through krill, and the season started instantly, in a rush at the continental shelf (heard that it's a Super El Nino in the Northern Hemisphere this year – impact on our fishery?). Last year the sea surface temp maps showed warmer patches, which made it easier to find the SBT, this year seas surface temperature maps were 'more smudged' but the SBT were easy to find because they were localised at the shelf feeding.

Forms should ask if SBT have been seen visually, because often when you see SBT feeding, they're not caught.

Forms could also record bird activity, which is often used as a signal of SBT presence–feeding on baitfish; gannets and little terns (fairy trial) in close, albatross and shearwaters in deeper waters.

Other suggestions

Pre-print as much as possible on the forms, i.e. make them specific to each operator/boat, rather than generic.

Remove as many columns as possible, e.g. number of fishers or release reason; note that in Victoria, it's possible to have more than one trip each day, as a trip may be completed upon 'bagging out', whereas in Tasmania, for comparison, clients pay for a day trip.

From Portland, the SBT charters (March–July) are usually trips of 8-10 hours, travelling 1-1.5 hours to get 50 km or so offshore to the fishing grounds. A 6 person boat charter costs ~$1500 on a weekday, $1750 on a weekend, or for mixed persons/individuals $250-300 per person on a weekday, $320 per person on a weekend (may be a minimum of 4 persons required).

Size of SBT is not very variable throughout the season, and could be something removed from the data requirements to simplify the datasheets. Might get one or two operators who would record lengths, or who would take photos on a standard size cleaning table for comparison.

A smartphone app might be an easier option for instantaneous reporting (as per Victorian mandatory reporting of commercial sea urchin trip reporting).

Appendix B: Bootstrap simulation

Bootstrap simulation for Victorian SBT survey 2011

Fisheries Victoria conducted an onsite boat ramp survey to provide an estimate of the recreational daytime trailer boat catch of SBT off the Victorian coast at the key ports of Portland, Port Fairy, Warrnambool and Apollo Bay (Green et al. 2012). Subsequently a non-parametric bootstrap simulation study was carried out to examine the effect of varying levels of coverage on the precision of the population estimates. For each level of weekday and weekend coverage combinations, the following steps were followed:

i. obtain a bootstrap sample of appropriate sample size by re-sampling original data randomly with replacement

ii. compute the bootstrap version of the parameter estimate

iii. repeat the steps in (i) and (ii) N number of times and obtain an estimate of the bootstrap distribution.

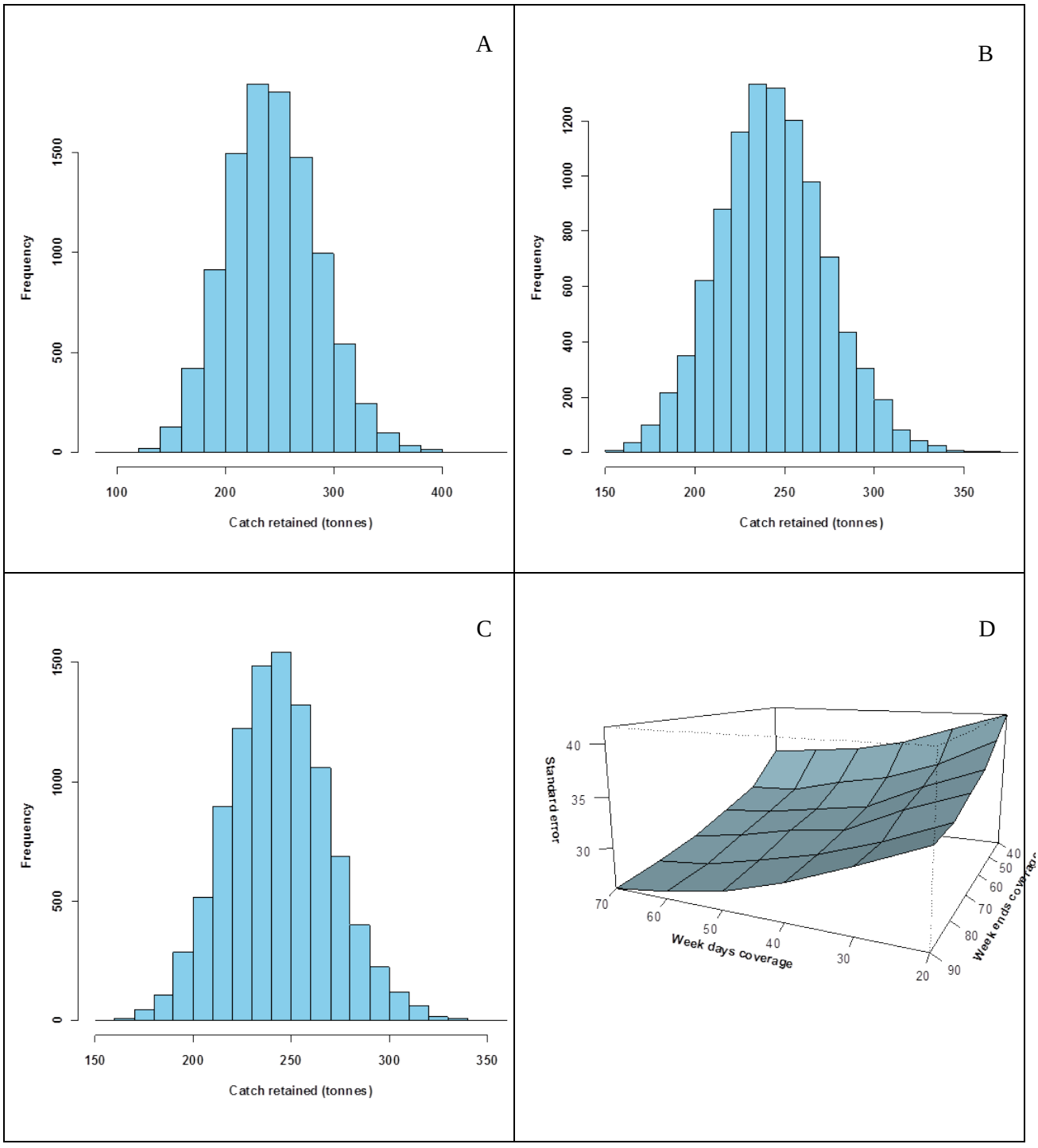
In Green et al. (2012), the level of coverage during weekdays was about 45 per cent and during weekends was about 90 per cent.

The estimated total SBT retained in Victoria was 240 tonnes with a standard error of 31 tonnes resulting in a relative error of 0.13. (Sigma/Total estimate), which is similar to the coefficient of variation. The bootstrap simulation was carried out by varying the level of weekday coverage from 20 per cent to 70 per cent and weekend coverage from 40 per cent to 90 per cent (Figure 19).

In the simulation study, even the lowest weekday and weekend coverage of 10 per cent and 20 per cent respectively, produced a relative error of 0.25 — which is almost double the size of the original relative error. When the weekday and weekend coverage were increased to 70 per cent and 90 per cent respectively, the resulting relative error was 0.10.

It was found that any changes in weekend coverage had a slightly bigger impact on relative error than any changes in weekday coverage; which was expected as the fishing effort is much higher on weekends compared to weekdays. It is worthwhile to note that 60 per cent of anglers from Portland, 27 per cent from Port Fairy and Warrnambool and 15 per cent from Apollo Bay were targeting SBT during the survey period and most of them were successful in catching SBT. SBT catch was consistent among sampling days during the peak period.

Figure 19 Histograms of bootstrap estimates of total catch retained when weekday and weekend coverage were respectively: A) 20 per cent & 40 per cent, B) 50 per cent & 70 per cent and C) 70 per cent & 90 per cent. D) Perspective plot of standard errors.



Bootstrap simulation to study bias in the estimation

A bootstrap simulation study was also undertaken to study the sampling bias that may be introduced to the population estimate of SBT. This may happen if characteristics of a selected sample differ to the characteristics of a population and this may happen in SBT fisheries which are very sporadic and episodic. Even in the case of an unbiased estimator, if the sampling estimation is repeated many times, there will always be a 1 in 20 chance that the absolute error or bias (B) exceeds 1.96 times the standard error, resulting in a bias over sigma ratio of 0.1 and a probability of error of 0.051 (Cochran 1977). Even when the bias over sigma ratio is 0.4, the probability of error is 0.068. The following bootstrap simulation considers a population of SBT catch with a temporal sampling frame of 214 calendar days (1 January 2014 to 31 July 2014) with the daily catch randomly generated from a negative binomial distribution with multiple peaks (6 peaks during the sampling period). The design of this arbitrary survey is simple random sampling and days are considered to be the primary sampling units. The general algorithm for bootstrap simulation was similar to the previous Victorian bootstrap simulation study.

From this simulation study, at 20 per cent temporal coverage (Figure 20), the bias/sigma ratio was 0.61 with a probability of error being 0.1 (Table 14). The bias was then reviewed at 50 per cent coverage (Figure 21). When the temporal coverage was increased to 80 per cent (Figure 22), the ratio of bias/sigma was 0.21; equivalent to a total error of 0.055 which is almost a 1 in 20 chance of committing an error. However, in all of the simulation scenarios, the relative error is fairly acceptable with the highest coverage resulting in the smallest relative error. Thus, even in a simple scenario of sampling, for a single ramp with multiple temporal peaks in SBT catch, a fairly high sampling coverage is required (more than 50 per cent) to minimise bias to within an acceptable range.

Figure 20 Histogram of bias (population total-estimated total), bias/sigma and relative error (sigma/total) when the temporal coverage is 20 per cent

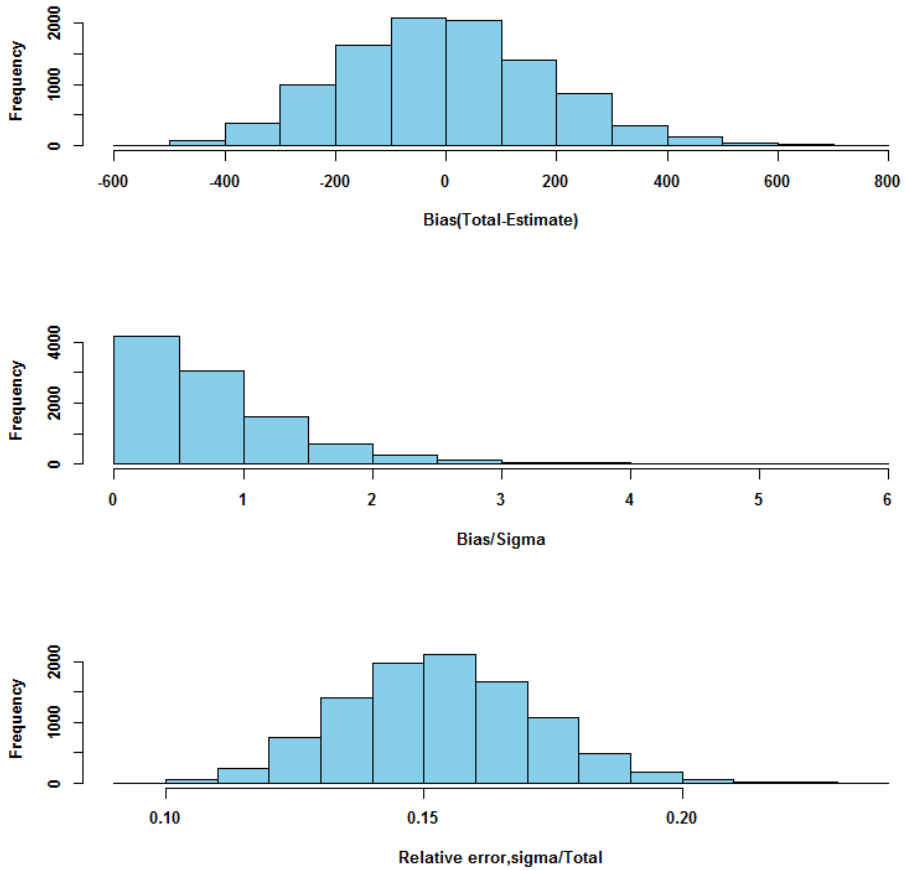


Figure 21 Histogram of bias (population total-estimated total), bias/sigma and relative error (sigma/total) when the temporal coverage is 50 per cent

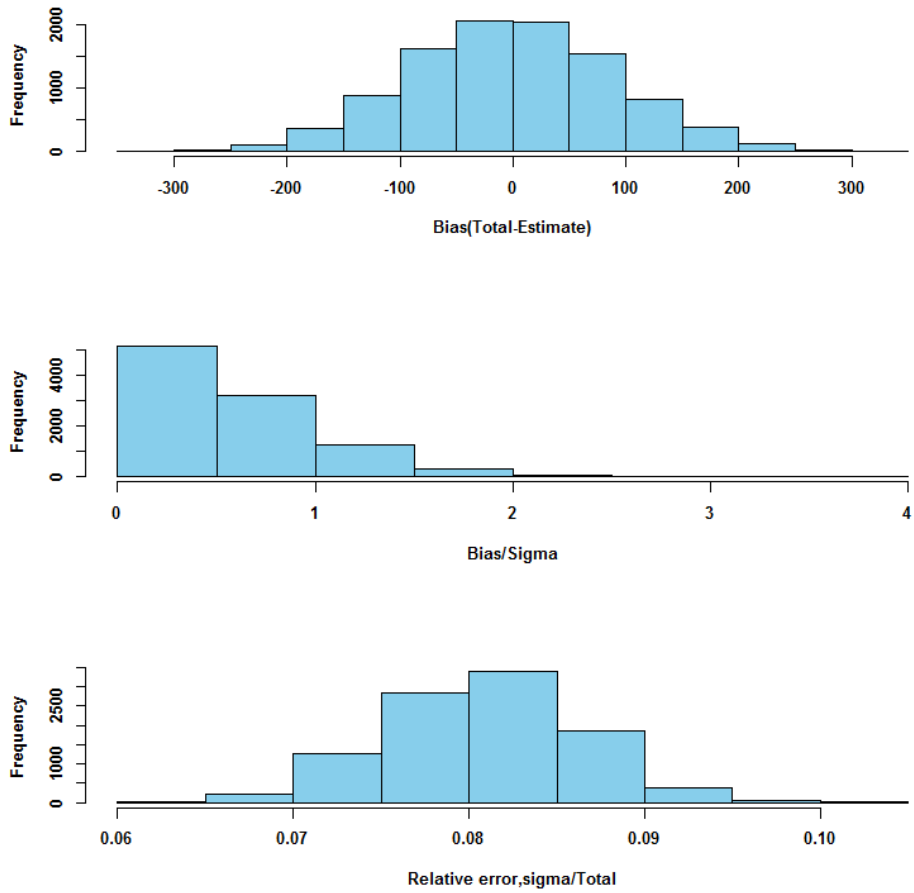


Figure 22 Histogram of bias (population total-estimated total), bias/sigma and relative error (sigma/total) when temporal coverage is 80 per cent

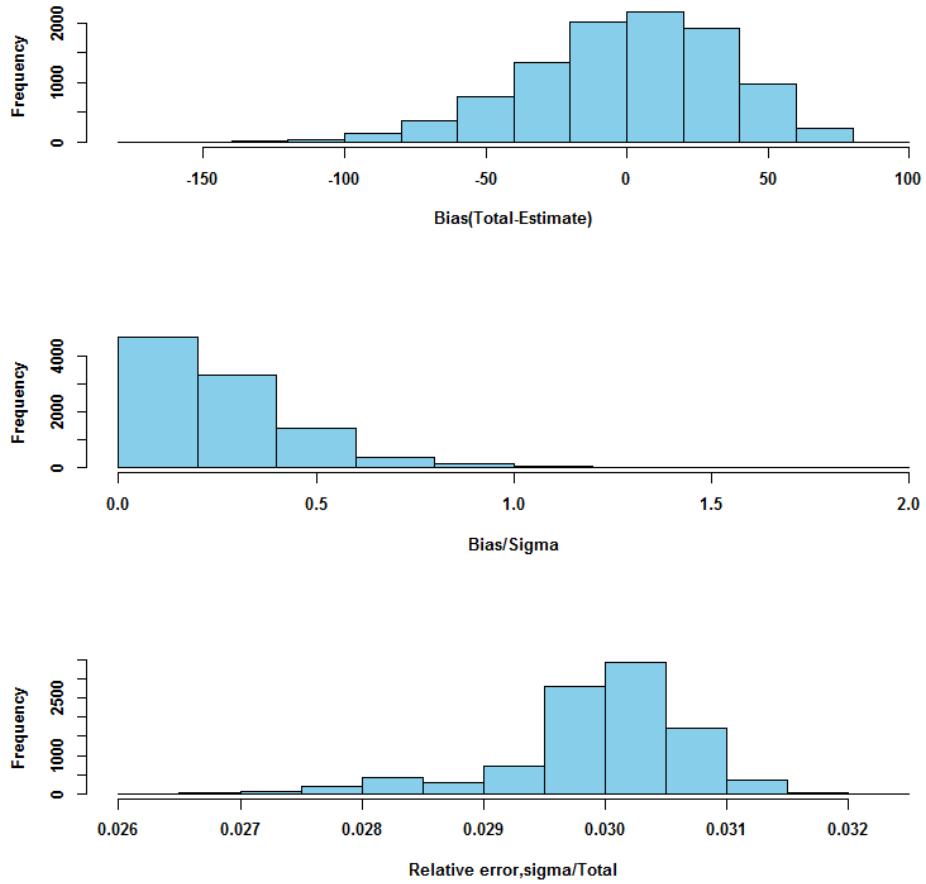


Table 14 Bias/sigma and relative error of bootstrap estimates at various levels of temporal coverage for the arbitrary SBT catch population

Temporal Coverage%	Bias/sigma	Relative error (sigma/total)
20	0.61	0.15
50	0.48	0.08
80	0.21	0.02

Appendix C: Expert surveys

Expert surveys

Eight ‘expert SBT anglers’ were identified for the fishery in South Australia and five in New South Wales. Each was interviewed by telephone or face-to-face and asked a set of questions about their familiarity with, and knowledge of, the SBT fishery in their State. A standard structured interview was used to determine:

- their SBT fishing avidity, by assessing their frequency of fishing in their State (annually, monthly, weekly, daily) during the SBT season
- the origins of their relevant knowledge and level of experience
- the regions of their State that they were familiar with in terms of the SBT fishery (high, medium, low ratings). In South Australia, interviewer experience was categorised geographically as relevant to seven regions: Eyre and Western; Far North; Yorke and Mid North; Barossa; Adelaide; Fleurieu and Kangaroo Island; and the Limestone Coast. In New South Wales regions were categorized as: Sydney, South Coast (North of Ulladulla) and South Coast (South of Ulladulla).With the aim of identifying regions appropriate to focus SBT surveys in their respective States, the experts were asked (for the regions they knew well:
- to rate the recreational SBT fishing activity (high, medium, low) and to comment on any specific fishing grounds for SBT, such as named reefs, and the distances offshore within their State
- to rate a complete set of coastal boat ramp locations relevant to their state as high, medium or low SBT fishing activity. Experts were also asked to suggest the ‘highest use’ boat ramp in each region for SBT fishing activity, and to nominate any relevant boat ramps omitted from the list. To identify the appropriate temporal scope for SBT surveys, the experts were asked to suggest the timing and duration (in months) of the SBT fishing season, including identifying the peak period as well as any trends in fish-size through the season.

To assign selection probabilities between samples of weekdays and weekends and public holidays, the experts were asked to estimate the relative SBT fishing effort activity between weekends and weekdays. To determine the appropriate timing of survey activity at the sampled boat ramps, the experts were asked to estimate the relative SBT fishing activity (returns to the ramp) in morning, afternoon and night periods.

For South Australia, the design of the onsite survey testing then considered the key boat ramps and locations and timing of fish availability reported by the experts to determine logistical arrangements and an appropriate sampling design.

The onsite access point survey design was based on methods developed by Robson (1960) and Robson and Jones (1989), and was consistent with the methodological recommendations presented by the Australian Government to the Commission for the Conservation of Southern Bluefin Tuna (CCSBT) (Rowsell et al. 2008) as previously utilised to obtain an estimate the total catch and effort of the Victorian recreational SBT fishery (Green et al. 2012). The survey design was also consistent with the recommendations from the onsite survey design workshop. As recommended in Hall et al., the scope did not include night time fishing, nor consider catch and effort from moored boats. Catch weight was calculated from CCSBT weight for length regression. The selection probabilities and proportional allocation of sampling within strata (‘large’ verses ‘small’ ramps; weekend or public holiday verses weekday for onsite survey testing) was determined based on project budget and informed by the ‘expert knowledge’ interviews, as were key regions and ramps. An analysis was made of distances between ramps and regions to determine the number of staff required (two creel clerks required for each survey day) and potential locations for their ‘home-bases’.

South Australia

Rating of regions of the state that experts were familiar with in terms of the SBT fishery (high, medium, low ratings)

Eyre and Western

- 1 Port Lincoln based with high knowledge of Farm Beach, Coffin Bay, Port Lincoln, and medium knowledge of Sceale Bay, Venus Bay, Anxious Bay, Elliston
- 1 Vic based with medium knowledge of Fowlers Bay, Ceduna, Port Lincoln
- 1 Port MacDonnell based with high knowledge of Port Lincoln
- 1 Adelaide based with high knowledge of Ceduna, Coffin Bay, Port Lincoln
- 1 Adelaide based with high knowledge of region

Far North

- 1 Adelaide based with high knowledge of region – Port Augusta region (i.e. Upper Spencer Gulf) not relevant in terms of the SBT fishery

Yorke and Mid North

- 1 Vic based with medium knowledge of Marion Bay
- 1 Adelaide based with medium knowledge of region

Barossa

- 1 Adelaide based with high knowledge of region – Port Parham, Webb Beach, Middle Beach, Port Gawler not relevant in terms of the SBT fishery

Adelaide

- 1 Port MacDonnell based with high knowledge of Adelaide Outer Harbour
- 1 Adelaide based with high knowledge of Adelaide Outer Harbour
- 1 Adelaide based with high knowledge of region – Adelaide region (i.e. Gulf St Vincent) not relevant in terms of the SBT fishery

Fleurieu and Kangaroo Island

- 1 Vic based with medium knowledge of Cape Jervis, Victor Harbour
- 1 Port MacDonnell based with high knowledge of Cape Jervis
- 1 Adelaide based with high knowledge of Cape Jervis, Kangaroo Island, Victor Harbour
- 1 Adelaide based with high knowledge of region

Limestone Coast

- 1 Vic based with high knowledge of Kingston, Robe, Beachport and Port MacDonnell
- 1 Port MacDonnell based with high knowledge of Robe and Port MacDonnell
- 1 Adelaide based with high knowledge of Port MacDonnell
- 1 Adelaide based with high knowledge of region

Rating of regions of the state that experts were familiar with in terms of recreational SBT fishing activity (high, medium, low)

Eyre and Western

- While the region in general was rated as high activity, the boat ramps from Fowlers Bay to Streaky Bay were rated as low use for SBT access, Sceale Bay, Venus Bay, Anxious Bay, Elliston, Farm Beach were rated low-medium use, with Coffin Bay and Port Lincoln rated medium-high use (high activity at Port Lincoln specifically March to May with the Port Lincoln Blue Water Classic held in April).

Far North

- No use

Yorke and Mid North

- The region in general was rated as medium activity; of specific boat ramps, Marion Bay was rated as medium activity

Barossa

- No use

Adelaide

- Only the Outer Harbour boat ramp was rated, as medium activity for SBT rec fishing (by two of the experts)

Fleurieu and Kangaroo Island

- The region in general was rated as high activity; Cape Jervis was rated by two experts as being of high activity, and by one expert as being of medium activity; Victor Harbour was rated as being of medium activity. Cape Borda off Kangaroo Island was specifically mentioned as an area of high SBT fishing activity.

Limestone Coast

- The region in general was rated as high activity; Kingston was rated by one expert as being of high activity; Robe and Port MacDonnell were rated by two experts as being of high activity.

Listings of specific fishing grounds for SBT (named reefs, distance offshore) within regions of the state that experts were familiar with

Eyre and Western

- From Ceduna, The Isles of St Francis (Commercial vessels from the Port Lincoln tuna cage fishery go to the St Francis group early in the season to catch SBT around 25kg, for grow out in the Port Lincoln pens (SBT are brought back in nets)
- From Sceale Bay, The Lumps (approx. 10 miles) (North eastern shoreline of islands/reefs)
- From Venus Bay, Ward Lumps (approx. 37 miles)
- From Anxious Bay and Elliston, Pearson Isles off the coast from Elliston, approximately 90 nautical miles from Coffin Bay and Ward Lumps
- From Coffin Bay, Point Whidbey, Greenley Island and Rocky Island (Point Whidbey is the western most tip of Coffin Bay peninsula (SBT caught as close as three miles offshore). Greenley Island is west of Coffin Bay 34°37'60" N, 134°46'59" E). Rocky Island is 12nm south of Greenley Island
- Off Coffin Bay, the closest 'wildfish' SBT fishery would be three to five miles offshore (but escapees from farming are also targeted)

- From Port Lincoln, Low Rocks and Neptune Islands (60–70km offshore). Taylor Island. The Cabbage Patch (40miles offshore). The closest 'wildfish' fishery would be three to five miles offshore (escapees from farming are also targeted. Four hummocks reefs (Whidbey Islands) 34°47'S 135°02'E west of Coffin Bay (40km offshore). Neptune Islands are south of Port Lincoln 35°28'S 136°10'E (approx. 40km offshore)
- Generally - around the islands - e.g. Wedge, Rocky, Pearson, Kangaroo
- Long range vessels are required, the shelf is 200km offshore at the top of the Bight, shelter is taken overnight at the islands
- The Pearson Isles are among South Australia's most remote offshore islands, and represent one of the lasting fishing frontiers of our state. These islands are approximately 90 nautical miles from Coffin Bay and are off the coast from Elliston on the Eyre Peninsula. Pearson comprises five granite islands, the tallest peaking at 238 metres and descending into almost 100 metres of water
- Greenly Island is approximately 60 nautical miles from Coffin Bay on the Eyre Peninsula Greenly Island has a well-protected anchorage and is where charter/larger boats will moor at night
- Rocky and Greenly Island charter trips - live on board three days and two nights. These islands are arguably hold the best fishing grounds the state of South Australia has to offer. SBT and albacore tuna school around the islands between the months of February and May.

Far North

- Not applicable

Yorke and Mid North

- From Marion Bay and Foul Bay, Wedge Island (Gambier Islands), 30km offshore West from Marion Bay. Althorpe Island, 20km south offshore from (Inneston) Marion Bay.

Barossa

- Not applicable

Adelaide

- Not applicable

Fleurieu and Kangaroo Island

- From Victor Harbour Cape Borda is a headland with a lighthouse on the west coast of Kangaroo Island,70 kilometres west from the town of Kingscote, good fishing 16km offshore.

Limestone Coast

- From Robe SBT are accessible 4–20 miles offshore, 30km offshore
- From Port MacDonnell The 100 fathom depth mark; 23km offshore
- Productive waters in southern SA - Bonney upwelling

Notes: South Australia has 346 Islands, Kangaroo Island and Hindmarsh Islands are probably the most popular of the South Australian Islands.

"SBT will be located based on current and temperature/food availability. While there may be baitfish shoals around islands, SBT are pelagic hunters, and have no 'structure' requirement. Knowing their prey, and reading the environment (e.g. water temperature, bird activity), they will be caught in open water. Anglers, however, like a point of reference (GPS)".

Listing of any boat ramps omitted (see excel spreadsheet) within regions of the state that experts were familiar with

Question 1: Please name, (or rate on the spreadsheet) the biggest/highest use ramps for SBT in each region?

Question 2: Please use an 'M' to note locations that you know to have moored boats on the spreadsheet.

Note: see spreadsheets, only two experts did this. These were compared to a relative size rating of coastal boat ramps by number of lanes/accessibility to trailer boats >4.5m.

Question 3: For each region you know well, can you tell us about: the timing of catches (e.g. January to June), and if there are any seasonal changes (e.g. a peak period during the fishing season, a change in the average size or weight of harvested fish)?

Eyre and Western

- Far west e.g. Fowlers Bay November to February; around The Lumps, Pearson Island, Ward Island December to March or April; Greenly Island to Rocky Island from January to April; Low Rocks to Neptune Island from January to May.
- SBT are present in the Bight from as early as November, then move down the coast
- November to June, SBT usually come past Port Lincoln in February–March. In March, when penned SBT are 50kg, they are sold to overseas markets and farmers can then bring in SBT off Port Lincoln.
- Streaky Bay from January to March (peak in February); Coffin Bay from February to May (peak February to March)

Far North

- Not applicable

Yorke and Mid North

- Jan-May (peak in March)

Barossa

- Not applicable

Adelaide

- Not applicable

Fleurieu and Kangaroo Island

- Jan-April (peak in February)
- From February to March onwards around Victor Harbour to Cape Jervis

Limestone Coast

- From February to July, increased catches when SBT move in closer to shore in Autumn when they are then more accessible to the trailer boat fishery (smaller fish (6–14kg) at this time, but maximum effort and maximum catch)
- From February to July, a rough guide is two to three weeks after Kangaroo Island catches; big fish come in first in February (25–30 kg in schools) and then through March to May, smaller fish (15–20kg); can still get individual big ones from May to June up to 100 kg (game fishers will often run two sets of lures, with one targeting the chance 'big one')

- March to June (peak in April)

Fishing effort trends within regions of the state that experts were familiar with

Question 1: Fishing activity (weekend versus weekday)?

Question 2: Return from fishing (morning versus afternoon or night?)?

Question 3: Seasonal changes (earliest/latest times of return to port throughout the season)?

Eyre and Western

- weekend 70 per cent, weekdays 30 per cent; fishing is mainly b/w 8–11am (peak SBT feeding time), anglers may return to shore around 2-3pm
- Angler catch reports (especially via internet) drive effort
- Activity starts medium with first catches (November to December), then becomes high with better weather, more time (e.g. summer holidays), money invested
- Tournament periods are high effort periods and also indicate expected 'peak' SBT season i.e. March to May.

Notes: Early in the season effort might be as much as 70 per cent on weekends, but from Dec-April around Christmas and public holidays, more weekday effort is observed.

90 per cent of anglers fish 8am–6pm ('workday'), but from 11an–3pm SBT go deep, to cool. Their hunting is dependent upon the angle of the sun. Game fishers usually fish daybreak until 10am, then from 3pm until an hour before dark (bigger/overnight vessels would then seek overnight shelter). Travel could be two hours to or from the fishing grounds.

Most boats would come off the ramps 6–7pm, during daylight saving 4–9pm. Night fishing is rare, most are back to the ramp around 5pm.

SBT are known to favour temperatures between 19–21°C, adjusting their depth to the vertical temperature distribution. Distinct diurnal diving patterns are observed as they make adjustment of depth to maintain constant ambient light levels over a 24-h period (Patterson et al. 2008).

Far North

- Not applicable

Yorke and Mid North

- 70 per cent weekend/30 per cent week, night fishing rare
- most back to ramp around 5pm

Barossa

- Not applicable

Adelaide

- Not applicable

Fleurieu and Kangaroo Island

- 70 per cent weekend/30 per cent week, night fishing rare
- most back to ramp around 5pm

- Higher effort at weekends/public hols/long weekends, especially Labour Day, Easter, Anzac Day
- As the season progresses, fishing effort increases, and fish move in closer and are caught closer to shore
- At Port MacDonnell, anglers also fish for albacore tuna, striped tuna and dolphin fish
- Early in the season, get Victorians travelling interstate to fish at Port MacDonnell, in preference to travelling to NSW e.g. Bermagui
- From Port Mac, could potentially be back in under an hour with bag limit, as early as lunchtime?
- 70 per cent weekends, 30 per cent weekdays (increase in weekday effort with catch reports). As season comes on, SBT move in closer to land, in April to May SBT are approximately 10 miles offshore
- Fishing from daybreak to 11am–12pm, then break for lunch, then fish 2pm–dark (SBT feed during the day, drop off in feeding around midday–2pm)
- Some anglers targeting shark at night may also fish for tuna
- The weather shuts down the trailer boat fishery in winter; charter boats are less constrained by the weather. 80 per cent of catch might be taken by charter boats, but they have a boat limit of six fish/boat
- 70 per cent weekend/30 per cent week, night fishing rare
- most back to ramp around 5pm.

Expert angler post-survey reviews

Expert anglers were contacted after the surveys had finished, with a request for comment on the SBT season.

At the start of the year, you were contacted by Fisheries Victoria, and shared your knowledge of the South Australian SBT fishery (thank you!).

Commencing 8 January, and running through until 2 August, Fisheries Victoria coordinated a recreational angler interview boat ramp survey at many of the South Australian boat ramps to trial the methodology of onsite surveys as a means of assessing recreational catch of SBT.

In that we were testing methodology, and not attempting to obtain catch estimates, we spread our resources to potentially over-sample 'large' and 'medium' use boat ramps, and also sampled for as much of the SBT season as possible.

We would like your assistance again please, if you'd care to comment on the recreational SBT fishery in SA this year.

Particularly as compared to previous years, in terms of timing, locations of catches, size of SBT and anything else you can think might benefit our analysis of the survey data.

And perhaps you'd like to comment on our choice of ramps? Within each region, alphabetically, the ramps we sampled were:

Fleurieu & Limestone

Beachport

Cape Jaffa

Cape Jervis

Robe (Lake Butler)

Robe (Long Beach) (Medium)

Victor Harbor (east of causeway) (Medium)

Victor Harbor (Encounter Bay)

Victor Harbor (Kent Reserve) (Medium)

Victor Harbor (Yacht Club) (Medium)

Wirrina

Kangaroo Island

American River

Emu Bay (Medium)

Penneshaw (Christmas Cove)

Shoal Bay

Stokes Bay (Medium)

Adelaide and Yorke

Aldinga Beach (Medium)

Foul Bay

Marion Bay

Moana Beach (Medium)

Seacliffe (Medium)

Port Moorowie (Medium)

Port Noarlunga (Medium)

Sellicks Beach (Medium)

Eyre and Western

Anxious Bay (Medium)

Coffin Bay (Caravan Park) (Medium)

Coffin Bay (Esplanade)

Ceduna (Day/O'Loughlin Terrace) (Medium)

Ceduna (Puckridge)

Elliston (Medium)

Haslam (Medium)

Mount Dutton Bay (Medium)

Port Lincoln (Axel Stenross)

Port Lincoln (Billy Lights Point)

Port Lincoln (Lincoln Cove Marina)

Port Lincoln (Proper Bay) (Medium)

Port Lincoln (Snapper Rock) (Medium)

Port Lincoln (Yacht Club) (Medium)

Sceale Bay (Medium)

Smoky Bay

Streaky Bay (Moores Landing)

Thevenard (Bosanquet Bay)

Venus Bay (Medium)

RESPONSE 1

I would like to make comment about Fleurieu, Adelaide, Yorke and Kangaroo Island boat ramps surveyed.

Fleurieu & Limestone

Beachport

Cape Jaffa

Cape Jervis

Robe (Lake Butler)

Robe (Long Beach) (Medium) - not worth doing

Victor Harbor (east of causeway) (Medium)

Victor Harbor (Encounter Bay)

Victor Harbor (Kent Reserve) (Medium) - not worth doing

Victor Harbor (Yacht Club) (Medium) - not worth doing

Wirrina

Should include:

Port MacDonnell

Carpenters Rocks

Blackfellas Caves

Pelican Point

Southend

Nora Creina

Kangaroo Island

American River

Emu Bay (Medium)

Penneshaw (Christmas Cove)

Shoal Bay

Stokes Bay (Medium)

Adelaide and Yorke

Aldinga Beach (Medium) – not worth doing

Foul Bay

Marion Bay

Moana Beach (Medium) - not worth doing

Seacliffe (Medium) - not worth doing

Port Moorowie (Medium)

Port Noarlunga (Medium)

Sellicks Beach (Medium) - not worth doing

Should include – Corny Point

Pondelowie

Gleesons Landing

Regarding the timing of the survey to commence in early January: at the end of 2013, many SBT were caught in the week leading up to Christmas from Fleurieu Peninsula launch sites. Probably the other sites as well (outside of the Limestone Coast) but I don't have first-hand knowledge of this.

Creel staff post-survey reviews

Creel officers were requested to complete a survey review, with topics provided as prompts.

1) *How did this SBT season compare to the last few seasons?*
2) *How did you find the management of the survey (e.g. recruitment, the instructions provided, supply of gear, timesheet and mileage management/procedure/payroll etc., but mostly, suggestions for improvements on the process (e.g. obtaining parking permits, signage, means of identification of commercial anglers, local vs remote management, scheduling difficulties and adaptations)?*

3) *Survey design improvements: How did you find the duration of survey period in terms of appropriateness with the timing of the tuna season? How did you find the large vs medium ramp approach, and how appropriate were the ramps selected for the survey? Which ones should be dropped off the list completely, in terms of use by SBT anglers, and did we miss any that should have been sampled? How would you have targeted ramps to obtain more SBT angler interviews? Was the duration of the survey period appropriate (Jan-July)? Would fewer hours (e.g. 2-5 pm) over more days target more returning anglers for the same effort/cost?*

The following transcripts have been lightly 'edited' to remove identifying details.

Upper West Coast of South Australia – Elliston to Ceduna (Streaky Bay) region

SBT catches and season comparison

Anecdotally, it appears that catches made by SBT fishers in this region were good this year. The number of days fished were limited as SBT fishing only occurs when the weather is extremely calm. Elliston, Venus Bay, Sceale Bay, Smoky Bay and the Puckridge boat ramp in Ceduna seemed to be the main departure points for SBT fishing. In previous years fishers departing from Smoky Bay have usually travelled to Cannon Reef when targeting SBT, a 200 km+ day trip. This year SBT schools were in very close, some as near as Franklin Island which halved the distance fishers normally have to travel. SBT catches started in November and ran through to March/April with some minor sightings made in the following months. The fish in the majority of cases were of a small size, under 20 kg, with the odd exception of bigger fish to 40 kg. On most occasions the limit of two fish each or 6 per boat were taken. Numerous large schools were sighted when the weather permitted anglers to fish, and most fishers agreed that sightings of large SBT schools were much more prevalent than in previous years.

Non SBT catches

People surveyed, in the main, were willing participants, and agreed that it is good to see an effort being made to monitor fish stocks. Fishing pressure is higher in the warmer months from November to April. The majority of people surveyed appeared to be compliant with regard to fish sizes and numbers caught. One or two interstate and one local angler, were unaware of the legal fish lengths of lesser known species e.g. snook and trevally. Standard bag limits and sizes signage at each boat ramp would assist anglers. We obtained a supply of hand-out sheets with compliance details from the Fisheries Office and were able to supply those in doubt with the relevant information.

Concern was expressed by a number of fishers who were happy that we now have possession limits for whiting, but who had observed some anglers who were heavily targeting squid, crabs and razorfish once they had their bag limit (10 kg) of whiting. Fortunately this appears to be a minority of anglers. This information was hearsay and impossible to verify, and outside the scope of the survey, but it was a concern expressed by a number of anglers.

Survey Process — Boat Ramps, Weather, Time of Survey

The random allocation of boat ramps caused problems in a couple of ways. Firstly some ramps were infrequently used, if at all e.g. Haslam, O'Loughlin Terrace, Thevenard and Sceale Bay. The first three we would eliminate from the survey list. Although we recorded no data on the days we were at Sceale Bay (no boats, due to wet, rough weather) it is probably the main departure point for SBT fishing in our region, although is only used when the weather is perfect; for example following a week of hot weather and on a day with very light winds and little or no swell. These days do occur but are more likely to be from November to March. No survey days were selected in February, and the days that were selected for Sceale Bay were in winter and corresponded with inclement weather days.

We feel that calm hot days at Sceale Bay, Elliston, Venus Bay, Smoky Bay and Puckridge ramps need to be targeted if any real picture of SBT stocks are to be obtained for our region. Fisherman travel from Tumby Bay, Adelaide, and further afield to target SBT, for a week or more, if the weather is predicted to be suitable. Surveys during the winter months of June, July and August will miss the peak fishing in our region. Data on catches could be collected from this cohort, by the use of a local contact person to who catch details could be forwarded. Timing of the surveys from 10am to 5pm would work well in summertime, as some anglers have their limit by 10am and on some occasions a little earlier. Winter-time 11am to 4pm would see 99 per cent of anglers surveyed.

Forms

We feel that the survey form layout could be made more user friendly. Space at the top is good for use of clipboards, but a lot of the border space is wasted and could be used for recording data. By listing the fish species normally found in the region, with room for the addition of other species, data entry (and data extraction) would be much easier. In our region: tuna, whiting, Tommy ruff, squid, blue swimmer crabs, snapper, weedy whiting, red mullet and leatherjackets. Perhaps creel clerks from each region could produce a form they think would work for data collections in their region. These could be collated, analysed, and modified to produce a suitable new form if similar surveys are to be conducted in the future. A suggested modified form is attached.

Data collection suggestions

1 Collection of data through local contact

A local contact person may be a fishing expert, or an interested person (such as a Fishcare volunteer) to whom data could be forwarded, or who could contact fishers on particular days. They could also ring around the district to collect data on a regular basis. This would require the creation of a network of contacts in the region. We have been told there is already in existence a group who have been asked to ring-in details of their own catches. Perhaps this could be extended to enable these people, or selected people, to collect data from range of other fishers.

2 Game fishing clubs

Adelaide Game Fishing Club – there are some members in Port Lincoln and probably fishers in our region

Riviera Game Fishing Club – this club specifically targets SBT in its annual fishing competition at Port Lincoln.

3 Charter Operators (*Note- Charter operators, and Commercial Fishers report mandatory catch data monthly*)

4 Tagging by amateurs – provision of tagging equipment, training, and recording sheets for recreational anglers

5 Fishing SBT webpage – photos, lengths/weights, daily/monthly capture details (incentives for people to provide data, e.g. prizes for the best photo of the month, year)

6 Telephone based angler diary (*Note – A random sample of anglers are currently undertaking a telephone diary survey throughout SA*)

Management of surveys

Recruitment and training/instructions were good. Separating professionals from amateur's boat trailers at the start of a survey day was problematic, but was usually solved by the end of a day by questioning fishers and

visiting locals. Builders' tape measures provided were good for measuring large fish e.g. snapper, although no tuna were recorded, as predicted could be the case using the scheduled timetable for visiting ramps. The extended commercial fish measure attached to a cutting board, which we manufactured, balanced on the edge of a medium sized tub worked well for us when measuring smaller species. At times having another tub proved useful to separate species prior to measuring.

Port Lincoln region

If SBT remain the focus

- Align the surveys to better match the migration of the fish in our region (for the lower Eyre Peninsula the SBT peak months would generally be November to April, although due to seasonal variation extension will be required)

- Some of the medium-small sized ramps that see SBT activity and could be considered for inclusion are: Farm Beach (beach launch entrance to Coffin Bay used regularly in summer); Avoid Bay (beach launch at Coffin Bay National Park) and Fishery Bay (beach launch)

- We believe the start time is suitable (10.30am), however finish time during daylight saving could be 8pm and during the non-daylight-saving period, the finish time could be 6pm to better match daylight hours and hence retrieving times.

- Surveys of berthed recreational/charter vessels should be considered, especially in Port Lincoln where there is a strong contingent of these vessels e.g. postal survey to all berth owners.

- Provided SBT remains the focus the following ramps could be removed:

    - Port Lincoln Marina
    - Snapper Rocks
    - Port Lincoln Yacht Club
    - Dutton Bay
    - Coffin Bay Caravan Park
    - Proper Bay

However, if the surveying is to include general species some of the above ramps could be kept on the list

General recommendations

- If a snapshot of general fishing is desired then surveying for a 12 month period would give a better snapshot due to the surveys being stacked toward the lower fishing pressure times of year.

- May be able to write-off certain boat ramps in certain conditions i.e. wind above 20 knots and in some locations swell above 6m.

- Could have a survey board/stand to notify public of survey activity (Neil suggested this).

- Additions to the data sheets could include:

    - Number of non-fishing recreational vessels retrieved
    - Number of commercial vessels retrieved
    - Location to tally number of boats launched during the day
    - Place to record whether they have targeted SBT in the past 12 months as well as approximate number of trips and details of fish caught

General feedback

- All equipment provided has been adequate and useful.
- Most fishers were co-operative and could see the value in surveying.
- Some fishers questioned whether the surveys would lead to; fishing licences, tighter bag limits, increased marine parks or the end of the world!
- There were several fishers who suggested the bag limits for blue swimmer crabs and garfish were excessive.
- Most fishers were keen to voice their opinions on 1 or 2 aspects and so there could be a section for comments/feedback from fishers especially in regard to; bag and boat limits, seasonal closures and any general issues.
- Although compliance is not the purpose of the surveys, the summary sheet could include information on observed or suspected compliance breaches that could be used by compliance officers for non-prosecution intelligence gathering purposes.

Thank you for the opportunity to take part in the surveying - I enjoyed the work and was keen to be involved in a project that will provide data that is necessary for the sustainable and equitable management of our fisheries. Hope you have some useful data from across the state; it looks like you have from your last email.

I found it very interesting seeing the day to day differences in fishing catch rates and species; it's clear that surveying provides the knowledge to create a much clearer picture of different aspects related to fishing activity. For example, the whiting generally are hit and miss in local bays. They're not there/biting, smaller fish move in or larger fish are present. I will know next time smaller whiting are on the bite, I won't bother trying to find larger ones! A certain bonus of the job.

Marion Bay region

No response

Victor Harbor region

From anecdotal evidence it appears that the 2012–13 summer season had better catch rates than the 2013–14 season.

Survey management was good. To improve things we'd suggest a note in the instruction manual on how to identify commercial boats i.e. 'M' at the start of a boat registration number indicates a marine scale commercial fisher.

To enable easier access and safety for creel officers, parking permits may be required. Perhaps if problem areas are known from previous surveys then permits could be obtained for those areas at the start.

The ID tags worn around the neck didn't work that well initially, as they blew around and ended up getting tucked into clothing and were not seen, however, combined with the hi-visibility vests, where they could fit into the clear panel on the front, a workable solution was identified.

Staff could be issued with a few prepaid envelopes for times when there are a large amount of forms to be sent at once, when there are too many to easily scan and attach to an email.

It appears SBT are more accessible to trailer boat fishers in the warmer months. A more concentrated method targeting the warmer months and at the three key boat ramps in the Victor Harbor survey, being Wirrina, Cape Jervis and Encounter Bay in Victor Harbor, would likely see more SBT catches being surveyed.

Sorry for leaving you and my fellow creel clerk in the lurch with my untimely cardiac arrest! I am pleased to say that I am making good progress with my recovery.

I thoroughly enjoyed working with my colleague on the recent survey.

I had no issues with training, instructions, supply of equipment or other management matters. The issue with the parking permit for Encounter Bay Ramp was unfortunate. The local Council is very sensitive to criticism from nearby residents who ring the council office to complain whenever a vehicle without a trailer is observed entering the boat ramp parking area, including Police and Emergency Service vehicles. The parking inspector has been obliged to issue a parking infringement notice to a Fisheries Patrol that was checking boats at the ramp! Similar parking restrictions apply at the Causeway Boat Ramp, yet the same parking inspector was quite happy for us to park there without a permit! In future it may pay to contact Councils where ramps are located to obtain a "permit" to park close to the ramp to facilitate the conduct of the survey. Most ramps we attended did have parking/access restrictions in place; however Encounter Bay was the only location where we had problems.

Whilst we had days where there were no contacts, I accept that is part of the process. Weather has a considerable outcome on results. The timing of the survey for our area did contribute in part to missing the main SBT season locally. The reason being not so much the weather but more so that the main fishing activity is during the school holidays over the Christmas period. The other fishing activity that we missed is the recreational rock lobster activity that peaks during the holiday period also. Most rock lobster fishers also fish hours before we commenced the surveys – generally 5.30am to 8.30 am.

The only ramp(s) that I would exclude from a future survey would be the Yacht Club ramp at Victor Harbor; this ramp is a beach launching site and is unsuitable for the majority of trailer craft - small yachts use the ramp for club events only. The Kent Reserve ramp is only used by very small boats, less than 4 m, and then mainly to access rock lobster pots, no boats targeting SBT would use this ramp.

I think the hours during which the survey was conducted were suitable, although for the area we were working there is little point staying after "last light" as few recreational boats operate after dark in these waters.

Thank you for your support and assistance during the survey and I look forward to working with you again should the opportunity arise.

Kangaroo Island region

The survey interviews proved to be pleasant and responsible, with most fishing parties being very responsive to the need for the research. Coordination and management of the surveys was carried out by Kylie Hall from Fisheries Victoria this was done in a professional manner from induction to administration, advice and positive response, which made the whole project run seamlessly, great job. I don't feel it would be managed locally any better apart from maybe some site visits.

No Bluefin Tuna were brought into the ramps on my survey dates. However with feedback from recreational and professional fishers it soon became apparent that the surveys started two to eight weeks after the main run of tuna which were caught in the 2013–14 holiday season mainly by tourists. The survey period could probably have been better if it had run from December to June. The feedback I got was that the season was better than previous for tuna numbers, but local fishers tend to target them once or twice only per season and

mainly on north coast of island. I also think after daylight saving ends surveys would be better starting and finishing earlier, some fishers had retrieved before the 10.30am start of the survey.

Boat Ramp summary

Stokes Bay and Emu Bay are the two main launch sites within striking distance of tuna schools on the north coast where 90 per cent of bluefin tuna catches came from in this season. These should have been targeted early January.

Shoal Bay Ramp is the most used ramp being a good facility that serves Kingscote the main town. However from the feedback I received it has not been a hotspot for tuna.

American River Ramp is a good facility with sheltered waters but it is a long distance from main tuna schools but reports of small schools in outer reaches of estuary have been made on rare occasions.

Christmas Cove Ramp Penneshaw is an excellent facility It is a busy ramp at times, reports of boats travelling to lower backstairs passage targeting bluefin tuna from this site have been made when weather permits.

Apart from these main ramps there are various beaches to launch smaller craft on the island not really suitable for surveys.

It is obvious from the surveys if they are not done start of the year not many tuna will be seen from recreational fishers. King george whiting and snapper are the main species targeted from the island.

Cape Jaffa region

According to the anglers we've spoken to, this season didn't do very well compared to the last few seasons. Not only have anglers not sighted many schools of fish this season but the catches were also smaller than previous years.

We found the management (both local and remote) of the survey excellent. With current technology, the communication was fast and easy between us and the management. Everything we needed for gathering accurate research information was provided before the start of the survey so it made us efficient and visible to the public during the limited time we had with the anglers participating in the survey. Having the local advantage, our suggestions were taken into consideration which made the survey more productive especially on the days we rescheduled due to bad weather or change of location. As the survey started during the off peak season, we didn't need parking permits; however, if it was done during the peak season we would have needed a parking permit to enable us to be stationed closer to the incoming boats.

The duration of the survey period wasn't very appropriate with the timing of the tuna season in our location. Apparently, tuna fishing in the east of the State, at our survey area doesn't start until June, whereas we started the survey in February, although the survey period was appropriate for fishing in general.

Few anglers target the survey areas for fishing tuna as they say it is too far from the continental shelf where most schools of tuna are sighted during the tuna season. Otherwise the ramps were appropriate for the surveys except for the Robe Long Beach ramp (the only medium ramp in the survey) which hasn't been used for launching boats in a very long time according to the locals. Since the opening of the Robe Lake Butler Marina, which provides easy, and safe access, the Robe Long Beach ramp has been used even less often (it is additionally a beach ramp and is only used as 4WD access to the beach).

While we appreciate the reasons for the Port MacDonnell boat ramp having not been included in this survey, we would suggest it be added to future surveys as it is the main ramp used by anglers targeting tuna in the Mt

Gambier region and would certainly achieve more SBT angler interviews (starting February as it is the closest ramp to where the tuna are sighted at the start of the season according to the anglers we've spoken to).

The best times to get the most interviews (regardless of the target species) would have been 8am until 5pm in summer as most anglers start fishing early. Based on our experience, we missed quite a few returning anglers not starting the interviews until 10:30am. Also, most anglers return to land before it starts getting dark so the interview period should be reduced in Autumn and Winter as most anglers wouldn't go out fishing until later (when it's warmer) in the day; this also applies to when daylight savings time ends because anglers are more likely to come in before dark.

We believe the best chance of talking to returning anglers who target SBT is between 2pm to 6 pm, over summer (every weekend and a few weekdays after the crayfish season ends as most of the anglers targeting tuna are also professional crayfish fishermen) and autumn on good weather days.

New South Wales

Rating of regions of the state that experts were familiar with in terms of the SBT fishery (high, medium, low ratings)

Sydney

Three respondents considered they had a high degree of knowledge of this region, with one each reporting a medium and low degree of knowledge regarding the use of Sydney Harbour to access the SBT fishery.

South Coast (North of Ulladulla)

Three respondents considered they had a high degree of knowledge, with one each responding a medium and low degree of knowledge regarding the accessibility to the SBT fishery adjacent to this region.

South Coast (South of Ulladulla)

Two respondents considered they had a high degree of knowledge, two considered they had a medium degree of knowledge and one responding a low degree of knowledge regarding the accessibility to the SBT fishery adjacent to this region.

Rating of regions of the state that experts were familiar with in terms of recreational SBT fishing activity (high, medium, low)

All five respondents indicated that each of the three regions had a high degree of activity targeting the recreational SBT fishery based on the timing of the availability of fish as well as consideration of weather conditions. One respondent stated ‘The fishery is highly mobile because of the currents and as a result the anglers are as well. They will chase the fish up and down the coast following the bite. “

One respondent noted that the condition of the barway at Narooma can greatly effect fishers ability to launch from this region.

Listings of specific fishing grounds for SBT (named reefs, distance offshore) within regions of the state that experts were familiar with

All respondents agreed that fishing for SBT adjacent to NSW occurs well off the coast, and in most cases beyond the continental shelf. While it was indicated that there are certain areas along the shelf break, or offshore seamounts that fishers may use as a starting point, in general they are looking more for sea surface temperature breaks as indicated by their echo sounders and utilising their marine radios to communicate with other fishers to increase the search area to find fish.

Listing of any boat ramps omitted (see excel spreadsheet) within regions of the state that experts were familiar with

Only one boat ramp was identified as not on the list. This was a newly developed ramp in Sydney Harbour at 'Container Wharf' on Foreshore Road in Botany Bay. This ramp was added to the list.

Respondents with knowledge of Sydney Harbour indicated that there is a very large moored fleet in Sydney harbour (all through the harbour, not necessarily associated with boat ramps). One respondent thought that a low number of the moored boats in the Harbour would be involved in recreational fishing for SBT, but did indicate that he felt that maybe 30-40% of the fleet fishing adjacent to the Sydney region is comprised of larger moored boats.

Respondents familiar with the south coast indicated that reasonably large moored boat fleets were located in several major towns along the coast, including Ulladulla, Batemans Bay, Bermagui and Eden.

Question 3: For each region you know well, can you tell us about: the timing of catches

Sydney

The three respondents with a high degree of knowledge of the SBT fishery adjacent to Sydney Harbour were in agreement that the timing of the fishery in this region was from June to July,

South Coast (North of Ulladulla)

There was consensus amongst four of the respondents that the recreational fishing season for SBT in this region ran from June to July, one respondent indicated however that in the past it has run as late as September.

South Coast (South of Ulladulla)

There was consensus amongst three of the respondents that the recreational fishing season for SBT in this region ran from June to July, one respondent indicated that in the past it has run as late as August, and another respondent indicated that in the past it had started as early as May.

All respondents noted that the recreational season for SBT is very short relative to other areas around Australia.

Fishing effort trends within regions of the state that experts were familiar with

Question 1: Fishing activity (weekend versus weekday)?

One respondent indicted that weekends tend to be busier than weekdays, but noted that when the weather is good many fishers will arrange leave days to be able to fish during the week. All other respondents indicated that weather was a bigger determinant of fishing effort than whether it was a weekday or weekend day.

Question 2: Return from fishing (morning versus afternoon or night)?

All respondents indicated that SBT fishing trips start early in the morning with the vast majority of boats not returning until dusk or later. This was due to the long distances travelled to sea, partly to account for travel time and also maximising fishing time when on the fishing grounds to justify the long travel distances. An exception to the late return times was if the weather turned bad, with fishers returning earlier if this was the case.

Question 3: Seasonal changes (earliest/latest times of return to port throughout the season)?

No seasonal changes in return times were noted. Fishing times within a day were maximised whenever possible.

Key sampling locations

Key sampling locations were ranked through expert surveys to guide designing on-site surveys in South Australia and New South Wales (Tables 15 & 16). This information was invaluable for the on-site trial in South Australia and the simulation and modelling work in New South Wales. Any future surveys should use this information in designing and implementing on-site surveys in these jurisdictions.

Table 15 Key survey locations in South Australia derived from expert surveys

	Boat ramp name	Predicted use (VH, H, M)	Survey strata
Eyre and Western	Thevenard (Bosanquet Bay)	H	L
Eyre and Western	Streaky Bay (Moores Landing)	H	L
Eyre and Western	Sceale Bay	H	M
Eyre and Western	Elliston	H	M
Eyre and Western	Mount Dutton Bay	H	M
Eyre and Western	Coffin Bay (Caravan Park)	H	M
Eyre and Western	Coffin Bay (Esplanade)	H	L
Eyre and Western	Port Lincoln (Proper Bay)	H	M
Eyre and Western	Port Lincoln (Billy Lights Point)	H	L
Eyre and Western	Port Lincoln (Lincoln Cove Marina)	H	L
Eyre and Western	Ceduna (Puckridge)	M	L
Eyre and Western	Streaky Bay (Slidy Ramp)	M	
Eyre and Western	Venus Bay	M	M
Eyre and Western	Anxious Bay	M	M
Yorke and Mid North	Marion Bay	H	L
Yorke and Mid North	Pondalowie Bay	M	
Yorke and Mid North	Foul Bay	M	L
Fleurieu and Kangaroo Island	Cape Jervis	H	L
Fleurieu and Kangaroo Island	*Emu Bay*	H	M
Fleurieu and Kangaroo Island	Victor Harbor (Encounter Bay)	H	L
Fleurieu and Kangaroo Island	Wirrina	M	L

Fleurieu and Kangaroo Island	*Penneshaw (Christmas Cove)*	M	L
Fleurieu and Kangaroo Island	*American River*	M	L
Fleurieu and Kangaroo Island	*Shoal Bay*	M	L
Fleurieu and Kangaroo Island	*Stokes Bay*	M	L
Limestone Coast	Port MacDonnell West	VH	Out of scope
Limestone Coast	Robe (Lake Butler)	H	L
Limestone Coast	Beachport	H	L
Limestone Coast	Cape Jaffa	M	L

Table 16 Key survey locations in New South Wales derived from expert surveys

Region	Boat ramp name	Predicted use (VH, H, M)
Sydney	Wharf Rd, Ermington	VH
Sydney	Wally's Wharf - Dolans Bay	VH
Sydney	Rowland Reserve	H
Sydney	Tunks Park	H
Sydney	Lyne Park	H
Sydney	Kyeemagh	H
Sydney	Wollongong Harbour	H
Sydney	Water Street - Caringbah	H
Sydney	Putney Park, Kissing Point	M
Sydney	Five Dock Bay, Taplin Park	M
Sydney	Horse Rock Point, Sylvania	M
Sydney	Holts Point	M
South Coast - North of Ulladulla	Kiama Harbour	VH
South Coast - North of Ulladulla	Shoalhaven Heads - Wharf Rd Ramp Shoalhaven River	VH
South Coast - North of Ulladulla	Woollamia Regional Ramp	VH
South Coast - North of Ulladulla	Murray Beach Jervis Bay	VH
South Coast - North of Ulladulla	Ulladulla - North Harbour	VH
South Coast - North of Ulladulla	Ulladulla - South Harbour	VH
South Coast - North of Ulladulla	Bellambi - alternate ramp beach	H
South Coast - North of Ulladulla	Bellambi (Beach)	H
South Coast - North of Ulladulla	Port Kembla Boat Harbour (Darcy Rd)	H

South Coast - North of Ulladulla	Boat Harbour, Gerringong	H
South Coast - North of Ulladulla	Shoalhaven Heads - River Rd Ramp Shoalhaven River	H
South Coast - North of Ulladulla	Shellharbour (Bass Point Ocean Ramp)	M
South Coast - North of Ulladulla	Warrain Cres Currarong	M
South Coast - North of Ulladulla	Greenwell Point - West St Crookhaven River	H
South Coast - North of Ulladulla	Watt St Callala Bay Jervis Bay	H
South Coast - South of Ulladulla	South Bridge, Batemans Bay	VH
South Coast - South of Ulladulla	Apex Park, Narooma	VH
South Coast - South of Ulladulla	Boat Harbour, Bermagui	VH
South Coast - South of Ulladulla	Quarantine Bay, Eden	VH
South Coast - South of Ulladulla	North Bridge, Batemans Bay	M
South Coast - South of Ulladulla	Bridge, Bermagui	M

Appendix D: Indicative costing

The cost calculations for on-site surveys were derived from costs provided by an external provider and are based on a costing structure of $1600/day, which includes employing and managing interviewers, travel, accommodation and data entry. These costs are only indicative and may change depending on provider and timing of survey. Administration costs and are based on a rate of $1146/day and includes overall project management, coordination, data analysis, reporting and report writing. Various levels of sampling coverage were investigated as can be seen in Table 17. The cost of each option was modelled and its coefficient of variation was used to determine the precision of each option.

Table 17 On-site sampling costs and coefficient of variation (C.V.) for South Australia, New South Wales and Victoria

	On-site survey costs	
South Australia		
Days sampled	**Cost**	**(C.V.)**
166	$265 600	7-day (46.11) 14-day (33.02)
250	$400 000	7-day (35.2) 14-day (25.13)
330	$528 000	7-day (28.59) 14-day (20.58)
500	$800 000	7-day (21.6) 14-day (15.29)
New South Wales	**Cost**	**(C.V.)**
166	$265 600	14-day transit (34.07) 21-day transit (24.67)
250	$400 000	14-day transit (25.67) 21-day transit (18.99)
330	$528 000	14-day transit (21.34) 21-day transit (15.56)
500	$800 000	14-day transit (15.01) 21-day transit (10.98)
Victoria	**Cost**	**(approximate C.V.)**
81	$129 600	0.02
130	$208 000	0.08
166	$265 600	
Administration costs	**Cost**	
100 days (year 1) 120 days (year 2)	$280 000	

Costs for an off-site phone diary and wash-up survey (Table 18) using an angling licence frame in New South Wales and Victoria was costed through an external research provider based on a hit rate for SBT of 0.02, a diary uptake rate of 0.9, a non0response rate of 0.9, sample loss rate of 0.9, with a target of 200 diarists per state. Various sampling coverage options (levels of coverage) were not modelled and compared. The parameters provided were based on surveys of other low participation recreational fishing surveys such as rock lobster and abalone.

The cost of an off-site survey in Tasmania (Table 19) was costed via an external research provider based on the most recent Tasmanian SBT survey and includes a wash-up survey, on-site validation and voluntary charter logbook components.

Table 18 Off-site survey cost for New South Wales and Victoria

Survey component	**Cost**
Screening sample	27 434 contacts
Development costs	$50 000
Costs per screening interview	$20
Total screening costs	$548 696
Diary costs	$40 000
Wash up survey	$20 000
Analysis & reporting	$80 000

Total	$738 696

Table 19 Cost of Tasmanian off-site survey

Survey component	Cost
Off-site survey cost	$69 186
Wash up survey	$6765
On-site validation	$86 065
IMAS costs	$93 475
Voluntary logbook program	$30,000
Total	$285 491

Table 20 includes various costing options including option 5, which is the preferred methodology based on weighing cost versus precision.

Table 20 Cost of alternative sampling options

Cost of sampling option 1	Cost of sampling option 2	Cost of sampling option 3	Cost of sampling option 4	Cost of sampling option 5
Off-site survey WA, 166 on-site days in NSW, 166 on-site days in SA plus 24 days in Port Macdonnell, 81 on-site days in Vic, off-site survey Tas, project management	Off-site survey WA, 250 on-site days in NSW, 250 on-site days in SA plus 38 days in Port Macdonnell, 130 on-site days in Vic, off-site survey in Tas, project management	Off-site survey WA, 330 on-site days in NSW, 330 on-site days in SA plus 48 days in Port Macdonnell, 162 on-site days in Vic, off-site survey in Tas, project management	Off-site survey WA, 500 on-site days in NSW, 500 on-site days in SA plus 48 days in Port Macdonnell, 162 on-site days in Vic, off-site survey in Tas, project management	Off-site survey WA, Offsite sampling in NSW, 500 on-site days in SA plus 48 days in Port Macdonnell, off-site survey in Tas, project management
$1 265 200	$1 634 800	$2 009 200	$2 502 000	$2 345 697
Risk: high	**Risk:** high	**Risk:** high	**Risk:** low	**Risk:** low

Appendix E: References

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