



NATIONAL SURVEY OF
**RECREATIONAL
FISHING FOR
SOUTHERN
BLUEFIN TUNA
IN AUSTRALIA**
2018/19

¹Tracey, S.R., ¹Lyle, J.M., ¹Stark, K.,
¹Gray, S., ²Moore, A., ¹Twinline, S.
& ¹Wotherspoon, S.



Australian Government
**Department of Agriculture,
Water and the Environment**
ABARES



¹Institute for Marine and Antarctic Studies
University of Tasmania
Private Bag 49
Hobart TAS 7001

²Australian Bureau of Agricultural and Resource Economics and Sciences
Department of Agriculture, Water and the Environment
18 Marcus Clarke Street, Canberra ACT 2601 Australia
GPO Box 1563 Canberra ACT 2601 Australia

Enquiries should be directed to:
Assoc. Prof. Sean Tracey
Institute for Marine and Antarctic Studies
University of Tasmania
Private Bag 49, Hobart, Tasmania 7001, Australia
Sean.Tracey@utas.edu.au
Ph. (03) 6226 8286

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Executive Summary

Southern Bluefin Tuna (SBT) *Thunnus maccoyii* have been managed internationally as a single breeding stock by the Commission for the Conservation of Southern Bluefin Tuna (CCSBT) since mid-1994. As a signatory to the international treaty, Australia are required to account for all sources of SBT mortality, including from recreational fishing. For 2018–2020, the global Total Allowable Catch (TAC) for SBT is set at 17,647 tonnes (t) per annum, of which Australia is allocated 6,165 t or 35%.

The recreational fishery for SBT in Australia has a long history, dating back to the early 20th century. It is a popular gamefish species, particularly along the south coast of Australia where juvenile SBT seasonally migrate. Sporadic catches of large adult fish are also occasionally caught by the recreational fishery. Over the last two decades, the recreational fishery for SBT has predominantly focused in waters adjacent to South Australia, Victoria and Tasmania, with the species also caught in New South Wales and Western Australia. Until now there has been no comprehensive assessment of the recreational harvest of SBT in Australia.

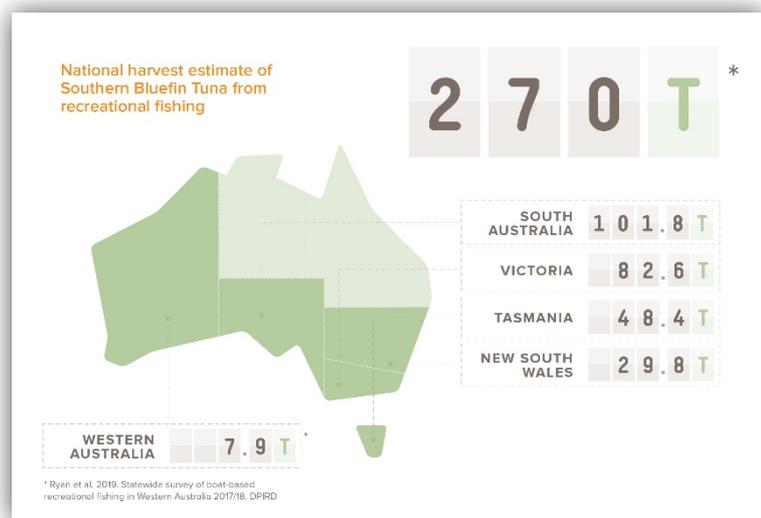
The present survey was designed to describe the recreational fishery for SBT in Australia in terms of fishing effort, harvest and released catch, and other sources of fishery-related mortality from South Australia, Victoria, Tasmania and New South Wales. With the inclusion of the most recent SBT catch estimates from the recreational fishery in Western Australia, this study is the first comprehensive national assessment of the recreational fishery.

Given the broad distribution of SBT across Australia, straddling multiple State jurisdictions each with their own nuances to consider in survey design, an ensemble of survey methods were required. Data from privately-owned vessels were gathered through on-site (boat ramp) surveys in South Australia and Victoria and off-site (telephone) surveys in Tasmania and New South Wales. Charter boat data was collected from mandatory logbooks in South Australia and New South Wales and incentivised voluntary logbooks in Victoria and Tasmania. Very high response rates were achieved for each of the survey components.

The survey period ran for 12 months from December 2018 to November 2019.

The estimated total harvest of SBT across the surveyed States was 16,410 ± 1,787 (95% confidence limits (CLs)) fish, representing 262 t (232–292 t: 95% CLs).

With the inclusion of the most recent estimate (2017/18) of SBT harvest from Western Australia, the national harvest of SBT by the recreational sector was 270 t (239–301 t: 95% CLs).



Private-vessels accounted for 77% of the harvest by weight, with the remainder caught from charter vessels. With consideration of all States, a further 6,460 (5,339–7,581: 95% CLs) individual SBT were released¹, equivalent to a release rate of 26%.

¹ Excludes released fish from the South Australian charter fleet, as they are not required to report this information in their logbook.



An additional source of recreational fishing-related mortality, depredation during a fishing event or observed post-release, was assessed. It was estimated that this mortality contributes an additional 17.5 t (13.7–21.3 t: 95% CLs) or 6% to the harvest estimate. The majority of this was due to predation on SBT by fur seals during fishing events in Tasmania.

Considering estimated harvest and fishery-related mortality due to depredation, the total mortality contributed by the recreational fishery in Australia for the 12 month period beginning December 2018 to November 2019 inclusive accounted for 4.7% (4.0–5.3%: 95% CLs) of Australia's current allocation of the TAC or 1.6% (1.4–1.8%: 95% CLs) of the current global TAC.

Survey coverage and considerations

In the absence of compulsory catch reporting, survey methods are required to garner an estimate of catch from the recreational fishery. It is common for survey methods to have limitations that need to be considered. In the present case, all care has been taken to reduce bias and maximise precision, however there is some degree of known under-coverage.

The on-site methods used in Victoria and South Australia surveyed a limited number of boat-ramps and, while expert opinion confirmed that these would cover the vast majority of SBT fishing activity, we are aware of small amounts of catch occurring beyond the surveyed ramps. Furthermore, as the on-site survey focused on boat-ramps used by trailer vessels, large moored fishing vessels were out-of-scope. Through careful consideration and qualification of these issues with a range of regional experts in the fishery, it is likely that any catch associated with this under-coverage would not have exceeded five tonnes.

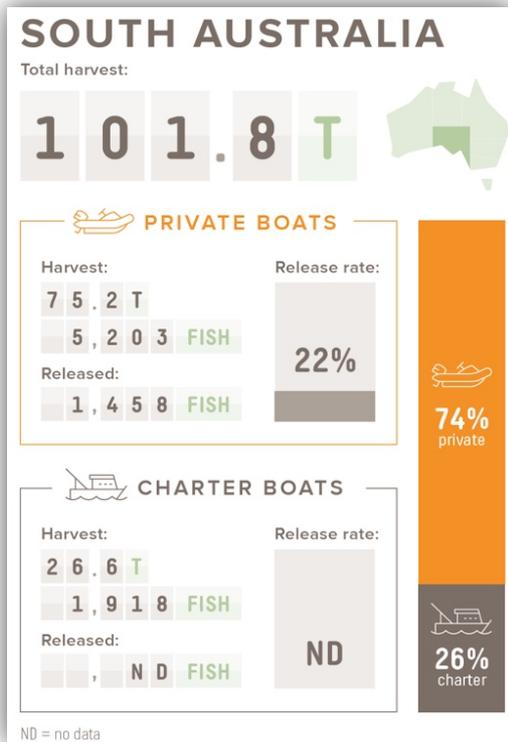
In Tasmania, the vessel registration database was limited to vessels greater than 4.5 m in length and excluded personal watercraft and yachts. It is possible that a small amount of catch may occur from these out-of-scope vessels, and from unregistered watercraft such as kayaks. Through consultation with regional experts in Tasmania, it is believed any catch from these sources would have been negligible.

In New South Wales, pension cardholders, First Nations people and individuals under the age of 18 are exempt from requiring a recreational fishing licence. The effect of the under-coverage of these fishers is unknown but likely to be small, especially since 2019 proved to be a poor year for SBT off New South Wales.

An attitudinal and perceptions survey conducted at the conclusion of the survey period indicated that 50–60% of respondents had less than 10 years of experience in fishing for SBT. However, in all States other than New South Wales, 10–30% of respondents reported more than 20 years of experience, compared with just 1% for New South Wales. As expected, most respondents fished in their home State for SBT, but some had also travelled to other States to fish for SBT over the past decade or so. This was particularly true for Victorian and South Australian respondents, with 38% of the Victorians indicating that they had fished in South Australia and 28% fished in New South Wales, while 23% of South Australians had also fished for SBT in Victoria.

Based on recall, there was a general perception among respondents that both the availability of SBT and targeted fishing effort had increased through time, however this may be influenced by cognitive confirmation bias, driven by social media and exacerbated by recall bias, as the vast majority of participants indicated that they had actually either fished fewer or a similar number of days than usual for SBT during 2018/19. Just over half of all respondents stated that, in their opinion, the quality of the recreational fishery had improved over time, and identified 'fisheries management' as a key reason for this improvement.

State summaries



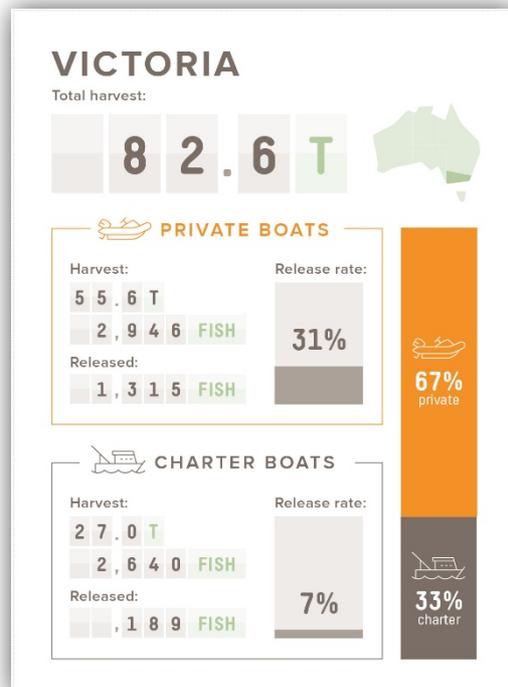
Fishing for SBT in South Australia spans the entire ocean coastline, with a focus on access points around Port MacDonnell, Victor Harbor and the Eyre Peninsula.

On-site survey methods were used to capture information about private-vessel recreational fishing activities targeting SBT in this State. These surveys were conducted at boat ramp access-points for trailer-vessels, which were identified by expert interview as having a high probability of use for SBT fishing. Charter boat catch data was recorded in a mandatory logbook.

Surveys were conducted across seven regions at 17 boat ramps, with a 99.7% response rate over 754 sample days and a total of 8,713 interviews, of which 1,312 reported tuna fishing.

The estimated total harvested biomass of SBT in South Australia by the recreational sector was 101.8 tonnes. Of this, fishers from private boats caught 74%, with 26% caught from charter boats. The release rate for private boats was 22% or 1,458 fish. The greatest percentage of

harvested biomass from private vessels was caught from the Fleurieu Peninsula (41%), followed by Port MacDonnell (33%), the Eyre Peninsula (20%), the Yorke Peninsula (3%), Western Region (3%) and Kangaroo Island (1%).

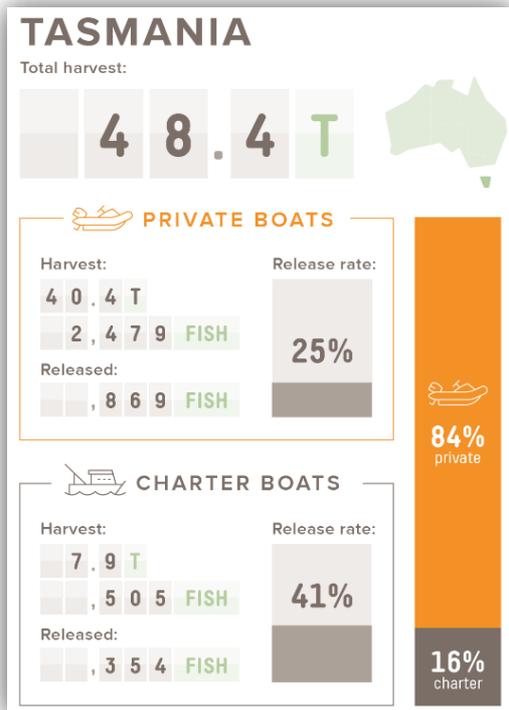


In Victoria, the fishery is focused on the western coastline with a limited number of access points. SBT is rarely targeted along the eastern coastline, with only occasional catches reported around the entrances of Port Phillip Bay and Western Port Bay.

On-site survey methods were used, as outlined for South Australia. Charter boat catch was reported in a voluntary logbook, with 100% participation. Surveys were conducted across two regions at five boat ramps, with a 99.7% response rate over 432 sample days and a total of 4,330 interviews, of which 1,513 reported tuna fishing.

The estimated total harvest of SBT in Victoria by the recreational sector was 82.6 tonnes. Of this, fishers from private boats caught 67%, with 33% caught from charter boats. The release rate for private boats was 31% or 1,315 fish, and 7% for charter boats.

An estimated total of 15,287 recreational fishing trips left the survey ramps, with 26% of all trips targeting SBT. Portland accounted for 82% of the harvest, with regional West Victoria accounting for 18%.

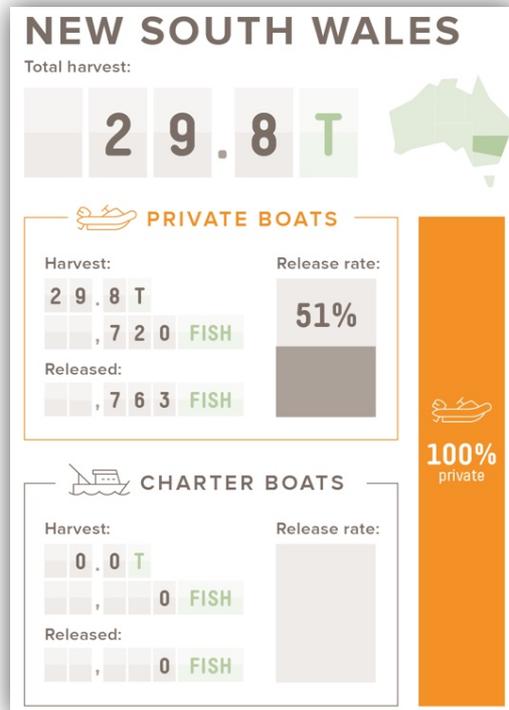


Fishing for SBT in Tasmania is concentrated in the south east, off the Tasman Peninsula. SBT have also been reported as far north as Flinders Island and at Pedra Branca off the south coast. Occasional catches are taken off the west coast of Tasmania.

An off-site survey method was used in Tasmania, and the results represent the game fishing activities of Tasmanian registered recreational vessels greater than 4.5 m in length, excluding yachts and personal watercraft. Charter boat catch was reported in a voluntary logbook with a very high rate of participation.

The telephone-diary survey contacted 2,053 vessel owners of which 98% provided full responses related to their vessel usage. Of these, 641 were identified as likely to do in-scope fishing with 91% completing the 12-month diary phase.

The estimated total harvest of SBT in Tasmania by the recreational sector was 48.4 tonnes. Of this, fishers from private boats caught 84%, with 16% caught from charter boats. The release rate for private boats was 25% or 869 fish, and 41% (354 fish) for charter boats. The vast majority was caught from the south east of the State.

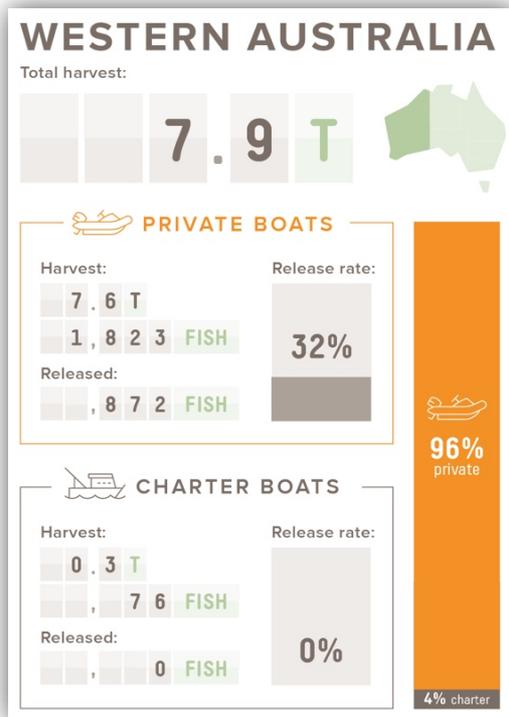


New South Wales has a diverse game fish fishery, with a long history of targeting large species of pelagic sharks, billfish and tuna. SBT appear occasionally off the coast, only for a short time. The fishery occurs much further offshore and comprises different age cohorts than in other States. The fish caught in New South Wales are, on average, significantly larger.

An off-site survey method was used in New South Wales with the results expanded to represent all one- and three-year recreational fishing licence holders in the State. A mandatory logbook is used in New South Wales for charter boats and provided information for this sector.

The telephone survey was used to contact 16,452 licence holders with 86% providing a full response. Only 2.9% of all licence holders were estimated to have participated in game fishing for large pelagics, and just 0.6% targeted SBT during the survey period.

The estimated total harvest of SBT in New South Wales by the recreational sector was 29.8 tonnes. Of this, fishers from private boats caught 100%, with none caught from charter boats. The release rate for private boats was 51% or 763 fish. The vast majority of catch occurred between Sydney and Bermagui on the south coast of New South Wales.



The recreational fishery for SBT in Western Australia targets the small juvenile fish migrating down the coast from the spawning area in the Java Sea. These fish generally do not exceed 5 kg.

The Western Australian catch of SBT was not assessed in this study, rather the results of the most recent boat-based recreational fishing survey in the State was considered in reporting a national harvest estimate.

The most recent boat-based recreational fishing survey in Western Australia was conducted by the Department of Primary Industry and Regional Development (DPIRD) in 2017/18. The survey uses an off-site phone-diary survey method, similar to that used in Tasmania in this study. Charter boat catch is reported in a mandatory logbook and the data for the period 2017/18 is reported here.

The total harvested biomass was estimated at 7.9 t with 96% of this taken by private vessels and the remainder from charter boats. A further 782 fish were released from private vessels, resulting in a release rate of 32%. There were no fish reported released from charter boats. The majority of catch was taken from the southwest and south coast regions.



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Ethics Statement

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1 General Introduction

1.1 Background

Southern Bluefin Tuna (SBT) *Thunnus maccoyii* is an iconic species both domestically and internationally. As well as being a high value commercial fishery, its popularity in Australia with recreational fishers has a long history and has seen a resurgence in the last two decades after a significant downturn in the availability of the species in coastal waters. The most recent assessment of stock status for SBT estimated that it remains in an overfished state, but is no longer subject to overfishing, with the spawning stock biomass at 11–13% of unfished levels (Patterson et al. 2018). This is an improvement since the 2011 stock assessment which indicated that, in 2010, the stock was at 5.5% of unfished biomass (Patterson et al. 2014).

Southern Bluefin Tuna is listed as conservation dependent under the *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)*, as endangered under the *New South Wales Fisheries Management Act 1994 No 38* and as threatened under the *Victorian Flora and Fauna Guarantee Act 1988*. The Status of Australian Fish Stocks report recently redefined SBT from ‘overfished’ to ‘recovering’. The stock is subject to an international management procedure to achieve a rebuilding target of 30% of the original Spawning Stock Biomass by 2035 (CCSBT 2019). To achieve this, the Commission for the Conservation of Southern Bluefin Tuna (CCSBT) set a global Total Allowable Catch (TAC), with proportions allocated to member countries. The Australian Fisheries Management Authority (AFMA) sets Australia’s domestic SBT quota at or below Australia’s allocation from the CCSBT.

SBT constitutes a single, highly migratory stock that spawns in the north-east Indian Ocean (off north-western Australia, south of Indonesia) and migrates widely throughout the southern temperate oceans (Grewe et al. 1997, Farley and Davis 1998, Basson et al. 2012). Young fish move from the spawning ground into the Australian Fishing Zone (AFZ) and southwards along the Western Australian coast. Juvenile SBT, up to approximately five years old, then typically aggregate in southern Australian waters from Western Australia to the eastern extent of the Great Australian Bight (GAB) during summer (Basson et al. 2012, Patterson et al. 2018). In autumn, they disperse from this region, either moving westward into the Indian Ocean or eastward in the GAB, around Tasmania and into the Tasman Sea, before returning to the GAB in the following summer (Hobday 2005, Hobday et al. 2011, Basson et al. 2012). From approximately the age of five, they disperse further through waters in the Tasman Sea and the Indian, Pacific and Atlantic Oceans (Patterson et al. 2008, Basson et al. 2012).

1.2 Need

In Australia, the Commonwealth is responsible for managing the commercial SBT fishery, engaging with the CCSBT and managing SBT as a conservation-dependent species under the *EPBC Act*. However, the relevant State Governments manage recreational fishing for SBT in their waters. While specific management regulations vary between states, all are fundamentally based on some form of daily catch limit which are either individual and/or boat-based limits. In isolation, daily catch limits are not capable of managing a fishery to within a quota or TAC since the total number of participants or their fishing effort are not typically constrained (Cox et al. 2003, MacKenzie and Cox 2013, Abbott 2015). Rather, this management approach can have the effect of suppressing harvest across a fishery, and facilitates a more ‘responsible’ approach in regard to the quantity of fish harvested by an individual.



In 2014, the CCSBT agreed to a common definition of attributable catch, under which member countries were expected to have a process in place by 2018 to account for all sources of mortality, including commercial, discards and recreational catch within their allocation (CCSBT 2014). From the 2018 fishing season, 250 t has been set aside from Australia's CCSBT allocation to begin to account for recreational catch. The results of this survey will help inform Australia's decision on a set-aside amount going forward.

As part of managing the species in Australian waters, it is also a wildlife trade operations condition under the *EPBC Act* for Australia's SBT fishery to account for all sources of mortality. Information on catch levels and the geographical and seasonal distribution of recreational fishing activities will contribute to this reporting.

Prior to this 2018/19 study, there were no comprehensive studies assessing the recreational harvest of SBT across Australia.

1.3 Recreational fishing activities for Southern Bluefin Tuna

Recreational fishing for SBT spans over 6,500 kilometres of Australia's coastline and is known to occur off Western Australia, South Australia, Victoria, Tasmania and New South Wales. Recreational fishing for SBT in Australia has a long history, with reports from 1936 of catches in both South Australia and New South Wales (Roughley 1951, Palmer 1984).

Game fishing is a small but highly specialised component of the broader recreational fishery in Australia. It generally requires a higher degree of financial investment and, as such, is often the realm of the more avid angler. However, it is an important component of the recreational fishery and, because it often occurs away from metropolitan areas, it contributes to regional economies (Ward et al. 2012, Deloitte 2013, Moore et al. 2015).

The availability of SBT to the recreational fishery is predominantly determined by the proximity of the fish to the coastline. Recreational boats are generally more limited than larger commercial vessels in the range they can travel, with the recreational fishery dominated by trailer boats. While there is a degree of predictability in the movements of SBT, which provides a seasonal trend in the recreational fishery for SBT in Australia (Green et al. 2012, Tracey et al. 2013, Moore et al. 2015), there is sufficient variability in the distribution and abundance of SBT causing the timing and scale of recreational fishery to fluctuate from year-to-year and by jurisdiction. This was particularly evident during the mid-1980s, when the availability of juvenile SBT inhabiting inshore waters throughout the GAB, Tasmania and the southern coast of New South Wales became all but absent. A rapid westward contraction in their distribution also significantly limited the recreational fishery throughout southern Australia (Caton 1994). This limited availability was likely due to significant overfishing in the previous decades, which affected recruitment of juveniles to the GAB (Caton 1994).

The CCSBT was formed in 1993, and formalised in mid-1994 in response to the recognition that the SBT stock was severely depleted and significant management intervention was required to allow stocks to rebuild. Interestingly, this was at a time when the recreational fishery for SBT in Australia had been largely absent for approximately a decade. This meant the recreational fishery was not included in the early deliberations of the Commission, nor considered by the



Australian Fisheries Management Authority (AFMA) in the domestic management of the fishery, as only the commercial sector routinely engaged with the species at that time.

More recently, as SBT stocks have rebuilt, the availability of juvenile fish in inshore waters along the south coast of Australia (with a notable absence of these juvenile fish in the inshore waters of southern New South Wales) has seen a contemporary resurgence in the recreational fishery for SBT (Green et al. 2012, Tracey et al. 2013).

The contemporary recreational fishery for SBT in New South Wales targets a different size-class of fish, with boats traveling long distances offshore to encounter schools of sub-adults aged five and up as well as adult fish (Tracey et al. 2016). These fish are only in range of the recreational fishery for a short period relative to 'school fish' on the south coast of Australia, most commonly during the winter months of June to August. The sub-adults tend to migrate seasonally along the sub-tropical convergence zone between Australia and New Zealand (Tracey et al. 2016).

These fish are also targeted by the commercial longline vessels that hold SBT quota on the east coast of Australia. However, these vessels tend to have longer access to the fish as they can travel further offshore. The recreational fleet on the east coast will often look for reports from the commercial longline fleet to assess when the fish schools may be in range. The advent of GPS and better equipped recreational vessels have been fundamental in the recreational fleet being able to engage with these fish schools, as at times boats will travel up to 100 km offshore and return within the same day.

Large adult fish constitute an important component of the recreational fishery due to the 'trophy' nature of their status within the sector (Gray 2006), but they are caught in far fewer numbers than school fish (Green et al. 2012, Tracey et al. 2013). The predictability of their movements is far less understood (Patterson et al. 2008) than school fish. They are only encountered episodically by the recreational fishery in the far east of the GAB, predominantly at Port MacDonnell in South Australia, around Portland and occasionally in other areas along the southwest coast of Victoria, around Tasmania and up the east coast of New South Wales.

It is likely that this unpredictability adds to the excitement, with a rush of fishers often traveling to areas when schools of large fish have been found in range of the recreational fishery. The ability of the recreational fishery to identify the location of these schools and rapidly notify their peers has been greatly enhanced by advancements in both on-water technology such as GPS and echo-sounders, and communication technology including mobile phones and social media.

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, comprised of anglers who may or may not be members of a fishing club
3. charter boats (commercial businesses that charter-out their vessel and crew for recreational fishing) engaged by anglers who may be part of the organised or the non-organised component of the game-fishing sector.

Most recreational game fishing activity appears to take place on privately-owned boats with a smaller proportion reported from charter boats (Forbes et al. 2009; Tracey et al. 2013). 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. Historically, this included juvenile SBT (e.g. around Jervis Bay, New South Wales), although catch of SBT from this form of fishing is exceptionally rare.

SBT are retained as an edible table fish or 'trophy fish' by anglers or may be released alive after capture. Dedicated surveys of recreational catch of SBT found release rates of 26% in Victoria (Green et al. 2012) and 24% in Tasmania (Tracey et al. 2013).

The most common method used to catch SBT in Australia is by trolling artificial lures behind a vessel. The lures are tied to fishing line attached to a rod and reel. Alternative but far less common methods used are casting artificial lures to schools of fish and spearfishing. Another method that is commonly used in New South Wales once a school of fish has been found is throwing cut up bait into the water, called 'cubing', then introducing a live or dead bait on a hook. This method seems to be less effective in the cooler waters along the south coast of Australia and Tasmania. This is potentially due to greater abundance of natural prey in temperate waters.

An SBT post-release survival study (Tracey et al. 2016) found that post-release mortality represents an additional source of fishery-related mortality. In Australia, post-release survival (PRS) associated with catch and release of recreationally-caught SBT has been estimated at greater than 83% (95% confidence interval: 75.9–90.7%). For the study, these fish were removed from the water to obtain a blood sample, to assess physiological condition after capture and application of a satellite tag (Tracey et al. 2016). This additional processing and time required out of water to do so may have contributed to a higher post-release mortality rate, hence why this is considered a minimum survival rate.

Studies assessing PRS of recreationally-caught juvenile Atlantic Bluefin Tuna (*Thunnus thynnus*) that were brought onboard and rapidly tagged and released, reported 100% survival (Marcek and Graves 2014). A further study assessing PRS of very large Atlantic Bluefin Tuna caught using recreational fishing methods and tagged boat-side rather than on-board reported a survival rate of 97% (Stokesbury et al. 2011). These results suggest a high survival rate of released bluefin tuna, particularly if the fish are left in the water and handled with care.

A further source of fishing-related mortality to be considered is depredation, due to predation of fish either during the fishing event while their ability to avoid predation is limited, or after release which was included as a component of post-release mortality by Tracey et al. (2016). A state-based survey of offshore fishing activity in Tasmania, which included estimates of SBT harvest, estimated seal-induced mortality (depredation) of line caught SBT at 32% of the total mortality from recreational fishing activities (Tracey et al. 2013). Seal-induced mortality appears to be an issue generally associated with Tasmania, with no previous estimates or significant anecdotal reports of depredation of SBT from other States.

1.4 Previous surveys of SBT recreational catch

Since the National Recreational and Indigenous Fishing Survey (Henry and Lyle 2003), several States and the Northern Territory have conducted regional or state-wide 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, along with 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 a component of a broader taxonomic descriptor such as 'tuna', which also includes other tuna species. SBT have been reported at a species level in a limited number of more focused recreational fishing surveys in some States, and are reviewed in Moore et al. (2015).

1.5 Recreational fishing survey methods

In the absence of mandatory reporting, a survey is required to provide estimates of effort and catch in a recreational fishery. Recreational fishing surveys for large regional areas are complex and the methods employed will need to take many factors into account, but ultimately must focus on the primary survey objectives (Pollock et al. 1994, Hartill et al. 2012).

Recreational fishing surveys targeting specific fisheries or species require careful consideration to develop robust yet cost-effective sampling methods (Pollock et al. 1994, Arlinghaus et al. 2010). The survey methods can be off-site or on-site approaches, or a combination of both (Jones and Pollock 2013).

Generally, off-site surveys are less expensive than large-scale on-site surveys. Information can also be obtained from fishers not easily contacted using on-site surveys, such as those fishing from private jetties or returning to moorings. The disadvantages of off-site surveys include a range of response and reporting biases since information is typically self-reported. However, some of these potential biases can be reduced with a diary-based longitudinal approach with regular contact (Lyle et al. 2014), and careful consideration of the survey design.

On-site methods are generally effective at capturing information relating to niche fisheries by targeting specific areas, such as boat ramps known to be used by fishers targeting the species. One advantage of on-site surveys is that they allow for the direct counting and measuring of landed fish, which can be used to estimate weights (Jones and Pollock 2013). However, application of on-site surveys on a large scale can be expensive (Jones and Pollock 2013).

A non-exempt registration system is considered the most rigorous sampling frame to assess a niche, episodic fishery with low participations rates, such as the recreational fishery targeting SBT (Beckmann et al. 2019). This allows for delivery of an off-site survey utilising a complete and refined population, from which a representative sample can be cost-effectively surveyed, with comprehensive and precise results. Coupling this off-site survey with a well-designed on-site creel survey to provide fisher independent data on the size of fish caught provides the 'gold standard' in harvest estimates from a recreational fishery, in the absence of compulsory catch reporting.

In the absence of a comprehensive sample frame, fishing licences with specific permits to species (e.g. Rock Lobster licence in Tasmania) (Lyle et al. 2019) or for a particular mode of fishing (e.g. boat based fishing licence in Western Australia) (Ryan et al. 2019) assist in refining to a specific target population.

A general recreational fishing licences can also be used, but as these often have exemptions, they may not be representative of the whole population. Other sample frames can be used for game fishing, such as private vessel registration databases (e.g. as used in Tasmania). On-site methods are an alternative where an appropriate sampling frame for off-site survey methods is not available.

Given the broad distribution of SBT across Australia, straddling multiple State jurisdictions where some have suitable sampling frames for off-site surveys and others do not, an ensemble of survey methods was required to deliver a national survey of recreational fishing for SBT in Australia.

A biennial state-wide survey of boat-based fishing is conducted in Western Australia (Ryan et al. 2019). By using a boat-based fishing licence, the sampling frame (or target population) is refined to a degree where SBT can be reported at a species level with acceptable levels of precision. Moore et al. (2015) recommend using this estimate as part of a national harvest estimate, rather than a dedicated survey to assess SBT in the State.

The rationale is that a dedicated survey would add significant cost and would not necessarily produce a more robust result. In the absence of an estimate of recreational catch of SBT from Western Australia in the survey year, the reported catch from the most recent state-wide survey of boat-based recreational fishing in Western Australia is considered in the national total reported by this study. This state-wide survey ran for a 12-month period beginning in September 2017 (Ryan et al. 2019). This current study surveys the remaining States where SBT are caught, including South Australia, Victoria, Tasmania and New South Wales.

1.6 Objectives

The objective of this study was to estimate the national recreational harvest of SBT in Australia over a 12-month period, along with an estimate of released and depredated catch reported by jurisdiction.

2 Catch and effort estimation from the recreational fishery for Southern Bluefin Tuna from private vessels in Victoria and South Australia

2.1 Introduction

Offshore game-fishing activities typically target billfish, tuna and pelagic sharks. Based on the distribution of these species around Australia, game fishers in southern States tend to focus on tuna species, including Southern Bluefin Tuna (*Thunnus maccoyii*), Albacore (*Thunnus alalunga*) and Skipjack Tuna (*Katsuwonus pelamis*), as well as pelagic sharks, primarily Shortfin Mako (*Isurus oxyrinchus*). More recently, the development of a recreational fishery for Swordfish (*Xiphius gladius*) has provided an alternate target species in eastern Victoria and Tasmania (Tracey and Pepperell 2018).

In particular, Southern Bluefin Tuna (SBT) has been a popular target of the recreational game fish fishery in Victoria and South Australia (Green et al. 2012, Moore et al. 2015). The fishery targeting this species has been shown to have great economic benefit to regional communities in the region (Ezzy et al. 2012, Deloitte 2013). However, the scale of recreational effort and catch of the species is poorly understood along the south coast of Australia, with only one dedicated survey conducted in 2011 to assess the catch of the species in Victoria (Green et al. 2012).

In South Australia, the fishery for SBT is thought to occur across the extent of the ocean coastline, from Ceduna in the west to the Victorian border in the east, with several focal points of access, particularly around Port MacDonnell, Victor Harbor and the Eyre Peninsula (Moore et al. 2015). In Victoria, the fishery tends to focus on the western coastline, with a limited number of access points (Green et al. 2012). In recent years, there have been reports on social media of occasional catches around the entrances of Port Phillip Bay and Western Port Bay. Effort targeting SBT along the eastern coastline of Victoria has, however, tended to be negligible, although historically SBT were caught from vessels fishing from Mallacoota (Anon. 1983).

South Australia does not have a recreational fishing licence and, at the time this survey commenced, it was not possible to access the Victorian recreational fishing database or the vessel registrations databases in each State due to privacy considerations. In the absence of an available sample frame for an off-site survey in South Australia or Victoria, on-site survey methods were necessary.

On-site surveys have been used extensively to assess catch and effort of recreational fisheries, including game fishing in Australia and internationally (Pollock et al. 1994, Steffe et al. 2008, Green et al. 2012, Tracey et al. 2013, Holdsworth et al. 2018). An on-site survey uses a spatiotemporal sampling frame to define the total fishery being studied. A stratified random sampling method is applied to the sampling frame, and survey sample data expanded to derive estimates of fishing effort and harvest for the fishery (Cochran 1977, Pollock et al. 1994, Steffe et al. 2008).

These surveys are conducted at defined access points for the fishery which, for this study, were boat ramps. This approach works well when fishers are concentrated at focal points (Pollock et al. 1994). On-site surveys have previously been used to estimate SBT catch at regional scales

in Victoria (Green et al. 2012) and Tasmania (Morton and Lyle 2003, Forbes et al. 2009, Tracey et al. 2013), and have been trialled in South Australia (Moore et al. 2015). An adaptive access-point survey approach has also been applied in New Zealand to assess the recreational fishery for SBT (Holdsworth 2020).

While it may not be feasible to survey every potential access point across both States, concerns about under-coverage can be minimised by focussing on the highest usage boat ramps. Furthermore, privately-owned vessels that do not access the fishery via boat ramps, such as moored vessels or those kept in marinas, are not covered by boat ramp surveys. However, this group is not considered to represent a major component of the private-vessel game fishing community in South Australia or Victoria. The implications of these potential sources of under-coverage are discussed in Section 2.4.

The primary objective of this component of the survey was to quantify recreational fishing activity from private trailer vessels for SBT in Victoria and South Australia, specifically:

- annual fishing effort – boat days
- annual catch – retained, released and depredated
- seasonal and spatial presentation of annual catch and effort.

Charter fishing and game fishing tournaments in both States were also monitored and results from these activities are reported in Sections 5 and 6.

2.2 Methods

The survey design in South Australia and Victoria was based on a random stratified access-point methodology (Pollock et al. 1994). The access-point design uses a spatiotemporal data frame. The survey period began on 1 December 2018 and ran until 30 November 2019, inclusive.

2.2.1 Spatial coverage and stratification

Seven regional strata were identified in South Australia, covering 17 key boat ramps, with two regional strata in Victoria covering five key boat ramps (Figure 1). Ramps or access points within each regional stratum were selected after a review of ramp usage for tuna fishing in South Australia as reported by Moore et al. (2015) and discussions with regional experts in the SBT fishery who had significant local knowledge on boat ramp usage.

Selection of ramps was prioritised to those that were expected to attract the vast majority of tuna fishing effort within each region. The ramps were assigned relative sampling fractions, based on expert opinion of levels of usage and activity at each ramp. Further details on ramp selection and weighting are provided in Appendix I. Within each region, survey days were allocated randomly to the different ramps in proportion to the ramp selection probabilities, reported in Appendix II for South Australia and Appendix III for Victoria.

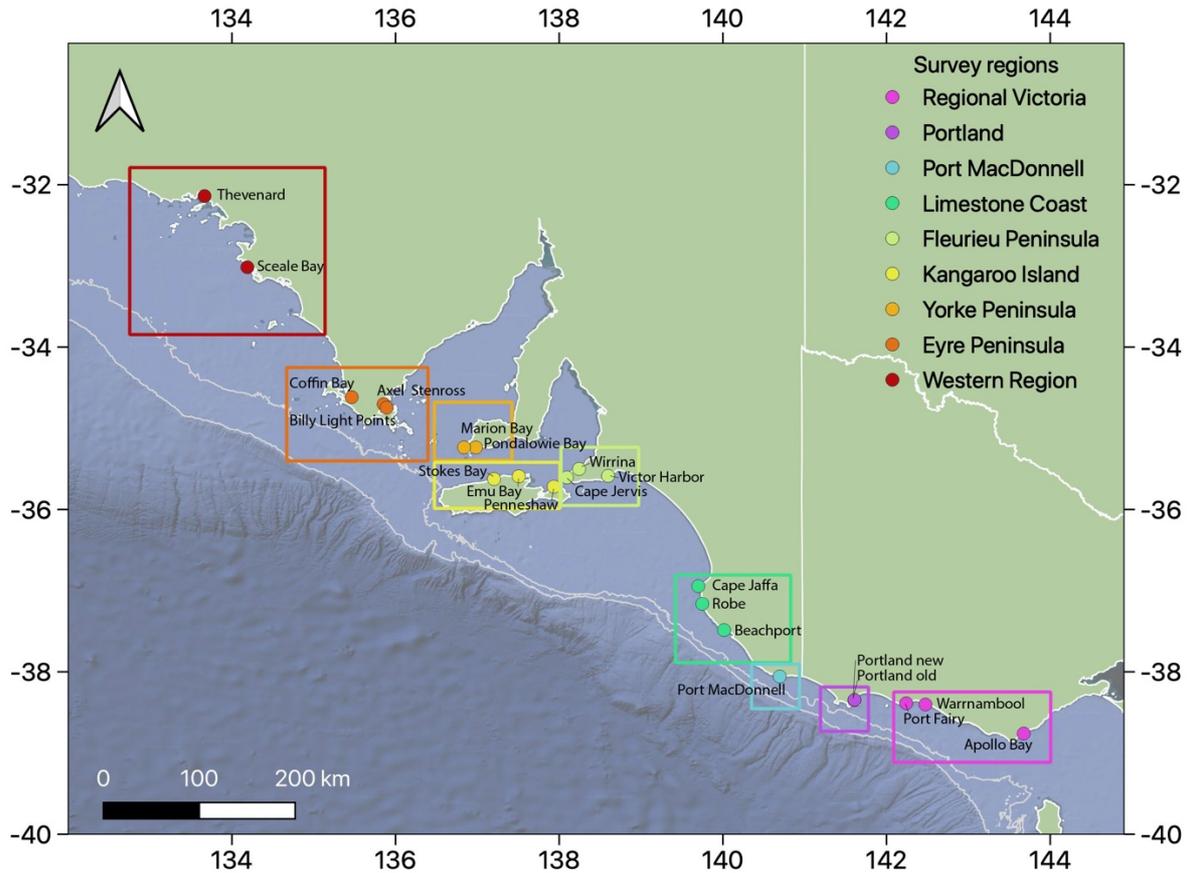


Figure 1. Surveyed boat ramp locations through South Australia and Victoria. The ramps are grouped into regions identified by colour and listed in the figure legend.

2.2.2 Temporal stratification

Temporal stratification involved a two-stage process to improve the precision of results by identifying strata that are more homogenous. Firstly, a seasonal stratification was applied – high season, low season and, in some areas, tail season (Figure 2). The seasons were defined based on expert interview (see Appendix I) and results from previous studies (Green et al. 2012, Moore et al. 2015), to define periods when there was a ‘high’ or ‘low’ probability of recreational fishing effort for SBT.

The ‘tail’ season stratum was applied where there was a reasonable probability for episodic, out-of-season pulses of SBT to be accessible to recreational fishers. For example, there have been anecdotal reports of pulses of large SBT outside of the traditional peak fishing seasons, in the waters adjacent to the Limestone coast in South Australia and the western Victorian coast. A higher sampling frequency was applied to the high and tail seasons as shown in Table 1, and in detail in Appendix II and Appendix III.



Figure 2. High, low and tail season strata profile applied to the 12-month survey period in each region.

Secondly, survey days were stratified within each season by weekday and weekend/public holidays. A higher sampling fraction was applied for the weekend/public holiday strata. Randomised sampling protocols were then used to select a total of 422 sample days in Victoria (Appendix III) and 751 sample days in South Australia (Appendix IV) based on the spatiotemporal stratification outlined above. Sampling was undertaken without replacement, therefore only one ramp in a region could be surveyed on a sample day.

Table 1. Range of sampling fractions assigned to seasonal and day type strata for the access-point survey to assess recreational catch and effort from private trailer vessels in South Australia and Victoria.

Seasonal strata	Day type strata		Regions
	Weekdays	Weekend / Public holidays	
Low season	12 – 31%	13 – 52%	All regions
High season	21 – 56%	35 – 77%	All regions
Tail Season	37 – 48%	47 – 100%	Portland, Port MacDonnell, Regional southwest Victoria

2.2.3 Creel survey

Creel clerks were stationed at selected boat ramps on allocated survey days, to intercept and interview returning fishers about their fishing activity for the day. From 1 December 2018 to 22 February 2019, survey shifts started at 10:30 am. For some ramps, due to anecdotal reports of a small number of boats returning from game fishing prior to this start time, the shift start time was changed to 9:00 am from 23 February 2019 and maintained through to the end of the survey. During peak times at larger boat ramps, two or three creel clerks were rostered on to reduce the likelihood of missing interviews with returning boats.

As a general rule, clerks either remained at the boat ramp until the last vessel had been accounted for (based on an absence of vessel trailers in car parks) or only vehicles and trailers known to belong to commercial or charter fishers remained on site. However, there were a small number of instances where not all vessels had been accounted for by nightfall, and therefore no information about their fishing activity was available.

Creel clerks were instructed to prioritise, as a minimum, the collection of basic information from every returning boat in relation to whether the trip was a tuna fishing trip and, if so, how many SBT were kept and released and the number of fishers on board. In situations where there was a risk of missing the next returning vessel, the clerks were instructed to forego collecting ancillary information for tuna trips, such as region fished, owner's postcode and measuring of fish, and to proceed to the next vessel. During expected busy periods an additional creel clerk was rostered on to reduce the potential for any missed interviews. With the exception of refusals, this strategy resulted in no missed vessel interviews while creel clerks were on shift.

Survey shifts were cancelled on days when the forecasted wind speed exceeded 30 knots at the selected ramp location. In such cases, nil SBT catch or effort was inferred based on the assumption that the weather conditions would deter recreational fishers from venturing into open waters to target SBT.

On several occasions throughout the survey period, boat ramps were closed for maintenance. If a boat ramp was closed on an allocated survey day, the assumption was made that no SBT catch or effort occurred from the boat ramp on that day.

2.2.4 Questionnaire delivery

A representative from each returning vessel was approached for interview at the boat ramp. In each case, every effort was made to complete a full interview, but the priority was to initially establish whether the party had been fishing for SBT and, if so, how many SBT had been caught and released. For parties that had fished for SBT, the number of active fishers by gender, the area fished, launch time, the vessel owner's postcode, and whether any seal or shark depredation of SBT had occurred was canvassed. Fishing areas were based on the Government Marine Fishing Areas (MFAs) in South Australia and an equidistant grid in Victoria, the latter replicating the spatial reporting from Green et al. (2012). Where feasible, individual SBT were measured for fork length to the nearest centimetre, with large SBT often 'weighed in' at boat ramp gantry facilities and these weights were recorded by the creel clerks.

2.2.5 Ancillary data

Ancillary traffic counter data were collected as a potential indicator of fishing activity at Port MacDonnell in South Australia and Portland in Victoria. The collection of ancillary data to deliver a supplemented access-point sampling design can provide a cost-effective method for improving the accuracy and precision of effort and harvest estimates from recreational fishing surveys (Steffe et al. 2008). Functionally, the ancillary data is a form of double sampling and is collected to provide a measure of effort on both sample and non-sample days. The primary survey data collected on sample days can then be related to the ancillary data, providing a relative likelihood of the primary fishing activity on non-survey days. The method relies on a strong statistical relationship between the primary and ancillary data.

A supplemented design was trialed in this study at the access-points predicted to have the greatest amount of effort targeting SBT in the region. Traffic counters were deployed at both boat ramps at Portland, Victoria and the boat ramp at Port MacDonnell in South Australia (Appendix I). The relationship between traffic count triggers and all recreational fishing events

was reasonably robust at Port MacDonnell (adj. $R^2 = 0.68$) and was particularly robust at Portland (adj. $R^2 = 0.93$) (Appendix IV; Figure 41). However, the relationship between traffic count triggers and game fishing events was not as robust at Portland (adj. $R^2 = 0.65$) and was particularly poor at Port MacDonnell (adj. $R^2 = 0.21$) (Appendix IV; Figure 41). The reason for the poor relationship between game fishing and traffic counter data was related to the seasonality of the SBT fishery being unrelated to the general trends in recreational fishing activity.

For example, a high number of traffic counts are registered in summer months as general recreational fishing activities peak around warm weather and school holidays. However, the SBT fishery in the region is more focused in autumn/winter. As such, the ancillary traffic counter data was not used in the expansion of effort or catch estimates, as it would introduce an additional source of error due to the poor relationship fit with the primary survey data. The traffic counter data, however, was particularly useful in verifying assumptions around the amount of effort that would occur on bad weather days, as well as to verify temporal patterns in boat ramp usage by hour within a day (see Appendix IV).

2.2.6 Analysis

On-site survey data was analysed in R (version 3.6.1) (R core team, 2019) with the survey package (version 3.37) (Lumley 2004, Lumley 2019) using a stratified single stage design to expand the sampled data, to generate regional and seasonal catch and effort estimates. The Primary Sampling Unit (PSU) was defined as the boat ramp sample day. Stratification was by season (two or three seasons defined for each site/region) and day type (weekday or weekend/public holidays). For regions involving multiple boat ramps, stratification was also by ramp. All survey designs included a Finite Population Correction, which was necessary given the large sampling fraction at each site. Estimated population totals and associated standard errors were calculated for variables of interest, such as numbers of SBT caught, using design-based Horvitz-Thompson estimators (Lohr 2010, Lumley 2010).

Catches of SBT could be clearly grouped based on size, namely smaller 'school fish' of less than 135 cm fork length (FL) or approximately 45 kg, although the vast majority of school fish were typically less than 15 kg, or larger fish often exceeding 100 kg in weight. While smaller school fish dominate catches based on numbers, small numbers of the large fish will disproportionately influence harvest weight estimation. Given the marked bimodality in the size of fish caught by the recreational sector, harvest weight expansion analysis was undertaken separately for fish less than 135 mm FL and fish greater than or equal to 135 mm FL.

2.2.7 Conversion of catch numbers to biomass harvest

The majority of individual fish sizes recorded were reported as lengths to the nearest centimetre, with fish measured by the creel clerk, or by the fishers but observed by the creel clerk.

For all length data, a length-weight conversion was applied using seasonally and regionally discrete parameters, according to the parameter table compiled at the CCSBT Southern Bluefin Tuna Trilateral Workshop in 1994 and reported in Edwards et al. (2016). Many of the large fish were weighed on certified scales at the boat ramp and, in these cases, weight was used

preferentially over the length-to-weight conversion. While estimated lengths and weights were recorded in some cases, these were not used when determining average fish weights.

Average fish weights were estimated for each region by season and, where there was bimodality in sizes caught, by size grouping (school fish/large fish). These averages were multiplied by the estimated total retained catch numbers (by region, season and size group). Either an estimated or measured size was reported for all large fish, as such, the average weight of school fish was applied to any fish where there was no size information recorded. Standard errors around the estimated harvest weight were calculated from the variance of their product, that is, the variance of the average weight and the variance of the estimated number of individual fish caught. Depredated fish were assumed to be school fish, and the average weight of these size classes was applied accordingly to convert to a depredated weight. As released fish were not routinely measured, no estimate of biomass of released fish is presented.

Regional expanded estimates were summed to provide state-wide estimates of effort and catch (retained, released and depredated), and the square-root of the sum of the regional variances was calculated to provide the accompanying standard error for the state-wide estimate.

2.3 Results

A total of 1,173 (751 in South Australia, 422 in Victoria) survey days were scheduled through the 12-month survey period, from 1 December 2018 to 30 November 2019, across the 21 survey boat ramps in South Australia and Victoria. Surveys were conducted on 88% of the scheduled days, equating to 663 survey days in South Australia and 374 in Victoria.

The remainder were cancelled due to wind speeds of over 30 knots or, in 10 cases, boat ramp closures. Traffic counter data indicated a significant decrease in traffic using the boat ramps on days where wind speeds exceeded 20 knots and becoming negligible at wind speeds of over 25 knots (Appendix I; Figure 39). These findings appear to justify the assumption of negligible game fishing when wind speeds are predicted to exceed 30 knots. Zero fishing effort and catch of SBT was assumed on these days.

A total of 13,043 interviews were conducted during the survey – 8,713 in South Australia and 4,330 in Victoria. Of these interviews, 12,855 were private vessels – 8,597 in South Australia and 4,258 in Victoria. The remainder were charter vessels.

Refusal to participate in the survey was low in both States, accounting for 0.3% ($n = 34$) of all interviews conducted. Of these, 20 were full refusals and 14 were partial refusals where the respondent at least confirmed whether they had been fishing for SBT or not.

Through the 12-month survey period, a total of 1,210 trailers were left in boat ramp car parks after the end of the creel clerk's shifts, equivalent to 8% of all boating party interviews. In many of these cases, creel clerks were able to determine that the trailer was associated with a commercial vessel, trailer yacht or Jet Ski ($n = 428$), or a charter vessel or recreational fisher not participating in game fishing ($n = 442$).

The latter group was identified based on a discussion with the fishers prior to launching, or direct observation of the boats fishing for other species. After adjusting for these observations, 340 trailers were unaccounted for after creel clerk shifts were completed, which accounted for 2% of all potential in-scope boating parties. No estimate adjustments have been made for these unaccounted vessels or interview refusals, since any adjustments would have minimal impact on the estimates.

Of the boating parties interviewed and the end-of-shift trailers that could be assigned as being used by recreational or non-recreational fishing parties ($n = 13,893$), 78% were using the boat for recreational fishing (including charter vessels) – 73% ($n = 6,821$) in South Australia and 89% in Victoria ($n = 4,016$). Catch and effort data for charter boats is reported in logbooks and is presented in Section 5.

All subsequent analyses reported in this chapter are based on private vessel interview data. In relation to game fishing for tuna or pelagic shark, 24% of all respondents ($n = 2891$) indicated they were participating in this mode of fishing – 1,333 in South Australia and 1,558 in Victoria, 98% ($n = 2,825$) of which indicated that they were specifically targeting tuna – 1,312 in South Australia and 1,513 in Victoria.

Launch times were reported for 2,601 (92%) of tuna fishing events. The median reported launch time for tuna fishing trips was 07:00 and 96% of all tuna fishing trips were launched before midday (Supplementary Figure 42).

Subsequent to adjusting the creel survey shift start time to 09:00 on 23 February 2019, a total of 41 tuna fishing interviews occurred prior to 10:30 (the previous shift start time), representing 1.8% of all tuna fishing interviews (Supplementary Figure 43). In South Australia, a total of 18 interviews where game fishing was reported (1.4% of all tuna fishing trips surveyed) occurred prior to 10:30, with SBT caught on three of these trips.

In Victoria, a total of 23 tuna fishing interviews (1.5% of a tuna fishing trips surveyed) were reported prior to 10:30, with SBT reported caught on four of these trips. These results indicate that very few SBT trips were likely to have been missed on the survey days when the original start time of 10:30 applied. No estimate adjustments were made to account for these missed trips.

2.3.1 Size composition of recreationally caught Southern Bluefin Tuna

In all regions assessed, catches were dominated by 'school fish' (< 135 cm FL), which are juveniles and are likely to range in age up to five years old (Gunn et al. 2008). With a few exceptions, fish between 135 cm and 160 cm FL were largely absent in the catches. A mode of large fish was reported from both Port MacDonnell and Portland (Table 2).

School fish and large fish are discussed in more detail below, with catch expansions by numbers caught and harvested biomass calculated separately due to the bimodal nature of the size distribution and the effect this could have on expanded estimates. Weights reported below are a combination of measured weights (predominantly for large SBT) or length-to-weight converted estimates using the parameters defined in Edwards et al. (2016).

Table 2. Size information of measured Southern Bluefin Tuna from survey regions through South Australia and Victoria. FL = fork length.

Region	Average FL ± SE	Range FL	Weight ± SE	SBT measured (n)	Measured catch (% of retained)
Western Region	66 ± 5 cm	49 – 91 cm	5.4 ± 1.0 kg	50	60
Eyre Peninsula	84 ± 7 cm	54 – 125 cm	12.1 ± 2.5 kg	112	66
Yorke Peninsula	87 ± 2 cm	60 – 108 cm	11.9 ± 1.0 kg	54	90
Fleurieu Peninsula	93 ± 1 cm	52 – 150 cm	13.6 ± 1.0 kg	353	57
Kangaroo Island	86 ± 7 cm	78 – 100 cm	11.1 ± 3.0 kg	4	100
Limestone coast	–	–	–	–	–
Port MacDonnell (school)	79 ± 2 cm	60 – 123 cm	9.1 ± 1.0 kg	415	93
Port MacDonnell (large)	181 ± 2 cm	144 – 221 cm	126.2 ± 4.1 kg	46	100
Portland (school)	82 ± 5 cm	63 – 132 cm	10.1 ± 1.0 kg	386	58
Portland (large)	179 ± 2 cm	136 – 207 cm	119.1 ± 3.7 kg	71	100
Southwest Victoria	89 ± 3 cm	65 – 114 cm	13.1 ± 1.1 kg	170	80

The average size of fish caught in the western region of South Australia was smaller than all other regions (Table 2; Figure 3). The average size of school fish was reasonably consistent for all other regions. Large SBT were only reported from Port MacDonnell and Portland (Table 2; Figure 3). The earliest reported catch of a large fish at Port MacDonnell was in April 2019, with numbers of large fish increasing through August and September. In contrast, most of the large fish reported from Portland were taken in April 2019, with few reported from May through to August, before numbers increased in September and approximately a quarter of the region’s large fish were reported.

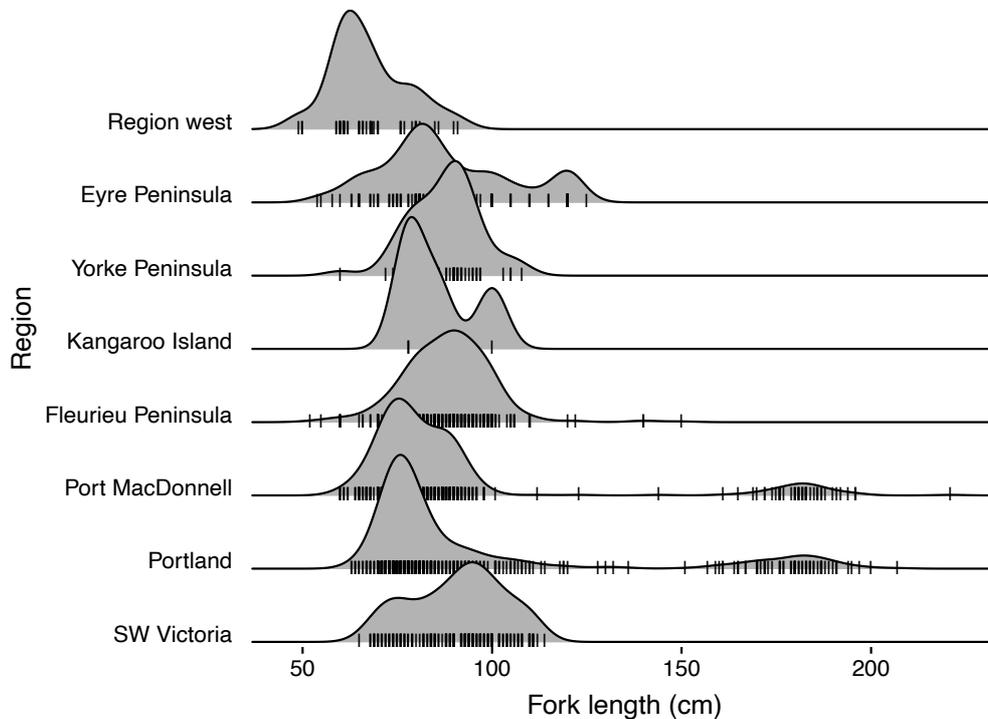


Figure 3. Relative size composition of Southern Bluefin Tuna caught by recreational private-trailer vessel in South Australia and Victoria during the survey period by region, illustrated using density plots. Rugs indicate individual fish measurements.

2.3.2 Estimates of effort targeting tuna and catch of Southern Bluefin Tuna

The subsequent results relate to expanded estimates, whereas the previous results have been based on raw data.

2.3.2.1 SOUTH AUSTRALIA

2.3.2.1.1 Effort

The total number of recreational fishing boat days from private trailer vessels using the selected boat ramps in South Australia over the 12-month survey period was estimated at 41,074 ($\pm 3,290$ SE) (Table 3). A total of 4,478 (± 517 SE) or 11% of these boat days were targeting tuna (Table 3).

Tuna fishing effort was greatest out of the Fleurieu Peninsula, accounting for 50% of all effort in South Australia, followed by Port MacDonnell at 27%. The combined Western Region and the Eyre and Yorke Peninsulas accounted for 18% of SBT effort, while Kangaroo Island and the Limestone Coast accounted for the remaining 5% (Table 3).

Table 3. Estimates of tuna fishing effort (boat days) \pm standard error from private trailer-vessels fishing in South Australia at selected boat ramps for the 12-month survey period. RSE = relative standard error.

Region	Number of recreational fishing boat days	Number of tuna fishing boat days	Percent of fishing boat days targeting SBT	Percent of successful SBT trips
Western Region	4,108 \pm 575 (RSE = 0.14)	260 \pm 60 (RSE = 0.23)	6%	62%
Eyre Peninsula	11,634 \pm 1,057 (RSE = 0.09)	377 \pm 86 (RSE = 0.23)	3%	79%
Yorke Peninsula	1,904 \pm 202 (RSE = 0.11)	186 \pm 44 (RSE = 0.24)	10%	44%
Fleurieu Peninsula	10,927 \pm 1,575 (RSE = 0.14)	2,227 \pm 472 (RSE = 0.21)	20%	42%
Kangaroo Island	2,286 \pm 312 (RSE = 0.14)	151 \pm 43 (RSE = 0.29)	6%	12%
Limestone Coast	6,666 \pm 2,580 (RSE = 0.39)	51 \pm 32 (RSE = 0.63)	<1%	0
Port MacDonnell	3,549 \pm 322 (RSE = 0.09)	1,226 \pm 170 (RSE = 0.14)	35%	38%
State total (SBT target ramps)	41,074 \pm 3,290 (RSE = 0.08)	4,478 \pm 517 (RSE = 0.12)	11%	44%

The postcode of the vessel owner was reported for 84% of all interviews where SBT were targeted in South Australia (Table 4). Of the tuna fishing boat days reported to have occurred in South Australia where the vessel-owner's postcode was reported, 86% were conducted by vessel owners from South Australia and 13% by Victorian vessel owners, with the remaining 1% reported by residents from other States (Table 4).

Table 4. State of origin of vessel owners for the estimated number of tuna fishing boat days conducted in South Australia by region. Vessel owner postcode was reported in 84% of interviews conducted. ND = no postcode data provided during interview.

Survey region	State of origin of vessel owner								Total
	Vic	SA	NSW	NT	QLD	TAS	WA	ND	
Western region	23	212	6					19	260
Eyre Peninsula	16	332		5				24	377
Yorke Peninsula	5	157			1			23	186
Fleurieu Peninsula	5	1,772			4			446	2,227
Kangaroo Island		86						65	151
Limestone Coast		51						0	51
Port MacDonnell	449	611	12		2		2	150	1,226
State total (SBT target ramps)	498	3,221	18	5	7		2	727	4,478

Most tuna fishing trips surveyed in South Australia were from vessel owners from the large Australian Bureau of Statistics (ABS) statistical area covering the western region of South Australia and the Eyre Peninsula, the statistical areas covering the Limestone coast and the Fleurieu Peninsula and Kangaroo Island, and some of the statistical areas surrounding the metropolitan region of Adelaide (Figure 4).

The vast majority of tuna fishing events in South Australia where the vessels had travelled from Victoria were at Port MacDonnell, with a total of 42% of all fishing events at this region conducted from Victorian registered vessels (Table 4). The origin of the Victorian vessels was from both western Victorian statistical regions (close to the border) and multiple regions around the metropolitan and surrounding areas of central Victoria (Figure 4). Fifty-one percent of the surveyed tuna fishing boat days by Victorian boats at Port MacDonnell occurred in August and September 2018. In these months, schools of large fish averaging more than 100 kg were present in the region. It is likely that the Victorian boats were targeting these large fish.

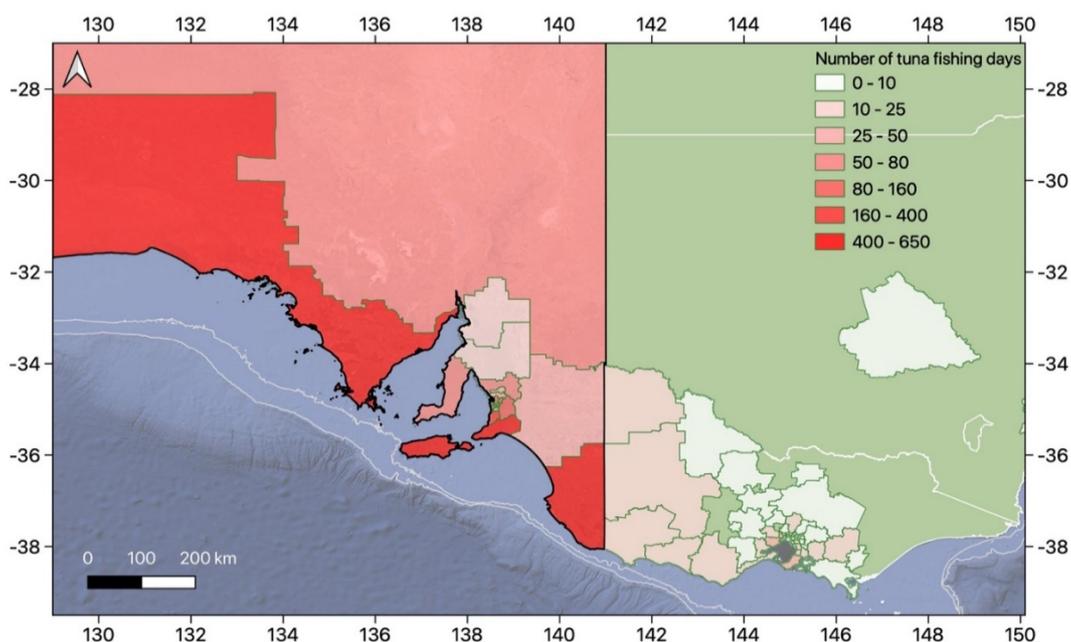


Figure 4. Number of recreational fishing days targeting tuna in South Australia (outlined in black) represented as ABS – Statistical Level 3 (SA3) place of residence of vessel owners (postcode converted to SA3 statistical level). Postcodes were provided for 84% of all interviews. Interviews where no postcode was provided resulted in an estimated additional 727 tuna fishing boat days (un-mapped).

On water, the greatest fishing effort targeted at tuna was reported from Marine Fishing Areas (MFAs) around the Fleurieu Peninsula and Port MacDonnell respectively (Figure 5). Fishing effort for tuna was reported in most other coastal MFAs in South Australia with the exception of the far west, which was not surveyed as the expert interviews indicated negligible fishing for SBT occurred in the region. Only a small amount of effort was reported in MFAs straddling the continental shelf edge, with most SBT targeted on the continental shelf (Figure 5).

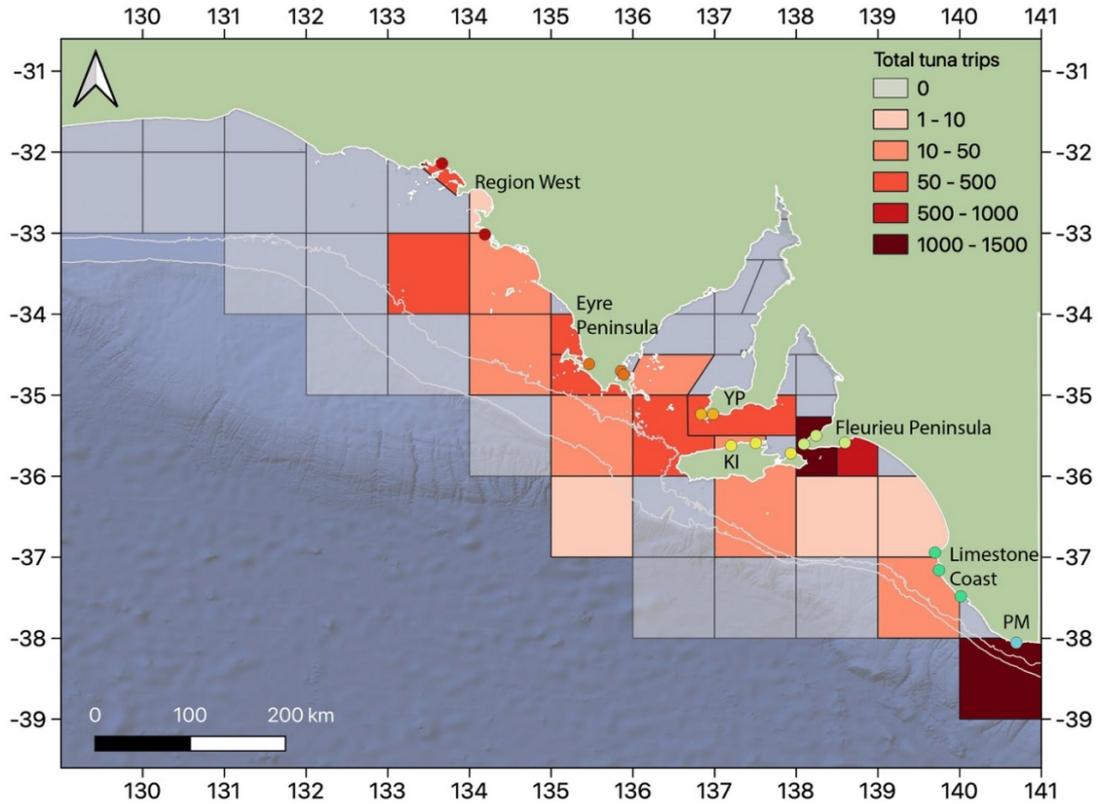


Figure 5. Estimated tuna fishing boat days from private-vessels in South Australian Marine Fishing Area blocks during the survey period. Coloured dots on land indicate locations of surveyed ramps. Region abbreviations are as follows: YP = Yorke Peninsula, KI = Kangaroo Island, PM = Port MacDonnell.

As expected, fishing effort was heaviest during the high season in each of the regions (Figure 6). No tuna fishing was reported in the low season from the Yorke Peninsula, Kangaroo Island or the Fleurieu Peninsula, while very low levels of effort were reported from the Western Region (SA) and Port MacDonnell.

Some tuna fishing was reported from the Eyre Peninsula during the low season, but reports were restricted to the two months directly after the transition from high to low season (May and June). A relatively significant amount of effort was reported at Port MacDonnell during the tail season, with large fish available for several months during the period (Figure 6).

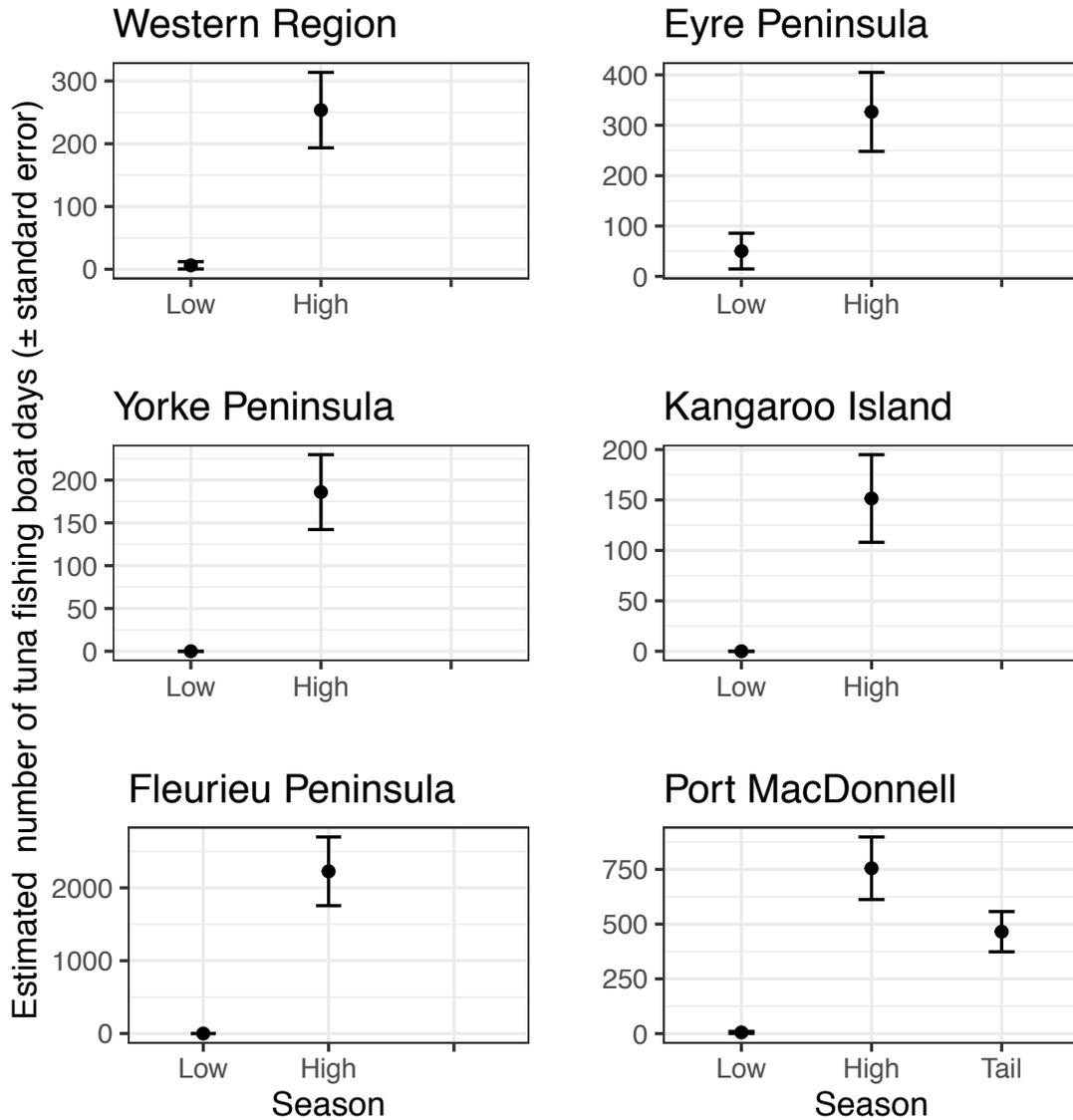


Figure 6. Estimated tuna fishing boat days (\pm standard error) from private trailer-vessels in each survey region of South Australia by seasonal strata (Figure 2). Limestone Coast region not shown.

2.3.2.1.2 Catch

The total retained catch of SBT from private trailer boats using the selected boat ramps in South Australia over the 12-month survey period was estimated at 5,203 (\pm 708 SE), equating to a harvested biomass of 75.2 t (\pm 9.7 SE). A further 1,458 \pm 275 SE SBT were estimated to have been released, equating to a release rate of 22% in South Australia (Table 5).

An additional 15 SBT were retained and 277 released from two SBT specific fishing tournaments conducted from Port Lincoln on the Eyre Peninsula. These competitions were out of scope of the access-point survey as they were predominantly large vessels (see Section 6). These tournaments are both primarily catch-and-release tournaments, and given the low number of fish retained, no adjustments have been made to the overall harvest estimates reported.

The greatest number of retained fish was reported from the Fleurieu Peninsula, accounting for 43% of SBT retained in South Australia and 41% by harvested biomass (Table 5). Port MacDonnell and the Eyre Peninsula each accounted for 23% of the catch by number. While relatively few tuna fishing boat days originated from the Eyre Peninsula, these trips had the highest success rate (79%) for catching SBT of all regions surveyed and accounted for 20% of the total harvested biomass for South Australia (Table 5).

Port MacDonnell accounted for a disproportionately larger percentage of the harvested biomass (33%), influenced by some large SBT caught from this region (Table 2). An estimated 103 (± 19 SE) large SBT were retained during the tail season with a further 10 (± 4 SE) taken in the high season. The remaining regions accounted for the balance of the State's SBT harvest (12% by number and 6% by weight) (Table 5). No catches of SBT were reported from the Limestone coast region.

Table 5. Catch estimates \pm standard error of Southern Bluefin Tuna from private trailer-vessels fishing in South Australia at selected boat ramps over the 12-month survey period. RSE = relative standard error.

Region	SBT caught and kept (n)	Weight of SBT caught and kept (t)	SBT caught and released (n)	Release rate
Western Region	347 \pm 92 (RSE = 0.26)	2.3 \pm 0.6 (RSE = 0.31)	68 \pm 33 (RSE = 0.49)	16 \pm 6% (RSE = 0.35)
Eyre Peninsula	1,177 \pm 296 (RSE = 0.25)	14.7 \pm 4.2 (RSE = 0.29)	457 \pm 143 (RSE = 0.31)	28 \pm 5% (RSE = 0.19)
Yorke Peninsula	219 \pm 69 (RSE = 0.31)	2.6 \pm 0.8 (RSE = 0.33)	47 \pm 30 (RSE = 0.63)	18 \pm 6% (RSE = 0.32)
Fleurieu Peninsula	2,241 \pm 583 (RSE = 0.26)	30.5 \pm 7.9 (RSE = 0.26)	544 \pm 204 (RSE = 0.38)	20 \pm 3% (RSE = 0.14)
Kangaroo Island	36 \pm 26 (RSE = 0.71)	0.4 \pm 0.3 (RSE = 0.78)	0	0
Limestone Coast	0	0	0	NA
Port MacDonnell	1,183 \pm 244 (RSE = 0.21)	24.7 \pm 3.7 (RSE = 0.15)	342 \pm 108 (RSE = 0.32)	22 \pm 6% (RSE = 0.26)
State total (SBT target ramps)	5,203 \pm 708 (RSE = 0.14)	75.2 \pm 9.7 (RSE = 0.13)	1,458 \pm 275 (RSE = 0.19)	22 \pm 2% (RSE = 0.11)

The majority of SBT were caught well inside the edge of the continental shelf (Figure 7). The greatest number of fish were caught in the Marine Fishing Areas (MFAs) adjacent to the Fleurieu Peninsula. The MFA block covering waters adjacent to Port MacDonnell had the second highest catch of SBT and, although this block straddles the shelf break, interviewed fishers reported that most SBT were caught on the continental shelf.

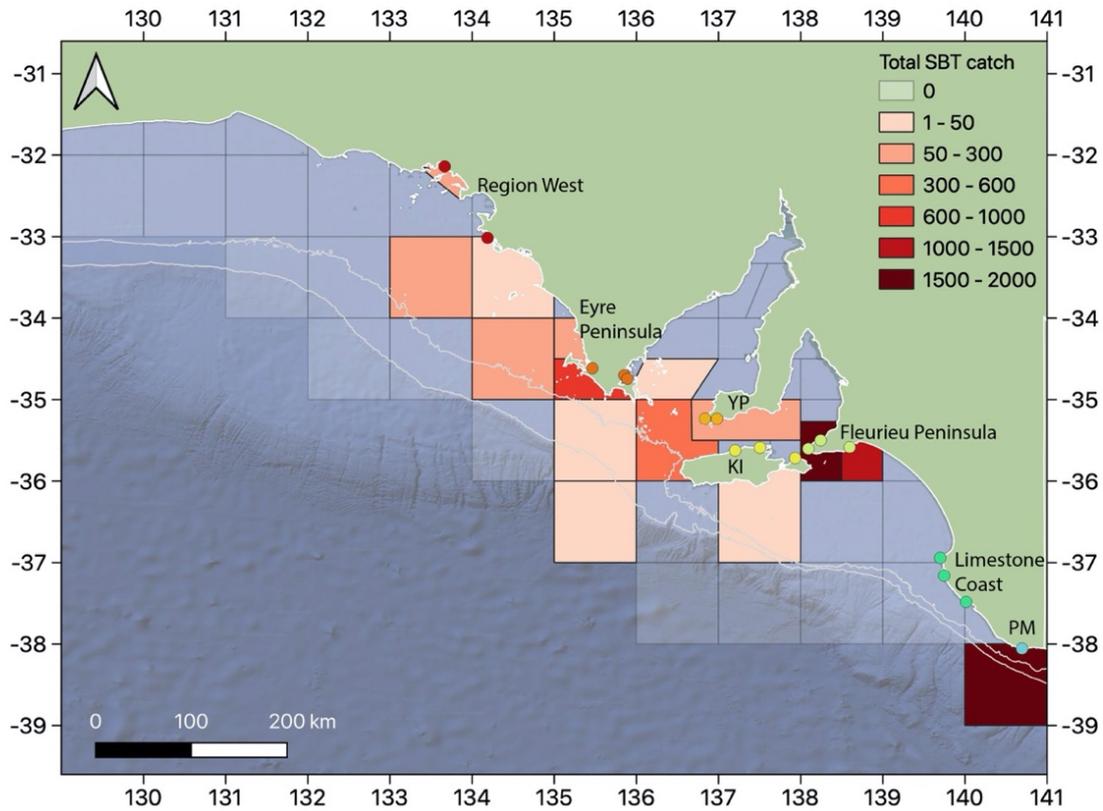


Figure 7. Estimated total catch of SBT by private trailer-vessels in South Australian Marine Fishing Area blocks during the survey period. Coloured dots on land indicate locations of surveyed ramps. Region abbreviations: YP = Yorke Peninsula, KI = Kangaroo Island, PM = Port MacDonnell.

The vast majority of SBT were caught during the ‘high season’ period (Figure 2) for each region in South Australia (Figure 8). Some catch was reported in the low season at the Eyre Peninsula. Minor catches of SBT were reported during the low season at the Eyre Peninsula and Western Region, generally within a month or two either side of the high season (Figure 8).

There was a relatively small number of fish caught during the tail season at Port MacDonnell. However, as they were predominantly large, these fish have a disproportional effect on the overall harvest total so are an important component of the South Australian harvest. There was a reasonably significant amount of effort at this time (Figure 6), which resulted in a lower catch per unit of effort (CPUE) compared to the high season when both large and school tuna were available to the fishery.

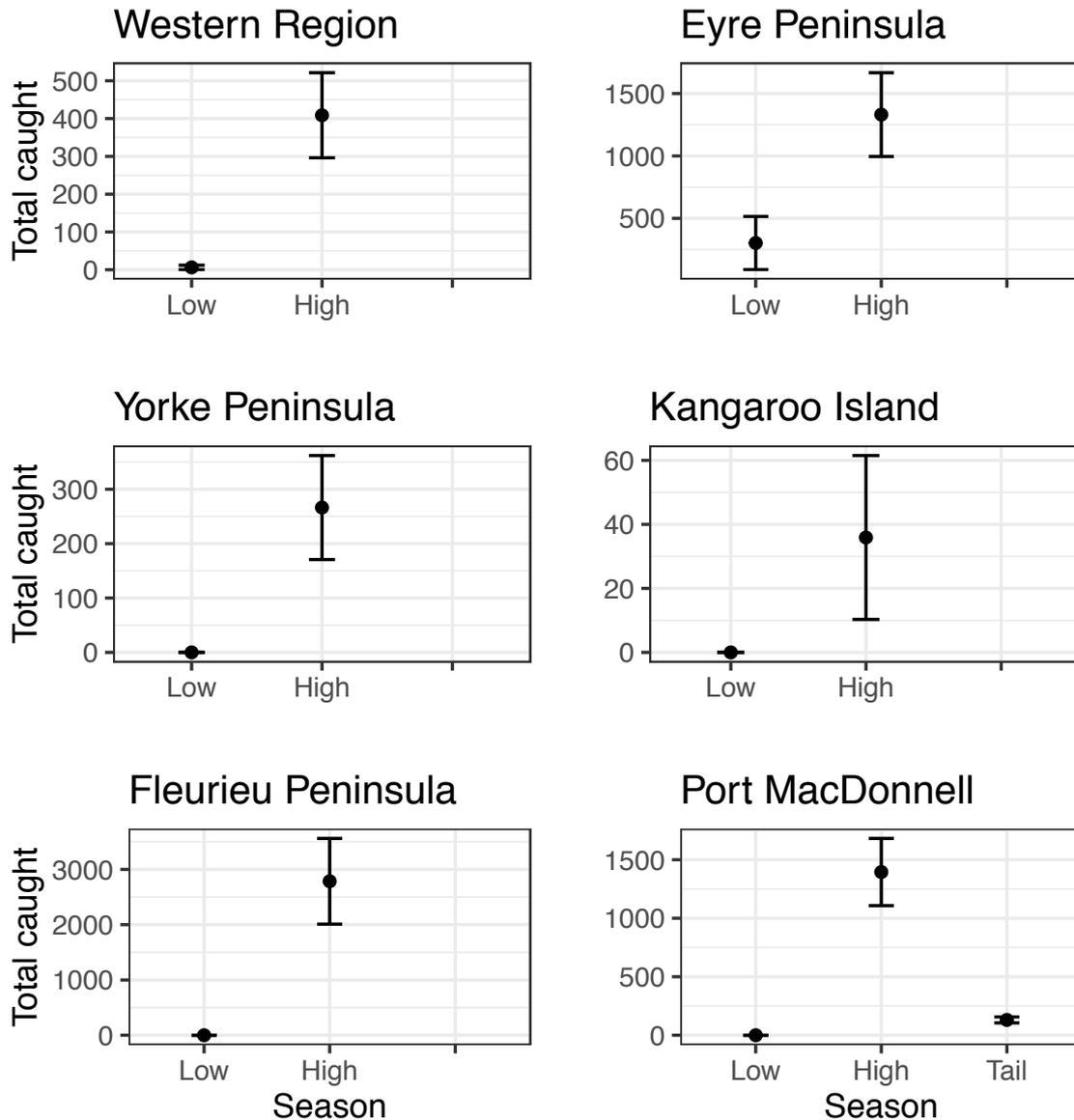


Figure 8. Estimated total number of Southern Bluefin Tuna caught (\pm standard error) by private trailer-vessels in each survey region through South Australia by seasons shown in Figure 2. Limestone Coast region not shown.

Release rates varied between regions, with the lowest release rates reported from the Western Region (16%) and the Yorke Peninsula (18%). Slightly higher release rates were reported on the Fleurieu Peninsula (20%) and at Port MacDonnell (22%). The highest release rate was reported from the Eyre Peninsula, with 28% of the SBT caught reported as released (Table 5). A total of 9% of all trips targeting SBT reported reaching the catch limit for the State (individual bag limit of two fish per person to a maximum boat limit of six SBT), with 20% of all trips where at least one SBT was caught reaching the catch limit.

2.3.2.1.3 Depredation

There was very little depredation of SBT catch reported from the private vessel fleet in South Australia. For the events that were reported, sharks were identified as the predator in each case. It was estimated that 12 (\pm 6 SE) fish were lost to a predator during the capture event from the Fleurieu Region, equating to 0.16 (\pm 0.08 SE) tonnes.

A further 17 (± 6 SE) fish were estimated to have been damaged by sharks at the Fleurieu Peninsula but were retained by the fisher. Catch damaged by sharks accounted for less than one percent of all fish retained in the region. Depredation was also reported from the Western Region with 20 (± 18 SE) SBT estimated to have been lost to a predator during the capture event, equating to 0.13 (± 0.12 SE) tonnes. Depredation of SBT was not reported from any other region in South Australia.

2.3.2.2 VICTORIA

2.3.2.2.1 Effort

The total number of recreational fishing boat days from private trailer vessels using the selected boat ramps in Victoria over the 12-month survey period was estimated at 15,287 ($\pm 1,047$ SE). Victoria had a greater estimate of total recreational fishing effort for SBT than South Australia, with an estimated 5,001 (± 444 SE) fishing days. This equated to 33% of all fishing events occurring from the selected boat ramps in Victoria (Table 6). Most of these fishing days occurred from Portland (82%).

Table 6. Estimates of tuna fishing effort (boat days) \pm standard error from private trailer-vessels fishing in Victoria at selected boat ramps for the 12-month survey period. RSE = relative standard error.

Region	Number of recreational fishing boat days	Number of tuna fishing boat days	Percent of fishing trips targeting SBT	Percent of successful SBT trips
Portland	9,069 \pm 779 (RSE = 0.09)	4,115 \pm 419 (RSE = 0.10)	45%	23%
Southwest Victoria	6,218 \pm 700 (RSE = 0.11)	886 \pm 148 (RSE = 0.16)	14%	41%
State total (SBT target ramps)	15,287 \pm 1,047 (RSE = 0.07)	5,001 \pm 444 (RSE = 0.09)	33%	26%

In Victoria, 98% of tuna fishing boat days where the vessel-owner postcode was reported were assigned to Victorian residents, 1% were from South Australia (Figure 9), and the remaining 1% were from other States, predominantly New South Wales (Table 7).

The greatest number of trips originated from the western statistical area and several statistical areas around metropolitan and surrounding areas in central Victoria. A lower number of tuna fishing boat days originated from the eastern Gippsland regions and inland statistical divisions that bordered with New South Wales (Figure 9).

Table 7. State of origin of vessel owners for the estimated number of tuna fishing boat days conducted in Victoria by region. Vessel owner postcode was reported in 98% of interviews conducted. ND = no postcode data provided during interview.

Survey region	State of origin of vessel owner								Total
	VIC	SA	NSW	NT	QLD	TAS	WA	ND	
Portland	3,740	50	32	–	11	5	–	277	4,115
Regional West Vic.	796	4	9	–		3	–	74	886
State total (SBT target ramps)	4,536	54	41	–	11	8	–	351	5,001

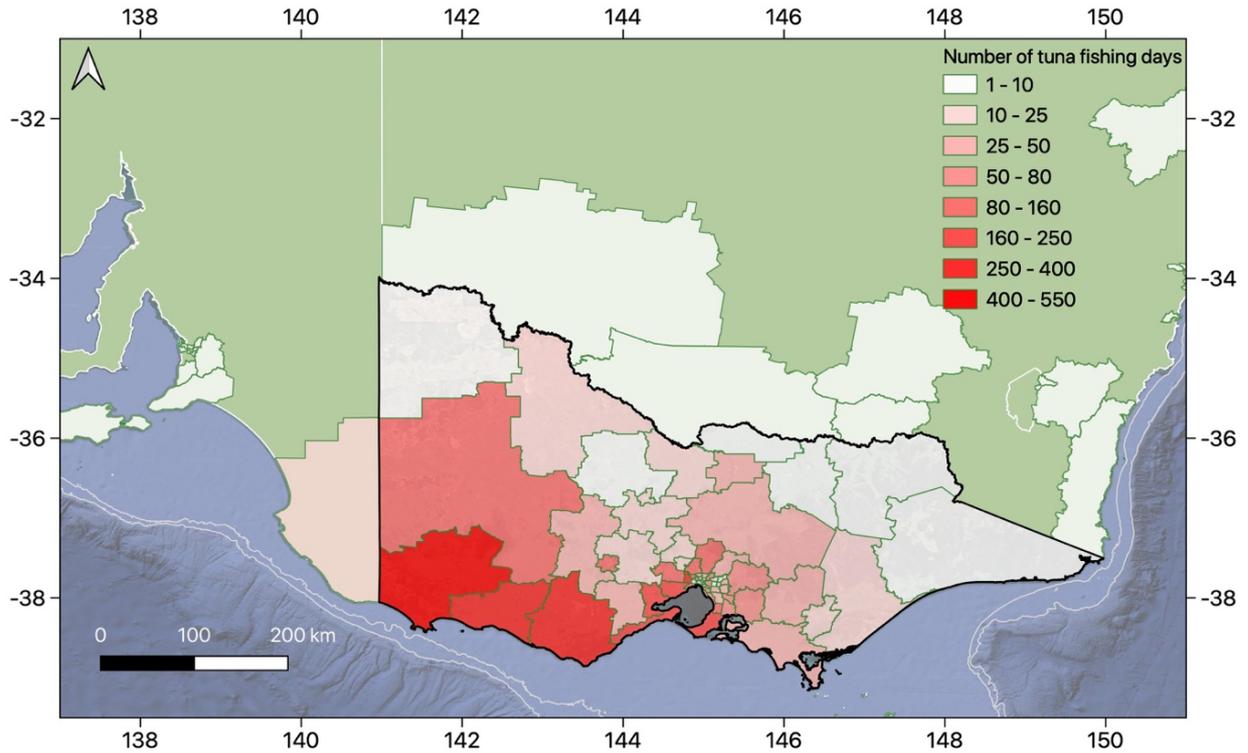


Figure 9. Number of recreational fishing days targeting tuna in Victoria (outlined in black) represented as ABS – Statistical Level 3 (SA3) place of residence of vessel owners (postcode converted to SA3 statistical level). Postcodes were provided for 93% of all interviews in Victoria. Interviews where no postcode was provided resulted in an estimated additional 351 tuna fishing boat days (un-mapped).

On water, the greatest amount of fishing effort was reported from fishing grids in the vicinity of Portland (Figure 10). Most trips were close to the coast, but there were reports of fishing effort occurring further out to sea and beyond the continental shelf edge. Note that the shelf edge is closer to land in southwest Victoria than for most of the South Australian coastline, except for the Limestone coast and Port MacDonnell.

Effort hotspots were also identified close to the access points at Port Fairy and Warrnambool, where there is an apparent trend for more fishers to travel further out to sea from these ports to fish for tuna (Figure 10). There was a small amount of effort from Apollo Bay, with effort directed well out from the coast.

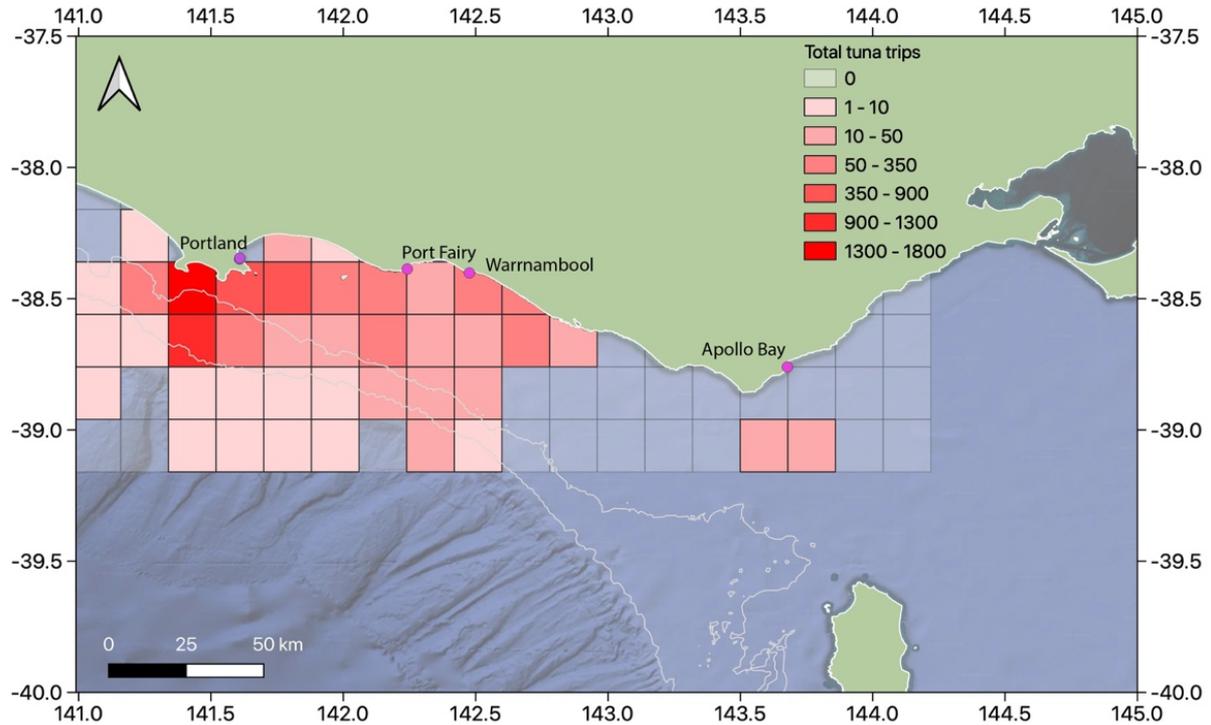


Figure 10. Spatial distribution of estimated tuna fishing boat days from private trailer-vessels in Victoria during the survey period. Coloured dots on land indicate locations of surveyed ramps.

In Victoria, tuna fishing effort was heavily concentrated during the high season, with limited activity in both regions during the low and tail seasons (Figure 11). At Portland, low season effort was estimated at 571 (± 147 SE) tuna fishing boat days, with a further 432 (± 147 SE) tuna fishing boat days estimated during the tail season. Boat days in the tail season were mostly focused on catching large SBT.

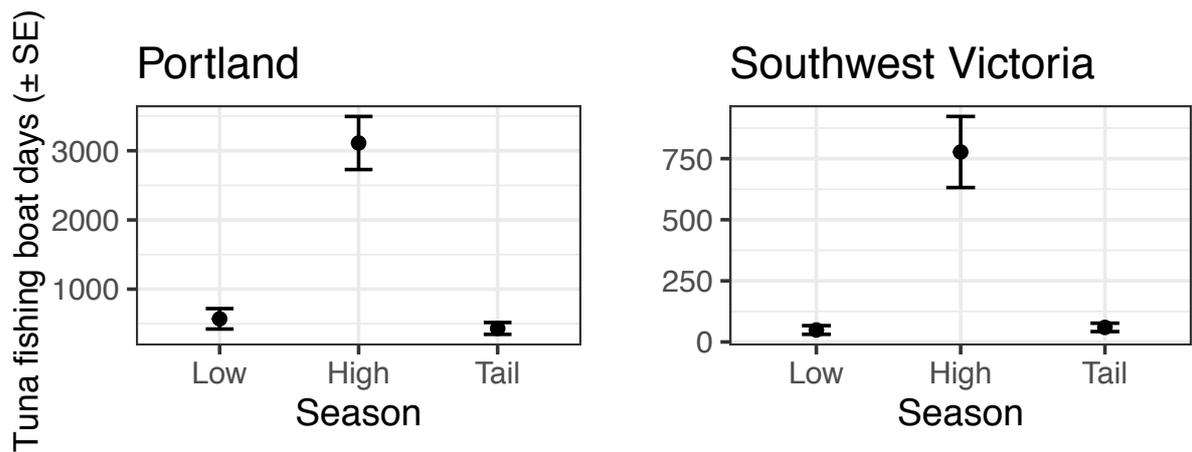


Figure 11. Estimated tuna fishing boat days (\pm standard error) by private trailer-vessels in each survey region surveyed in Victoria by seasonal strata (Figure 2).

2.3.2.2.2 Catch

The total retained catch of SBT from private trailer vessels using the selected boat ramps in Victoria was estimated at 2,946 (± 450 SE) fish, equating to a harvested biomass of 55.6 t (± 8.0 SE). A further 1,315 (± 285 SE) SBT were released, resulting in a release rate of 31% (Table 8).

Table 8. Catch estimates \pm standard error of Southern Bluefin Tuna from private trailer-vessels fishing in Victoria at selected boat ramps for the 12-month survey period. RSE = relative standard error.

Region	SBT caught and kept (n)	Weight of SBT caught and kept (t)	SBT caught and released (n)	Release rate
Portland	2,209 \pm 414 (RSE = 0.19)	45.6 \pm 7.6 (RSE = 0.17)	759 \pm 240 (RSE = 0.32)	26 \pm 5% (RSE = 0.20)
Southwest Victoria	736 \pm 178 (RSE = 0.25)	10.0 \pm 2.5 (RSE = 0.26)	556 \pm 153 (RSE = 0.27)	43 \pm 3% (RSE = 0.08)
State total (SBT target ramps)	2,946 \pm 450 (RSE = 0.15)	55.6 \pm 8.0 (RSE = 0.14)	1,315 \pm 285 (RSE = 0.22)	31 \pm 4% (RSE = 0.12)

Most retained fish were reported from Portland, accounting for 75% of the total number retained in Victoria and 82% of the estimated harvested biomass (Table 8). The higher percentage for harvested biomass was influenced by the number of large SBT caught from vessels launching at Portland, with 168 \pm 52 SE large SBT harvested in the high season and 56 \pm 19 SE in the tail season. The majority of the SBT were caught on the continental shelf (Figure 12), with the greatest number caught in fishing blocks adjacent to Portland. Some of the greatest catches from vessels launching from boat ramps in the remaining southwest region were further offshore in this region (Figure 12).

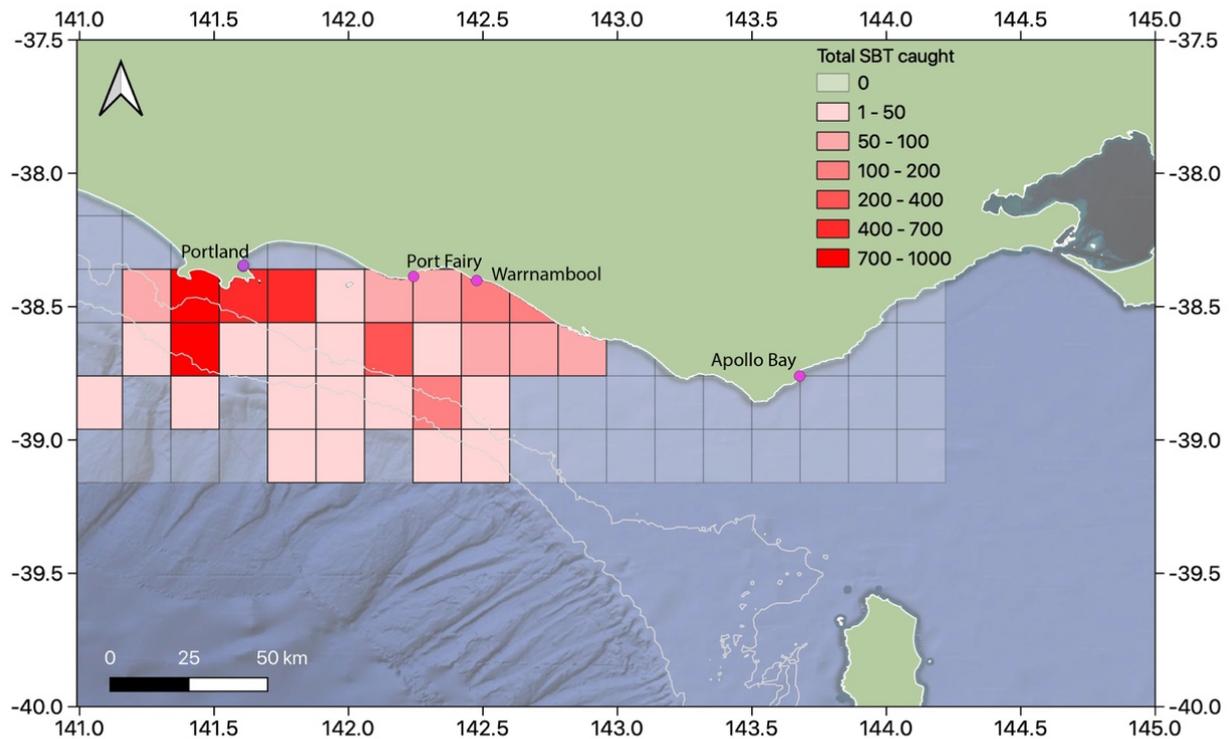


Figure 12. Spatial distribution of estimated total catch of Southern Bluefin Tuna from private trailer-vessels in Victoria during the survey period. Coloured dots on land indicate locations of surveyed ramps.

Most fish were caught during the high season in Victoria and relatively low catches were reported during the low and tail seasons (Figure 13). The catch reported during the tail season at Portland was predominantly large fish, with no large fish reported caught from the southwest region during any season.

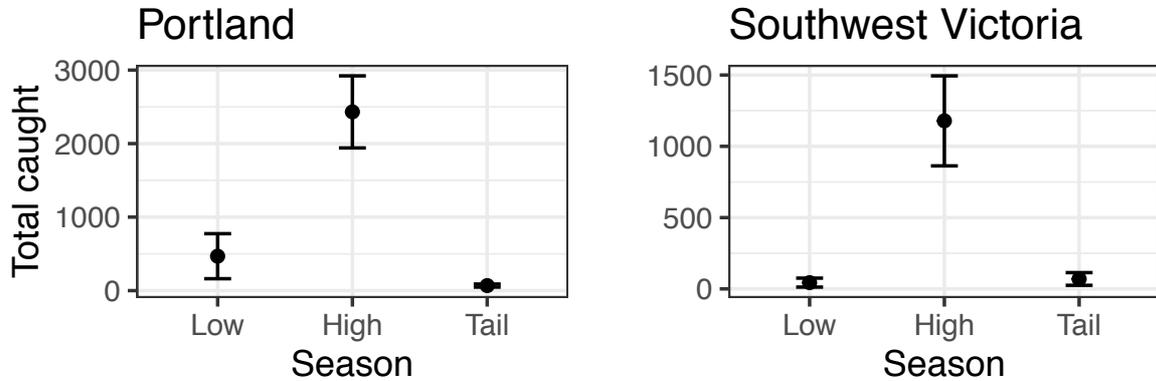


Figure 13. Total number of Southern Bluefin Tuna caught (\pm standard error) by private trailer-vessels in each survey region surveyed in Victoria by seasonal strata (Figure 2).

Release rates were significantly different between Portland and the southwest Victorian region. The release rate at Portland was estimated at 26%, similar to the highest release rate reported from South Australia, while the southwest Victorian region had a much higher release rate at 43% (Table 8). Overall, 5% of all SBT fishing trips reported reaching the catch limit for the State (daily bag limit of two SBT per person, no boat limit), with 19% of all trips where at least one SBT was caught reaching the catch limit.

2.3.2.2.3 Depredation

There was very little depredation of SBT catch reported from the private vessel fleet in Victoria. From southwest Victoria, it was estimated that three (± 2 SE) fish were lost to seals during a capture event, equating to 0.04 t (± 0.03 SE). Although no SBT were reported lost to a predator during the capture process at Portland, an estimated eight (± 4 SE) SBT were damaged but retained, and have been included in the harvest estimates.

2.4 Consideration of survey coverage

The on-site access-point design used in this study focuses on boat ramps that are used by vessels launched from towed trailers. As a result, it does not include catch from larger vessels that berth in marinas or are moored.

In South Australia, there are no permanent moored recreational vessels or marinas at Ceduna or Scaale Bay in the western region, nor Pondalowie Bay and Marion Bay on the Yorke Peninsula. Non-trailer vessels intending to fish areas suitable for SBT on the Yorke or Fleurieu Peninsulas would need to leave from marinas around Adelaide, with the distances prohibitive for regular trips.

There are some moored recreational fishing vessels at Penneshaw on Kangaroo Island, a small number moored at Robe, and none moored at Beachport, while the Cape Jaffa marina was under construction for most of the survey period. The harbour at Port MacDonnell is primarily used by commercial vessels. Creel clerks and regional experts confirmed that tuna fishing effort

by large non-trailer vessels through all these regions was exceptionally rare and any resulting catch was likely to be negligible during the survey period.

The greatest potential for SBT fishing from larger vessels is on the Eyre Peninsula. A follow-up interview with a regional expert from Port Lincoln identified that there are around 40 large 'game fishing' boats located at Port Lincoln, with approximately 10–15 of these vessels 'active'. However, the quantities of SBT caught by this fleet through the season are likely to be minimal.

The President of the Game Fishing Club of South Australia (GFCSA), who has extensive experience fishing for SBT on the Eyre Peninsula, was also interviewed to corroborate the comments from the regional expert. It was suggested that approximately 15–20 larger vessels are 'somewhat' active in the region, with approximately half of these vessels owned by members of the GFCSA who were likely to be more 'active' in the SBT fishery than the other vessel owners (*R. Czabayski, pers. comm.*).

With the exception of two tournaments held on the Eyre Peninsula (see below), it was estimated that approximately 20–50 SBT were likely to have been caught and retained and a further 200–250 released by GFCSA members on large vessels in the region (*R. Czabayski, pers. comm.*). If these estimates were doubled to account for possible catches from non-club member vessels, it would suggest that approximately 100 SBT were retained from large vessels operating from the Eyre Peninsula during the survey period.

It is worth noting that Port Lincoln hosted the Peter Teakle Wines Blue Water Classic and the Riviera Port Lincoln Tuna Classic game fishing tournaments in the survey year, the former a GFCSA event. Five boats entered the Peter Teakle Wines Blue Water Classic, of which some were non-trailer vessels. A total of 12 SBT were reported caught and retained and a further 100 caught and released (see Table 17). Twenty-two boats entered the Riviera Port Lincoln Tuna Classic, with the field being mainly non-trailer boats, including some that had come from Adelaide for the event. This is primarily a catch-and-release competition, with only three SBT reported as retained, while 177 were released (see Table 17).

In Victoria, at the Portland marina, creel clerks regularly checked in with charter boats moored at the marina and as such were well-positioned to observe fishing activity by moored private vessels. Observations of large private vessels returning from tuna fishing trips was very rare.

At Port Fairy, the marina is small and predominantly used by commercial vessels (including recreational charter operators) and recreational yachts. It is unlikely that there was any significant fishing effort for SBT from vessels using this marina, with the exception of charter operators whose catch was reported in the charter logbook program.

Warrnambool does not have a dedicated marina but some commercial fishing vessels, including one charter operator, use moorings inside the breakwater. Apollo Bay has a small marina used primarily by yachts and commercial vessels. It is highly unlikely much if any recreational fishing effort occurred from non-trailer private vessels in Warrnambool or Apollo Bay, confirmed by the creel clerks and regional manager through observation and discussions with locals and the Harbour Master at Apollo Bay. An interview with the former president and life member of the Warrnambool Offshore and Light Game Fishing Club confirmed that the

catch of SBT from private non-trailer vessels in southwest Victoria during the survey period was negligible if not entirely absent (*N. Dance², pers. comm.*).

There is also a possibility that commercial vessels may temporarily 'de-register' and use their vessel for recreational fishing activity targeting SBT. Anecdotally, this is thought to be a very rare event in Victoria and South Australia, and thus any unaccounted catch is likely to have been negligible.

Survey coverage was also limited to selected ramps in South Australia and Victoria. While a rigorous assessment of all ramps was made in consultation with regional experts on ramp use and suitability for vessels to launch to target SBT, there are potentially other regions or ramps from where SBT are caught. Survey staff, including creel clerks, did hear reports of fish being caught in other areas and a qualitative assessment of this catch was considered. Often the effort and catch from rarely-used ramps or those in remote areas were reported as likely to be negligible.

Reports of small and occasional catches were received from locations in the western region of South Australia, including Yanerbie, Davenport Beach at Ceduna, and Streaky Bay. Yanerbie and Davenport ramps are difficult beach launches and only used by a few locals, while the ramp at Streaky Bay is a long way from the main fishing areas for SBT in the region. The regional expert in the area confirmed that catches were negligible from these access points during the survey period.

There were reports of a number of school fish caught from a beach launch on the southern shoreline of Kangaroo Island in South Australia, with a qualitative assessment suggesting approximately 100 fish may have been caught.

In Victoria, there were no SBT reported caught on survey days at Apollo Bay, but survey staff did receive anecdotal reports of approximately 30 school fish being caught in the area during the survey year along with four large SBT. There were also reports of approximately five larger fish caught from the Port Campbell region.

The availability of SBT in areas where they had not traditionally been found also posed a risk to the survey estimates. For example, there were reports of SBT being caught in waters around Port Phillip Bay, along Cape Shank and the Rip at the entrance to the Bay. Any recreational fishing interactions with this run of fish was closely tracked through social media and in discussions with local experts, as well as being recorded in charter boat logbook returns. This tracking suggested there was not a significant number of SBT caught in the survey year.

A qualitative assessment suggested that about 200 school fish were caught during the survey period. This includes the quantitative assessment of the charter boat sector from which two vessels reported a combined catch of 24 fish in their logbooks. In most cases these fish were caught as incidental to the targeting on Yellowtail Kingfish *Seriola lalandi*. Charter boat catches in the region east of Apollo Bay were confirmed by mining information from each the social

² Former President, Warrnambool Offshore & Light Game Fishing Club.

media pages, of all vessels identified during the survey as potentially providing SBT charters. Charter boats routinely promote their catches on social media as a form of marketing.

It is worth noting that SBT returned to the same area in early 2020 and were caught over a period of approximately two months, beginning in late January. Charter boats in the area heavily advertised the availability of the fish and gained exposure on social media from the broader recreational fishing community. While it is likely that more fish were caught in this area in the summer months following the survey, anecdotal accounts suggest that while there were some days with good catch rates there were intermittent periods of low catchability during the timeframe they were available.

Due to the current COVID-19 pandemic in Australia, it is likely that the annual harvest of SBT by the recreational sector in 2020 will be suppressed. Recreational boating around Australia was heavily restricted through April and May, including a complete ban on recreational fishing in Victoria in April and much of May. Catches of SBT in these months typically contribute significantly to State harvest in Victoria and Tasmania.

In summary, there was some evidence of under-coverage for the on-site access-point survey design applied across South Australia and Victoria during the survey period. However, the resulting missed catch is likely to be less than 5 t or less than 2% of the total National estimate.

3 Catch and effort estimation from the recreational fishery for Southern Bluefin Tuna from private vessels in Tasmania

3.1 Introduction

Recreational fishing in Tasmania is an important activity for many people, with about one in four Tasmanians estimated to participate in some form of recreational fishing each year (Lyle et al. 2019). A recreational gamefish fishery has existed for many years in Tasmania, targeting large pelagic species such as tuna, sharks and billfish (Caton 1994, Tracey et al. 2013, French et al. 2015, Tracey and Pepperell 2018).

While game fishers may only represent a small proportion of the population of recreational fishers, they have been described as particularly avid, with higher overall investment required to participate in this activity (Forbes et al. 2009). This higher investment, such as purchasing a vessel that can access offshore fishing grounds, is considered a barrier to this particular fishing activity for many fishers (Tracey et al. 2013). Despite this, there has been a shift in Tasmania towards ownership of larger and more expensive boats and gear, coinciding with increased participation in offshore fishing activities (Tracey et al. 2013).

As in other southern States in Australia, Southern Bluefin Tuna (SBT) are a popular gamefish species in Tasmania, where access to the fish depends on season and location. Most fishing for SBT occurs off the Tasman Peninsula in south-eastern Tasmania, from January to July each year (Morton and Lyle 2003, Forbes et al. 2009, Tracey et al. 2013). However, SBT have also been reported as far north as Flinders Island and as far south as Pedra Branca off the south coast, with sporadic catches also taken off the west coast of Tasmania (Forbes et al. 2009, Tracey et al. 2013).

Popular access points for SBT fishing off the Tasman Peninsula include Pirates Bay, Fortescue Bay and Port Arthur. However, other access points along the eastern and southern coasts are also used by fishers targeting SBT when the fish are locally available (Forbes et al. 2009, Tracey et al. 2013, Moore et al. 2015).

In addition to the private boat fleet of recreational fishers, Tasmania has a charter boat industry that services the game fishing sector. Operators that offer game fishing charters are predominantly based in the south east, with much of the game fishing for SBT conducted off the Tasman Peninsula. Some operators are based in the north east, with a small number of operators that usually run larger vessels offering charters on the south coast. Tasmania also has a number of game fishing tournaments throughout the year, including SBT-specific competitions. Data on charter boat and tournament fishing for SBT in Tasmania are presented in Chapters 5 and 6.

Tasmania does not have a general recreational fishing licence, but the Tasmanian recreational vessel licence database administered by Marine and Safety Tasmania (MAST) is a suitable sampling frame to target recreational offshore and game fishing, as a vessel is a limiting factor to accessing these fisheries (Tracey et al 2013). The availability of a suitable, targeted sampling frame allows for the delivery of an off-site survey design, specifically a telephone-diary methodology which can be applied in this case to assess the recreational offshore and game fishery in Tasmania. This method has been the basis of many general state-wide fishing surveys

in Australia (Lyle et al. 2009, Giri and Hall 2015, West et al. 2015, Lyle et al. 2019), since it was first used as the delivery method for the National Recreational and Indigenous fishing survey in 2000/01 (Henry and Lyle 2003). Where an appropriately targeted sample frame, such as a species- or gear-specific permit or vessel registration database is available the method can also be used to estimate effort and catch from specific fisheries (Lyle and Tracey 2012, Tracey et al. 2013, Lyle et al. 2019).

The primary objective of this component of the survey was to quantify recreational fishing activity for SBT from private vessels in Tasmania, specifically:

- annual fishing effort – tuna fishing boat days
- annual catch – retained, released and depredated
- seasonal and spatial presentation of annual catch and effort.

3.2 Methods

3.2.1 Survey design

An off-site telephone-diary survey (TDS) approach was used to assess the catch and effort from recreational fishing of key game fish species from private boats in Tasmania, from December 2018 to November 2019 inclusive. The survey involved a two-phase design (Lyle et al. 2010) of an initial screening interview conducted by telephone to establish eligibility and collect profiling information, and a longitudinal phase conducted by telephone interview for eligible respondents in which boat-based game and offshore fishing activities were monitored in detail over the survey period.

In addition to the primary objective of assessing recreational game fishing activity, the Tasmanian Government provided supplementary funding to extend the survey scope to include offshore recreational fishing activity for other, primarily demersal, key species of interest. The methods and results reported here focus on the assessment of the fishery for SBT in Tasmania.

The survey ‘population’ consisted of all registered recreational vessels contained in the recreational vessel registration database administered by MAST. Fishing charter vessels are not listed in this database as they are registered commercial vessels. While it is possible for commercial fishing vessels to temporarily ‘de-register’ to conduct a recreational fishing trip, it is likely to be a rare event and any resultant catch be negligible in the context of that taken by private vessels.

A ‘target population’ was drawn from the entire list of registered recreational vessels, based on criteria relating to the perceived capability of the vessel to be used safely for offshore game fishing activity. All vessels other than yachts, personal watercraft, inflatables, vessels with trade plates (new boats registered for sale by merchants) and vessels less than 4.5 m in length were included in the target population. The primary sampling unit (PSU) was the registered vessel.

3.2.2 Stratification

The target population was divided into five regional strata based on the postcode of the registered owner of the vessel. These regions corresponded to the Australian Bureau of

Statistics (ABS) statistical areas (SA4) of Hobart, South East, West & North West and Launceston & North East. Interstate residents were grouped into a fifth ‘interstate’ stratum.

A stratified random sample approach was applied, where between 22 and 24% of all target population vessels were selected from each region in Tasmania and 30% of interstate vessels selected (Table 9). The sample was also stratified by vessel size, with five strata recognised, including ‘no vessel size recorded in the MAST database’, 4.5 – 5.5 m, 5.6 – 8.5 m, 8.6 – 11.5 m and greater than 11.6 m (Table 9).

Table 9. Sample fraction matrix showing sample percentages of the target population of recreational vessels in Tasmania by ABS– Statistical Level 4 (SA4) and vessel size categories defined in this report.

Size class	Hobart	Launceston & North East	South East	West & North West	Interstate	All target vessels per size class
No vessel size	54%	61%	68%	55%	100%	59%
4.5 – 5.5 m	16%	16%	16%	16%	13%	16%
5.6 – 8.5 m	30%	30%	30%	30%	30%	30%
8.6 – 11.5 m	51%	51%	53%	48%	50%	51%
11.6 m +	51%	53%	52%	48%	50%	51%
All target vessels per region	23%	22%	24%	22%	30%	

Vessels in the 4.5 – 5.5 m size class were the most common (64%) in the target population and, given the large number of vessels in this group, the sampling fraction was the lowest of all groups at 16% (Table 9). Vessels in the 5.6–8.5 m size category were the second most common group (29%). This category was considered the most likely size vessel to be used for offshore fishing, so a higher sample fraction of 30% was applied (Table 9).

Vessels 8.6–11.5 m and greater than 11.6 m were less common, representing 3% and 2% of the target population, respectively. Given the small number of vessels in these size classes, it was possible to achieve high sampling rates, equivalent to 51%. A further 2% of vessels had no size information recorded in the MAST database. A sampling fraction of 59% was applied for this group, and where possible, the size of each vessel confirmed.

3.2.3 Interview structure

Due to privacy requirements, it was initially necessary to contact the random sample of vessel owners by telephone on behalf of MAST, to request permission for the release of their contact details to the University of Tasmania for the purpose of a survey of recreational vessel usage. This was to ensure adherence to the Privacy Act (Act No. 119) 1988. To eliminate subject relevancy bias, it was not revealed at this stage that the survey related to recreational fishing. Vessel owners who gave permission to be contacted were subsequently contacted by telephone during November and early December 2018 to participate in the screening survey.

Phase one (screening) respondents were asked if their selected vessel (some respondents owned multiple vessels) had been used for recreational fishing in the previous 12 months and, if so, what types of fishing activities it had been used for by either themselves or others. The activities were categorised as freshwater fishing, inshore/estuarine fishing (including potting and netting), game fishing (including targeting tunas, billfish or Mako Shark *Isurus oxyrinchus*),

offshore fishing (specifically at depths typical for the capture of species such as Striped Trumpeter *Latris lineata* or Blue-eye Trevalla *Hyperoglyphe antarctica*), dive harvest or 'other fishing' in or adjacent to Tasmanian State waters.

If either game fishing or offshore fishing were identified, respondents were asked to give their 'best estimate' of the number of days the vessel was used for each of these specific activities in the preceding 12 months. All respondents, regardless of their response to the previous question, were then asked about the likelihood that their vessel would be used for recreational fishing during the 12 months commencing 1 December 2018. Respondents were then asked more specifically about the likelihood that the vessel would be used for offshore recreational fishing or game fishing during the same period. If the response to this question was 'quite likely' or 'very likely', the owner was invited to participate in the longitudinal component of the study in which their game fishing activity was monitored for 12 months, from December 2018 to November 2019, inclusive.

Phase two (longitudinal component) commenced on 1 December 2018 and ran through to 30 November 2019. Respondents who agreed to participate were mailed a simple fishing diary/logbook and a formal letter of introduction. Respondents were contacted by telephone shortly afterwards to confirm receipt of the diary and to have reporting requirements explained. Respondents were then contacted regularly by telephone throughout the 12-month study period by trained survey interviewers who recorded details of any game fishing or offshore fishing activities conducted from the selected vessel since last contact. The frequency of the contact was tailored to the amount of in-scope fishing activity undertaken by the vessel.

Specifically, owners of vessels used more frequently were contacted more regularly so detailed information could be routinely collected soon after each fishing event. This was designed to minimise recall bias for any information that was not recorded in the diary. By maintaining regular contact, interviewers were also able to immediately clarify any misunderstandings or inconsistencies at the time of the interview, thereby ensuring overall data quality and completeness. Most respondents were contacted at least once a month, even if no fishing activity was planned. The owners of all eligible boats were encouraged to participate in the diary survey.

Information recorded for each in-scope fishing event included the trip date, fishing location, departure location, whether game fishing was the intention, the number of hooks used or the number of lines used depending on the fishing mode, the primary target species (up to two), start and finish times (including any significant breaks from fishing), catch composition by numbers kept (harvested) and numbers released or discarded.

Information on any interactions with wildlife during the fishing event was also recorded, including the number of fish lost to predators, the number of retained fish damaged by predators and any observed predation of released fish. Individual size measurements for SBT were reported by some respondents, in a number of formats including weight or fork length and a combination of estimated or measured sizes. In each case, the measurement category was recorded. Fishing locations were allocated into one of 10 coastal regions (Figure 14).

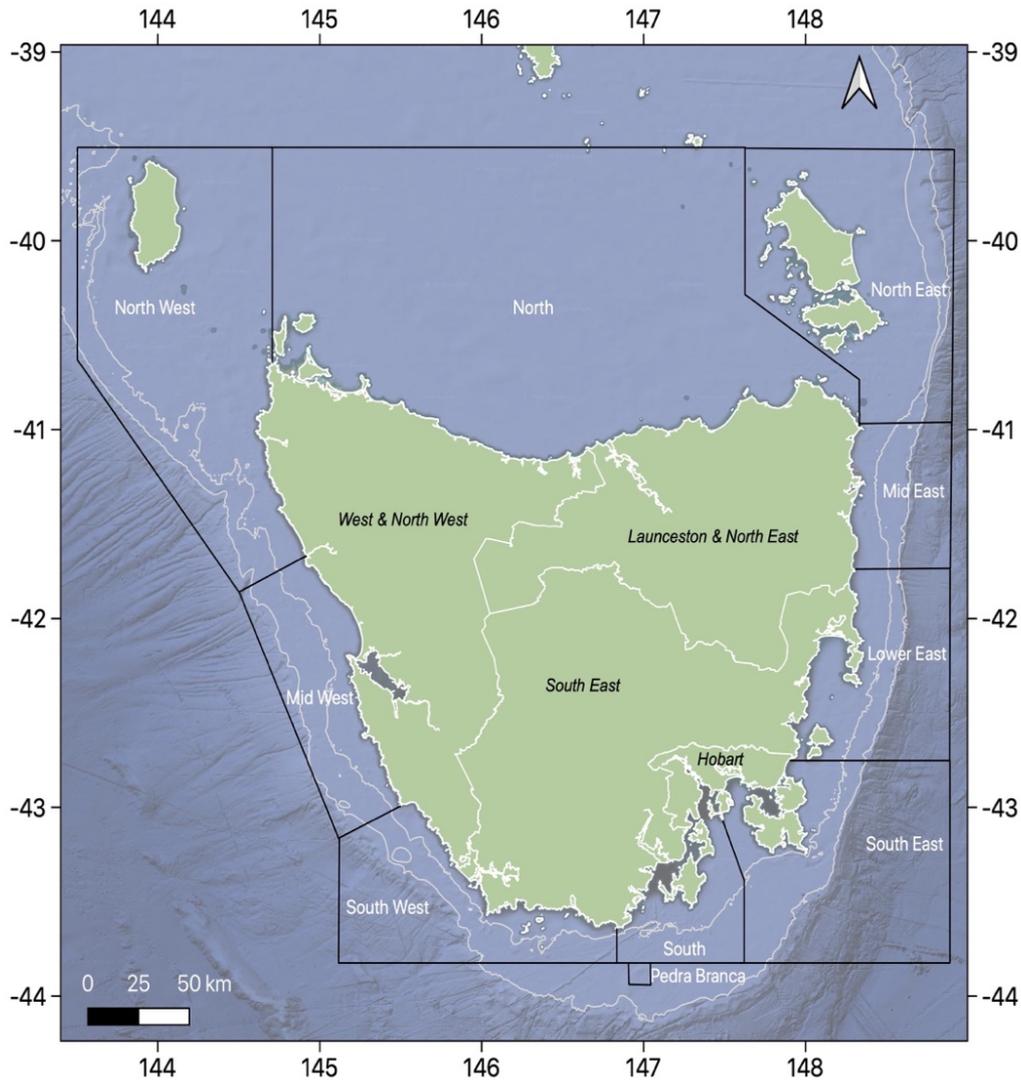


Figure 14. Map of Tasmania showing ABS 'Statistical Divisions' on land and coastal regions as categorised for assessment throughout the longitudinal recreational game fishing survey.

3.2.4 Non-intending vessel survey

A non-intending vessel survey was conducted after the completion of the longitudinal survey phase in December 2019. The purpose of this survey was to identify whether any vessels that were reported as unlikely to be used for game or offshore fishing during phase one (screening) did in fact participate in any of the in-scope fishing activities during the survey period, and if so, the number of days fished. This information is used to correct effort and catch estimates by accounting for the activities of these 'drop-in' vessels.

3.2.5 Fisher-independent fish measurements

In addition to fisher reported data, a creel clerk opportunistically travelled to major boat ramps to measure the size of SBT retained during the peak season for SBT.

3.2.6 Analysis

The telephone survey data was analysed using a model-based approach, using the survey package (Lumley 2004, Lumley 2010) in R version 3.6.1 (R Core Team 2019). A calibrated,

stratified two-phase design was used to expand the sample data to generate estimates of effort and catch for the 12-month survey period.

Initial sampling weights were determined from the target population totals by stratum, where stratum comprised the combination of the residential region for the vessel owner and the vessel size category. An adjustment to these weights was made within a generalised regression (GREG) calibration model (Särndal et al. 1992, Lumley 2010) to account for non-intending or drop-in vessel fishing activity. Vessels in the longitudinal phase were re-weighted based on the avidity profile of diarists at screening with avidity reported by non-intending respondents.

Some of the vessels in the MAST database did not have details regarding the vessel size. A sample of these unknown size vessels was included in the original gross sample, and the vessel size determined with the owner at screening. A proportion of these vessels were identified as too small (< 4.5 m) and as such were not in-scope and were removed from the sample. The relative proportions of allocation to the size stratum categories determined from this sample were applied to the unknown size vessels in the target population including a reduction in the target population to account for the proportion of vessels that were classified as too small (out of scope).

3.2.7 Conversion of catch numbers to biomass harvest

The majority of the SBT reported caught in Tasmania during the survey were 'school fish' but some large fish were also reported. Given the strong bimodality between these size classes, expanded retained catch estimates were derived for school and large fish separately. This facilitated the application of an appropriate cohort-specific average size to both school and large fish, rather than an unrealistic average size of all fish, which would impact both estimates and the precision of the estimates as size variance is reported in the error structure of total harvest by weight.

To classify the number of school fish relative to large fish, it is assumed that size information was reported for all large fish and thus any unmeasured were school size. This assumption was made because catching a large tuna is a memorable experience and respondents take pride in reporting this catch.

An analysis of variance (ANOVA) was conducted to test if there was a difference between the size of school fish reported by the diarists and those measured by the creel clerk. This analysis indicated that the fisher-reported lengths were substantially larger than those obtained by the creel clerk ($F = 25.9_{(1,119)}$, $P < 0.0001$), suggesting bias in the respondent-reported data. Consequently, the conversion of catch numbers to weight for the school fish was based on size composition data collected independently by the creel clerk.

However, as no large fish were measured by the creel clerk, it was necessary to use respondent-reported data for this group. This is justified as the larger fish tend to be 'weighed in' once the vessel returns to a boat ramp, and are thus considered an accurate measurement. All fish reported lost to seals or predated on after release (depredated) were assumed to be school fish and, accordingly, the average weight of school fish for Tasmania was applied to convert numbers to biomass.

3.3 Results

The MAST recreational vessel registration database contained 30,968 vessels when acquired by IMAS on the 24 September 2018. Of these, 15,323 or 49% were deemed eligible for the survey and constitute the ‘target population’ (Figure 15). Eligibility is based on the criteria outlined in the methods, relating to the suitability of the vessel to participate in offshore or game fishing. Overall, 3,503 (22%) of all vessels in the target population were selected to be contacted and constituted the gross sample (Table 11).

3.3.1 Response rates

The owners of 2,719 (78%) vessels randomly selected in the gross sample were contacted on behalf of MAST, to request permission for their contact details to be made available to the University of Tasmania for the purpose of the survey. Sample loss due to no valid telephone number being associated with the registered vessel accounted for 10%, while contact was unsuccessful with the remaining 12% of registered vessel owners selected despite more than 10 contact attempts (Figure 15).

Of the 2,719 respondents contacted, 63 (2%) no longer owned the vessel and 59 (2%) were not eligible after the size of their vessel was revealed to be less than 4.5 m. Of the remaining 2,597 respondents, 2,207 (85%) agreed to have their contact details passed on and 393 (15%) declined (Figure 15). A total of 2,053 of the 2,207 were contacted for the screening survey, 2,011 (98%) provided full responses (13% of all registered vessels in the target population), 42 (2%) declined to participate and 147 (7%) were non-contactable for a variety of reasons (Figure 15).

Results from the screening survey indicated that 641 vessels (32% of vessels from fully responding participants in the screening survey) were eligible for the subsequent diary survey. Eligibility was determined by a response indicating a likelihood of the vessel participating in offshore and/or game fishing during the 2018/19 survey period. Of those eligible vessels, 600 (94%) of the registered boat owners agreed to participate in the 12-month longitudinal study, with the remaining 6% declining to participate (Figure 15).

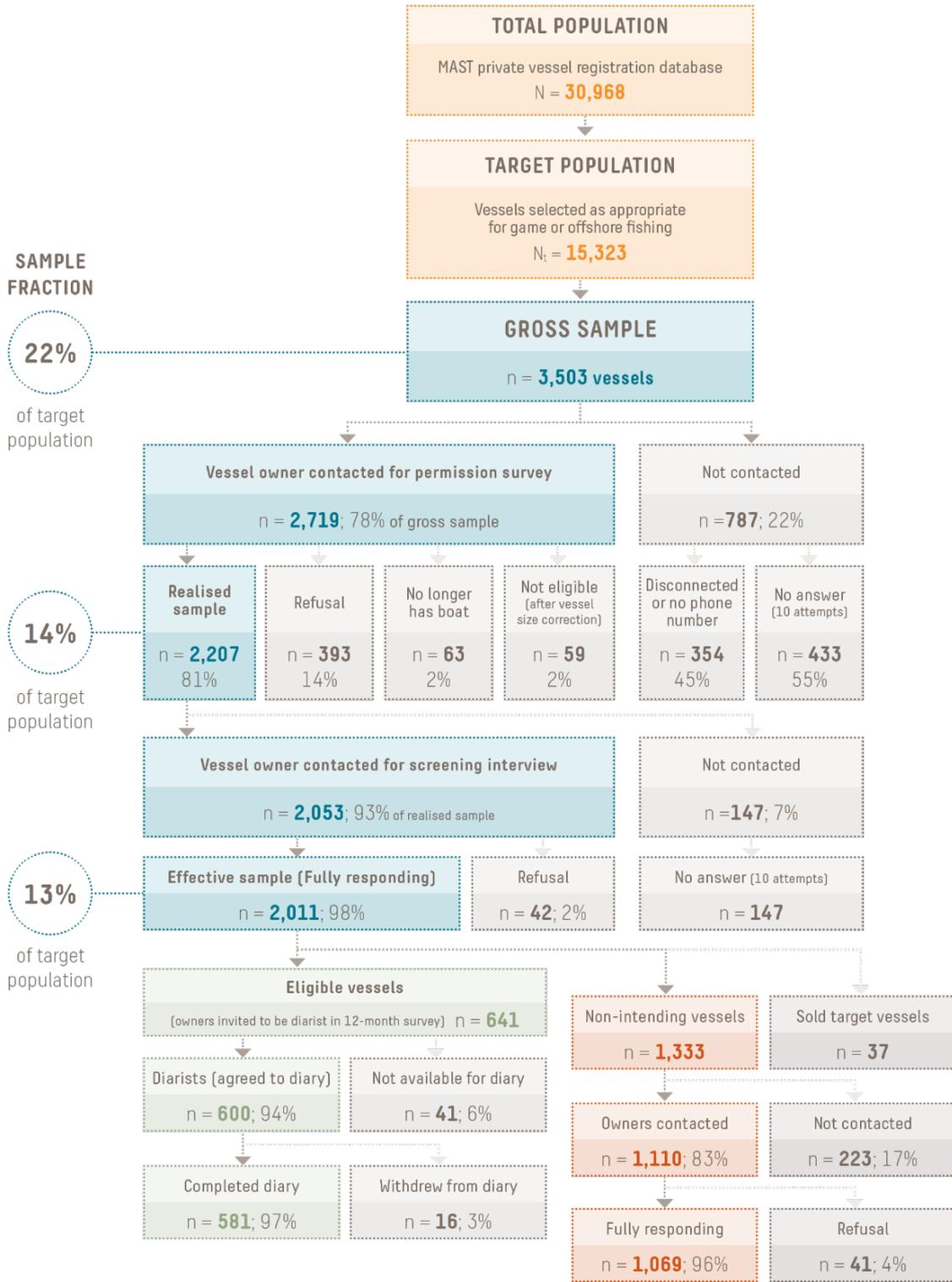


Figure 15. Pre-screening, screening and longitudinal diary survey response profile.

3.3.2 Population and sample correction – vessels with no size information in MAST database

Of the 326 vessels in the target population where no size information was provided, a gross sample of 191 (59%) was randomly selected. Of these, a full response was achieved from 116 or 61% of the gross sample, representing 36% of this stratum in the target population. The vessels where size information was provided were added to the sample in the appropriate size category (Table 10).

From this updated information, the percentage of each vessel size category was used to proportionally allocate the remaining vessels in the database into a size category. This included those vessels in the database that were not selected in the sample, and those that were in the sample but could not be contacted or were unable to provide size information (Table 10). Fifty-one per cent of the vessels where size data was provided were identified as out-of-scope as the vessel size was reported as less than 4.5 m (Table 10).

Table 10. Percentage of vessels reported by owners to each size category during the ‘permission call’ for vessels where no size information was reported in the MAST registration database. Four owners provided information on the size of their selected vessel but did not give permission to be contacted for the screening survey, hence the discrepancy between the total number here and the ‘realised sample’ size for this size category in Table 11.

Size category	Reported size	Percentage response
< 4.5 m	59	51%
4.5 – 5.5 m	30	26%
5.6 – 8.5 m	24	21%
8.6 – 11.5 m	2	2%
11.6 m +	1	1%
Total	116	

This resulted in a correction to the target population, reducing the number of target vessels from 15,323 to 15,158, as well as the effective sample numbers for each vessel size category (Table 11). For seven vessels, the listed owner was unsure whether the boat was longer than 4.5 m. Accordingly, these vessels were considered sample loss and retrospectively removed from the adjusted realised sample. Three of these were reported as sold boats, so were not considered in the effective sample, while the remaining four were considered as part of the effective sample and included in the screening survey to verify if the vessel was used for in-scope fishing activities. These vessels account for the discrepancies in the final realised and effective sample numbers between Figure 15 and Table 11.

Table 11. Size composition of boats in the target population, the gross sample, and the effective sample – adjusted to correct for updated vessel size information missing from MAST database. Percentages represent sample relative to target population.

Size category	Target population	Gross Sample	Adjusted effective sample
No size reported	326	191 (59%)	
4.5 – 5.5 m	9,739	1,558 (16%)	886 (9%)
5.6 – 8.5 m	4,418	1,326 (30%)	847 (19%)
8.6 – 11.5 m	479	244 (51%)	157 (32%)
11.6 m +	361	184 (51%)	118 (33%)
Total	15,323	3,503 (22%)	2,008 (13%)

3.3.3 Fisher profiling during screening survey

Results from respondents indicated that the vast majority of the vessels (1,599 or 80%) were used for recreational fishing at least once during the 12 months prior to the screening survey. Inshore fishing including line fishing, netting and potting, was the most prevalent activity reported for vessels used for fishing (1,456 or 91% of fishing vessels), followed by offshore fishing (395 or 25%), game fishing (368 or 23%), dive harvest (261 or 16%) and freshwater fishing (202 or 13%) (Figure 16).

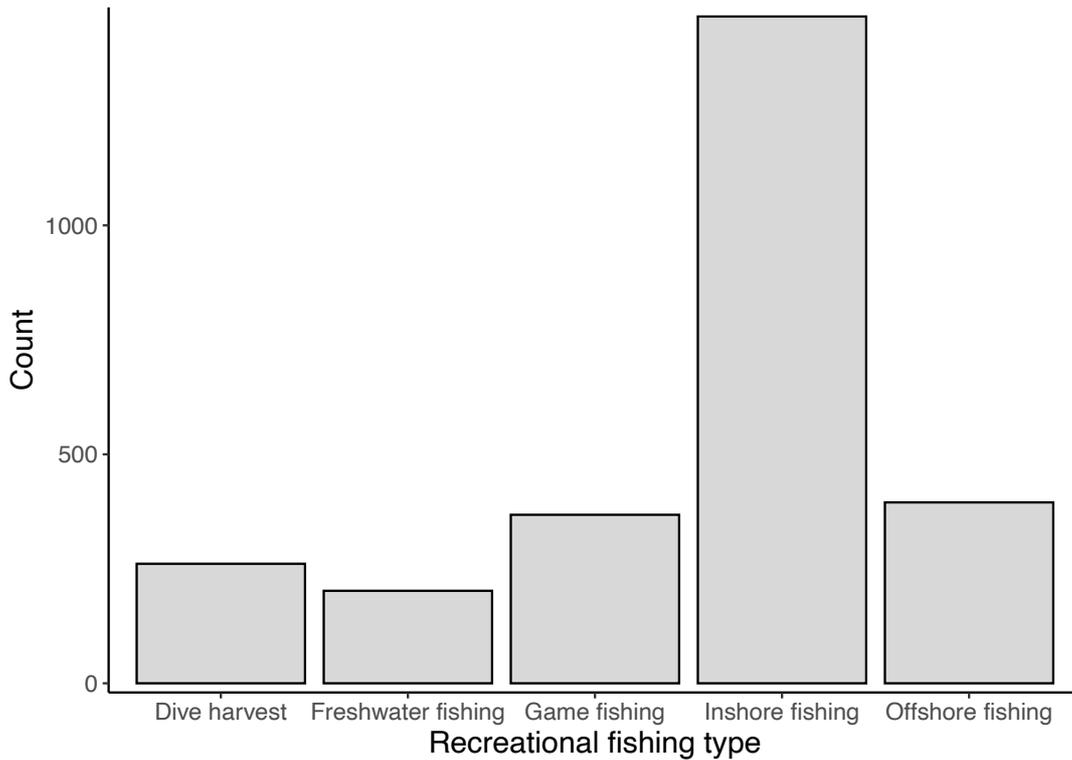


Figure 16. Modes of fishing reported for the 12-month period prior to the screening survey from 1,599 boat owners who reported some form of recreational fishing from their vessel.

Of the 368 boats used for game fishing in the 12 months prior to the screening survey, 81% were reportedly used for game fishing on 10 or fewer days, 12% for 11–20 days and the remaining 7% for game fishing for more than 21 days (Figure 17).

The average number of days reported game fishing by all respondents, who indicated their vessel had been used for at least one day for this mode of fishing in the 12 months prior to the screening survey, was 7.8 (± 0.5 SE) (Table 12). The highest average days game fishing in this period was reported for vessels in the 5.5–8.6 m size class at 8.2 (± 0.6 SE) days and by vessels from the West & North West geographic region at 8.5 (± 1.1 SE) days (Table 12).

Table 12. Weighted average number of days (\pm SE) a vessel was reportedly used for game fishing in Tasmania during the 12-month period prior to 1 December 2018, as recalled during the screening interview. Averages are reported by ABS Statistical Level 4 (SA4) and vessel size categories.

Size class	Hobart	Launceston & North East	South East	West & North West	Size class average
4.5–5.5 m	8.4 \pm 2.6	4.3 \pm 1.0	9.3 \pm 3.3	4.8 \pm 1.0	6.7 \pm 1.3
5.6–8.5 m	7.1 \pm 0.6	10.1 \pm 2.0	6.8 \pm 1.6	9.5 \pm 1.4	8.2 \pm 0.6
8.6–11 m	9.3 \pm 2.5	5.0 \pm –	4.2 \pm 1.3	7.5 \pm 2.5	7.7 \pm 1.6
11.6 m +	5.6 \pm 1.1	25.0 \pm –	6.0 \pm 1.0	7.0 \pm –	6.5 \pm 1.3
Regional average	7.4 \pm 0.6	8.4 \pm 1.5	6.8 \pm 1.2	8.5 \pm 1.1	7.8 \pm 0.5

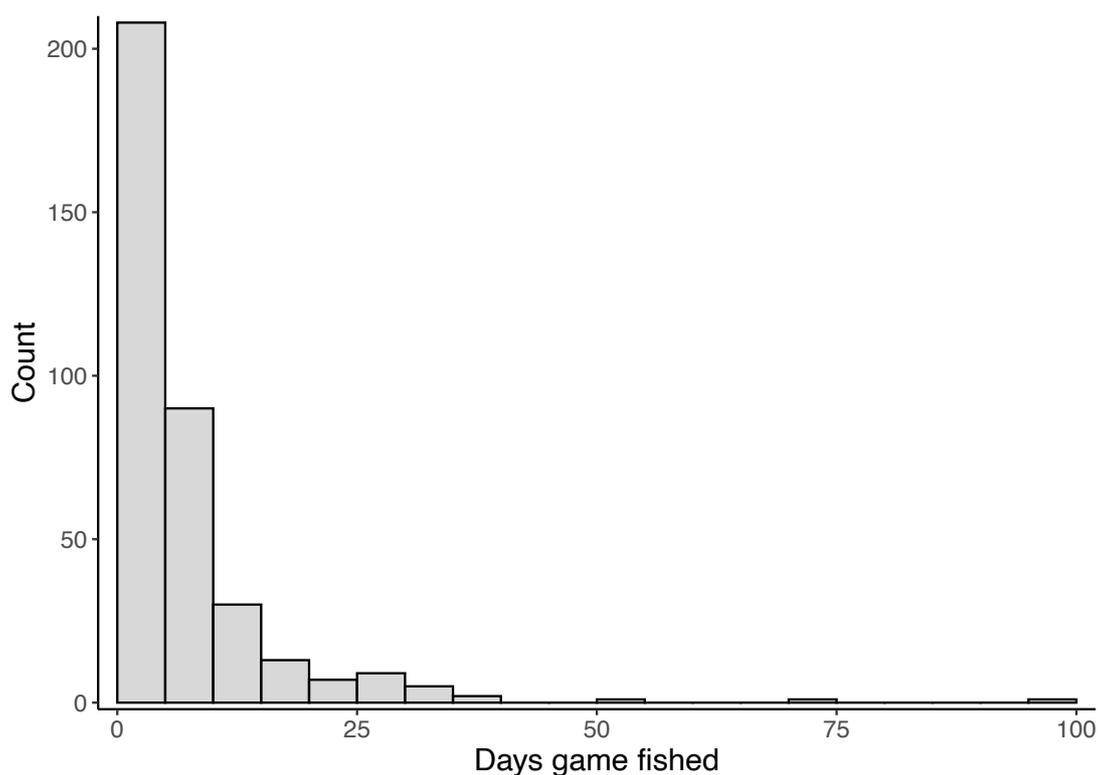


Figure 17. Frequency of days reported recreational game fishing for the 12-month period prior to screening survey.

3.3.4 Longitudinal diary survey

Retention of participants throughout the 12-month longitudinal survey period was high, with 581 diarists or 97% of respondents who accepted the diary participating for the entire survey period. Of the 16 participants who withdrew, 11 (69%) sold their boat during the survey, one vessel sank, and the remaining four (25%) withdrew for a variety of reasons including health issues and a lack of interest in participating.

Given the high completion rates, possible biases arising from non-response were not considered to be a significant issue in this aspect of the study, and analyses do not incorporate non-response adjustments. Data for the diarists who partially responded, either because they sold the vessel during the survey or declined to participate for the full period, were excluded from all analyses.

At least one game fishing trip was reported by 231 (40%) of the diarists who completed the diary phase. The remainder did not report game fishing activity but many did participate in other forms of offshore fishing (Tracey et al. *in prep.*).

3.3.5 Non-intending vessel survey

A total of 1,333 vessels owners indicated during the screening survey that they did not intend to use their vessel for game or offshore fishing during the survey period (Figure 15). An attempt was made to contact all owners at the end of the longitudinal survey, to confirm this was the case. In total 1,100 (83%) of owners were successfully contacted. The remaining 17% could not be contacted because their number was disconnected or they did not answer their telephone after 10 attempts.

Of those contacted 1,069 (96%) provided a full response to the non-intending vessel interview (Figure 15). Results from respondents indicated that 66 (6%) of the vessels had been sold during the survey period. Of the remainder, 971 (97%) confirmed they had not done any game fishing for SBT, while 30 (3%) indicated they had targeted SBT during the survey period, with SBT caught from 22 (2%) of those vessels. The effort and catch expansions were calibrated accordingly, as per the description in the methods.

3.3.6 Estimates of effort targeting tuna and catch of Southern Bluefin Tuna

3.3.6.1 OVERVIEW

Results reported for the remainder of this chapter are based on expanded estimates, unless otherwise stated, and represent the game fishing activities of Tasmanian registered (MAST) recreational vessels (> 4.5 m). In particular, this section focuses on trolling, which is the predominant method used when targeting tuna in Tasmania (Tracey et al. 2013).

Private vessels fished for tuna on an estimated 4,581 (\pm 383 SE) boat days around Tasmania during the 12-month survey period (Table 13). Overall, 32% of these targeted boat days were successful with at least one SBT reported caught, resulting in a total estimated catch of 3,348 (\pm 474 SE) SBT.

Of this total, an estimated 2,479 (\pm 328 SE) SBT were retained, representing a landed catch of 40.4 t (\pm 5.4 SE). The retained catch comprised 2,440 (\pm 324 SE) school fish with an average weight of 15.2 kg (\pm 0.5 SE) and 39 large fish with an average weight of 91 kg (\pm 11.8 SE). A further 869 (\pm 230 SE) SBT were estimated to have been released, resulting in a release rate of 25% (Table 13).

Table 13. Estimates of fishing effort, catch and depredation of Southern Bluefin Tuna (\pm standard error) from private recreational vessels in Tasmania, for the 12-month survey period. RSE = relative standard error.

Result	Estimate
Number of tuna fishing boat days	4,581 \pm 383 (RSE = 0.08)
Percentage of tuna fishing boat days where SBT were caught	32 \pm 3% (RSE = 0.08)
Number of SBT caught and kept	2,479 \pm 328 (RSE = 0.13)
Weight of SBT caught and kept (t)	40.4 \pm 5.4 (RSE = 0.13)
Number of SBT depredated (lost to predator)	1,111 \pm 248 (RSE = 0.22)
Weight of SBT depredated (t)	16.8 \pm 3.8 (RSE = 0.23)
Percent of total removals (kept + depredated) lost to predators	30% \pm 4% (RSE = 0.12)
Number of SBT caught and released	869 \pm 230 (RSE = 0.26)
Release rate	25 \pm 5% (RSE = 0.19)

Interactions between the recreational SBT fishery in Tasmania and Fur Seals (*Arctocephalus spp.*) commonly result in hooked tuna being attacked or taken by seals (Tracey et al. 2013, Cummings et al. 2019). Through observation, it is assumed that a fish taken from the fishing line by a seal will result in mortality. On rare occasions where fish are reported to be predated by seals directly after release, it is also assumed the result of the interaction is mortality. These events were considered as depredation and represent an additional source of fishery-induced mortality. Fishers will also often retain SBT that have been bitten by seals if they are able to, with these reported as damaged and included in the kept catch. An estimated 71 (\pm 24 SE) SBT (5% of the number retained) were reported to have been damaged by seals during the retrieval of the fish to the boat.

A further 1,111 (\pm 248 SE) SBT were attacked by seals during retrieval to the boat and not landed, as typically the seal pulls the fish from the hook or occasionally the fishing line will break. Assuming each lost fish resulted in a mortality, these losses would have added a further 30% by number to the total removals of SBT from the population attributed to recreational fishing activity in Tasmania. Assuming the vast majority of these losses were school fish, then seal depredation is likely to have contributed an additional 16.8 t (\pm 3.8 SE) of fishery-related mortality.

3.3.6.2 EFFORT

Tuna fishing was highly seasonal, with activity concentrated in the summer through to the early winter period, with a marked peak in effort during March and April (Figure 18). Relatively infrequent tuna fishing effort was reported between September and November. However, it is worth noting that three species of tuna are commonly available to game fishers in Tasmania – SBT, Albacore (*Thunnus alalunga*) and Skipjack Tuna (*Katsuwonus pelamis*). The timing of the availability of these species varies throughout the year and in turn influences seasonal fishing effort (Tracey et al. 2013). Therefore, the seasonal pattern in fishing effort presented here does not solely reflect the targeting of SBT.

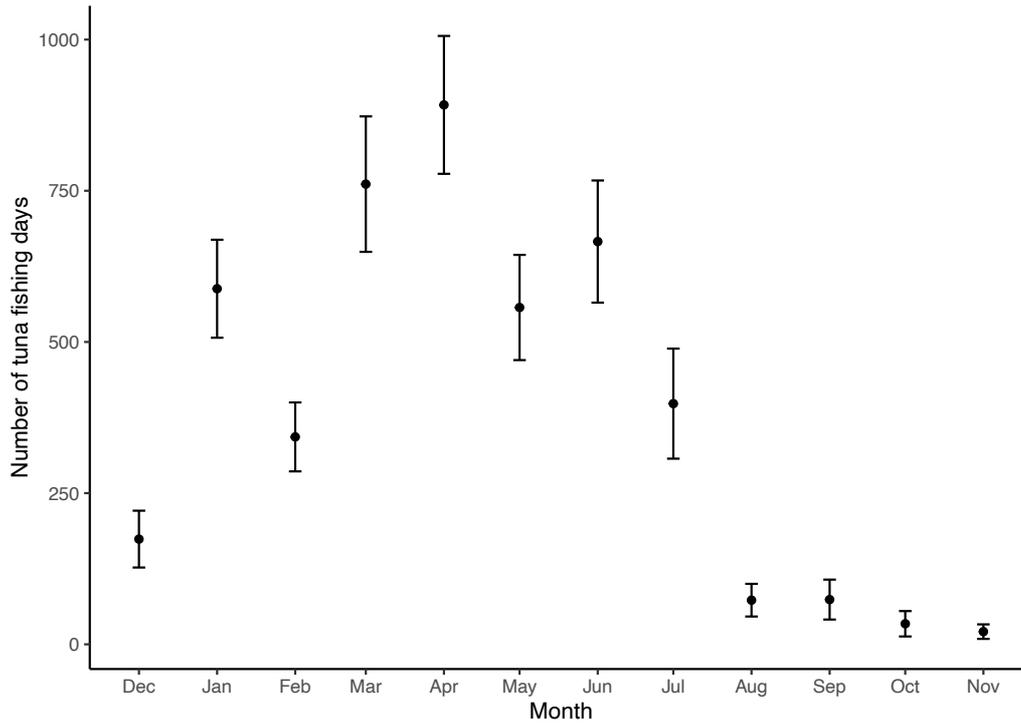


Figure 18. Monthly estimates of the number of tuna fishing boat days (\pm standard error) in Tasmania.

Tuna fishing effort was heavily concentrated in the waters adjacent to the Tasman Peninsula in southeast Tasmania (Figure 19). The lower East Coast, mid-East Coast, South Coast and Pedra Branca were also important areas for tuna fishing, with effort dropping away in the remote South West of Tasmania. There was limited fishing effort on the mid-West Coast originating from Strahan, negligible effort on the North West Coast, and there was no tuna fishing reported on North or far-North East coastlines (Figure 19).

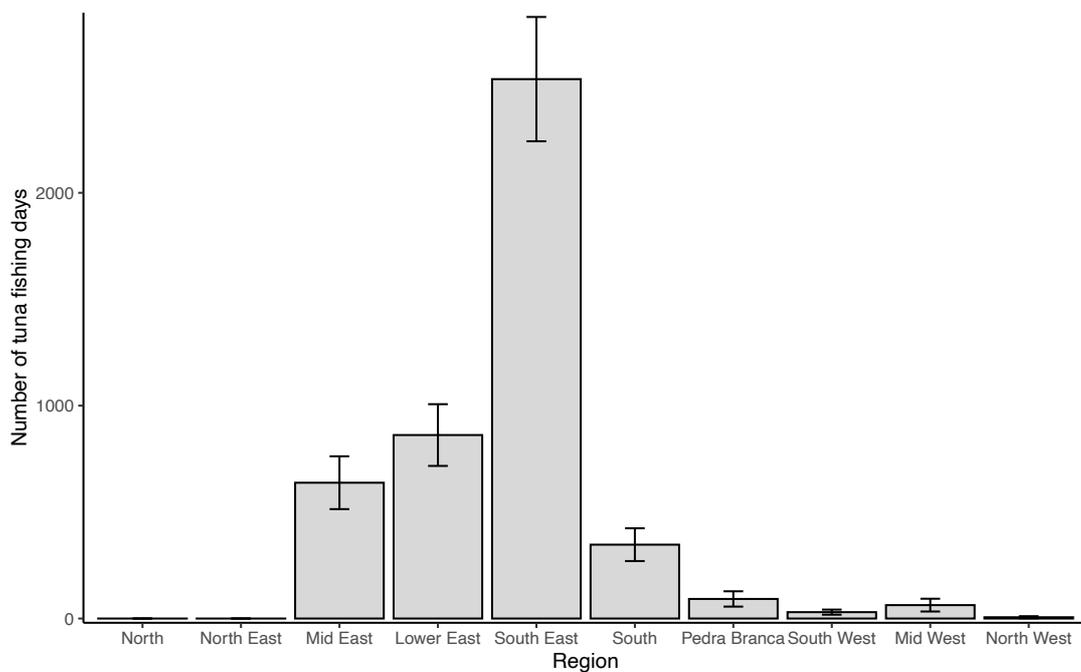


Figure 19. Regional estimates of the number of tuna fishing boat days (\pm standard error) in Tasmania (see Figure 14 for locations).

Vessels registered in the Hobart region accounted for 2,047 (± 244 SE) boat days of tuna fishing effort. Launceston and the North East region was of secondary importance, with vessels contributing a further 1,240 (± 199 SE) boat days. Effort linked to vessels registered in the South East and West & North West regions were similar in magnitude, at 626 (± 164 SE) and 648 (± 142 SE) boat days, respectively. Interstate-owned vessels accounted for negligible tuna fishing effort (20 ± 17 SE boat days).

3.3.6.3 CATCH

The catch of SBT in Tasmania was highly seasonal, peaking between April and June. This three-month period accounted for 69% of total catch by number for the 12-month survey period (Figure 20). Despite high fishing effort between January and March (Figure 16), SBT catches were relatively low, with tuna fishing effort being directed mainly at Albacore during this time. Minimal catches were taken between August and November, corresponding to the period of very limited tuna fishing activity in Tasmania.

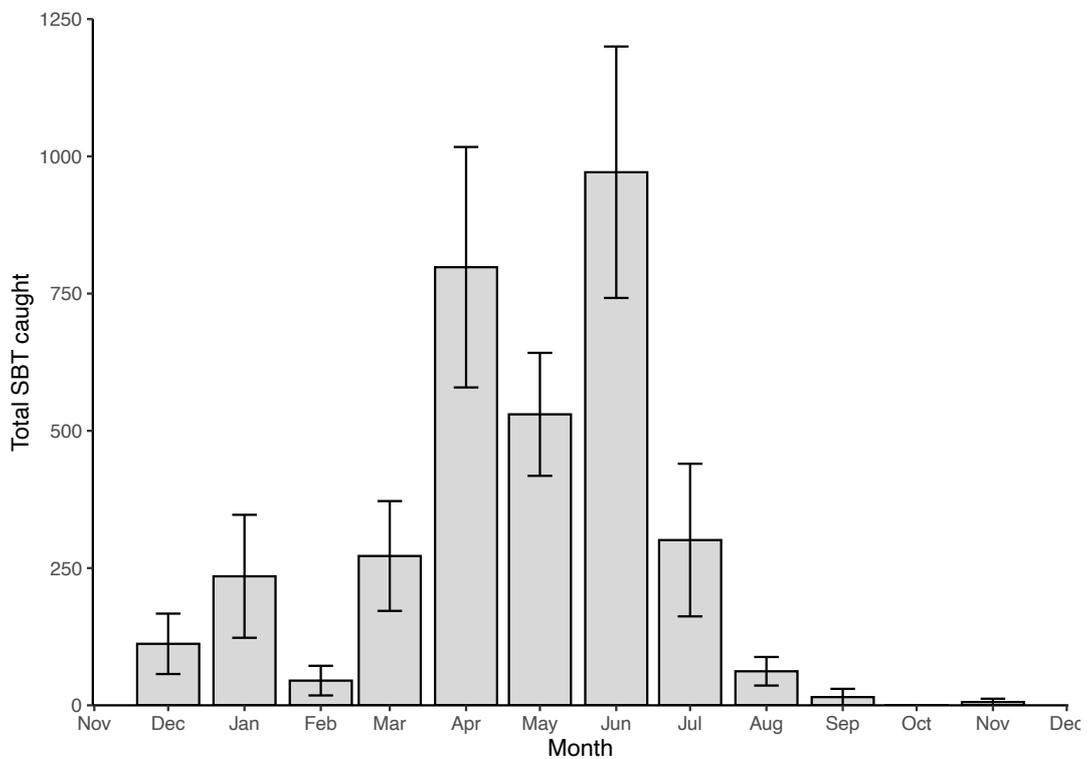


Figure 20. Estimated total number (retained + released catch) of Southern Bluefin Tuna caught by month. Error bars indicate standard errors.

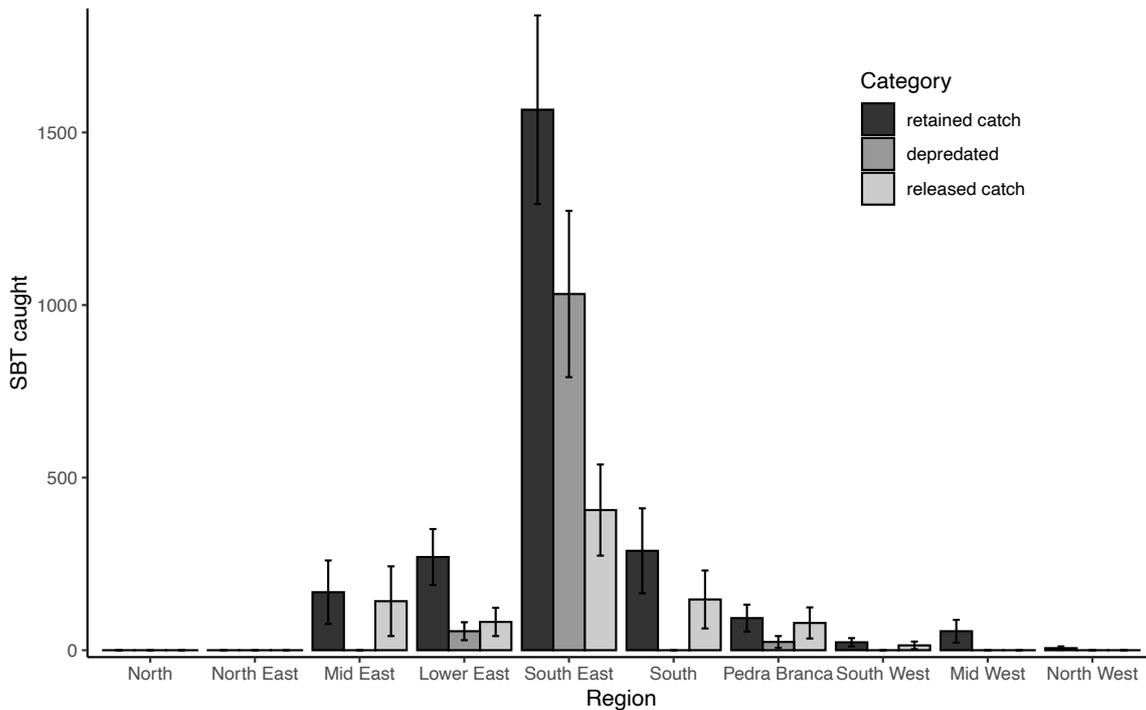


Figure 21. Estimated number of Southern Bluefin Tuna retained and released by recreational sector, and the estimated number depredated by seals and not retrieved to the boat within each coastal region of Tasmania for the 12-month survey period (see Figure 14 map for locations). Error bars indicate standard errors.

The vast majority of SBT were caught around the Tasman Peninsula in the South East region, with the South Coast and Pedra Branca of secondary importance, followed by the Lower and mid-East Coast (Figure 21). A small amount of catch was reported from the mid-West Coast and a negligible amount of catch from the North West Coast (Figure 21). Hobart registered vessels accounted for the greatest catch of SBT, with an estimated 1,334 (± 295 SE) SBT caught (kept and released). Launceston and North East vessels accounted for 923 (± 208 SE), while those registered in the West and North West accounted for a total catch of 631 (± 214 SE) SBT. Vessels registered in the South East accounted for the least amount of total tuna catch at 460 (± 209 SE) individual fish.

3.3.6.4 DEPREDATION

Depredation of hooked SBT by seals was experienced by fishers in South East Coast, lower East Coast and Pedra Branca (Figure 21). Overall, 25% of all SBT caught in Tasmania. With the rate highest (34%) around the Tasman Peninsula in the south east, followed by the lower East Coast (14%) and Pedra Branca (12%) (Figure 21).

3.4 Consideration of survey coverage

Yachts, personal watercraft and boats smaller than 4.5 m were excluded from the sample population as they were considered unsuitable or unlikely to be used for game fishing. This assumption allowed for a more refined sample frame but does introduce the potential for under-coverage of all vessel-based game fishing activities. We are aware of reports that tuna are occasionally taken by these out-of-scope vessels, including from sea kayaks that do not require registration with MAST. It is likely, however, that the contribution to the recreational catch from such vessels in Tasmania is minimal, an assumption supported by the current President of the Tasmanian Game Fishing Association (J. Edwards).

4 Catch and effort estimation from the recreational fishery for Southern Bluefin Tuna from private vessels in New South Wales

4.1 Introduction

New South Wales has a diverse game fish fishery with a long history (Harpur 1902). Off the coast of New South Wales, game fishers target species such as pelagic sharks, billfish and tuna. Southern Bluefin Tuna (SBT) is a species that appears sporadically in this fishery, with its availability in part determined by the East Australian Current (EAC) (Hartog et al. 2011, Hobday et al. 2011).

In warmer years, the distribution of SBT off the New South Wales coast is confined to the cooler waters in the south, while in cooler years, SBT are found further north (Hobday et al. 2011). In recent years, the SBT season in New South Wales has been relatively short compared with other States, with fish generally arriving off the coast in June and moving on by July or early August. Occasionally, there may be a second pulse of fish appearing off the coast in August and September.

The New South Wales fishery occurs much further offshore than other States, with fishers often having to travel up to 100 km offshore to access SBT (Moore et al. 2015). Fishing for SBT predominantly occurs along the southern half of the State from the southern port of Eden, with some fish occasionally caught as far north as Newcastle. Other major points of access along the coast include Bermagui, Batemans Bay, Narooma, Ulladulla, Jervis Bay, Wollongong and Kiama (Moore et al. 2015).

New South Wales implemented the Recreational Fishing Fee (RFF) in 2001. There are several exemptions from paying the recreational fishing licence fee, such as for those under 18 years of age and pension card holders who do not require a licence. The four categories of licence include two long-term (1 and 3 years) and two short-term (3 days and 1 month) licences. A database of licence-holders is managed by Service NSW. Most of the database contains information on long-term licence-holders, since valid contact information is needed to receive their plastic card licence in the mail. The number of *current* long-term licence-holders has fluctuated from year to year but is now stable at around 400,000–450,000 per year.

The New South Wales Department of Primary Industries investigated the potential of using the RFF database for a survey of recreational fishing in 2013/14, as an alternate and more refined population than the traditionally used White Pages listings sampling frame (West et al. 2015). These investigations showed that long-term licence-holders were responsible for large proportions of the state-wide effort and catch, and led to the development of the 2017/18 recreational fishing survey that used the RFF database exclusively as the basis for selection of respondents.

The RFF was used as the sampling frame for the present survey but, given the large number of licence-holders and specialised nature of game fishing with a small fraction of licence holders expected to participate in this niche activity, a sizable volume of calls was required to achieve a sufficient sample fraction. Given the cost and logistics associated with sampling for this specialised group of fishers, a telephone recall survey approach rather than the longitudinal telephone-diary survey method was applied.

The short season of SBT, the target species, off the coast of New South Wales is advantageous in minimising the potential for significant recall bias. By commencing the survey soon after the SBT run, the recall period can be reduced to no more than a few months.

The primary objective of this component of the survey was to quantify recreational fishing activity by individuals targeting SBT in New South Wales, specifically:

- annual fishing effort – fisher days
- annual catch – retained, released and depredated
- seasonal and spatial presentation of annual catch and effort.

4.2 Methods

A telephone recall survey (TRS) approach was used to assess the catch and effort by recreational fishers in New South Wales for key game fish species, with a focus on SBT, over a 12-month period between December 2018 and November 2019 inclusive. The survey 'population' or sampling frame consisted of all long-term (1 and 3 years) New South Wales Recreational Fishing Fee (RFF) licence holders, current on the download date of 1 July 2019. The primary sampling unit (PSU) was the licence-holder.

4.2.1 Regional stratification

Sample selection was based on a stratified random sample design, with sample weightings identified for 14 residential strata (Figure 22) that were either individual or a combination of ABS Statistical Areas (SA4 level) in the Australian Standard Geography Standard (ASGS) (Pink 2011). These regions include the 10 residential strata reported for the 2013/14 survey of recreational fishing in New South Wales and the ACT (West et al. 2015).

To ensure a more homogenous randomisation within each of the 14 regions, regional sample weights were applied at the SA4 level for New South Wales, while Victoria was split into two regions, one being SA4s that bordered New South Wales and the remainder in the other, with Queensland and Australian Capital Territory (ACT) reported at a State level and all other States pooled. As the focus of the study was SBT, which are predominantly caught from the south coast of New South Wales, residential strata adjacent to the south coast had the highest sampling fractions (Table 38).

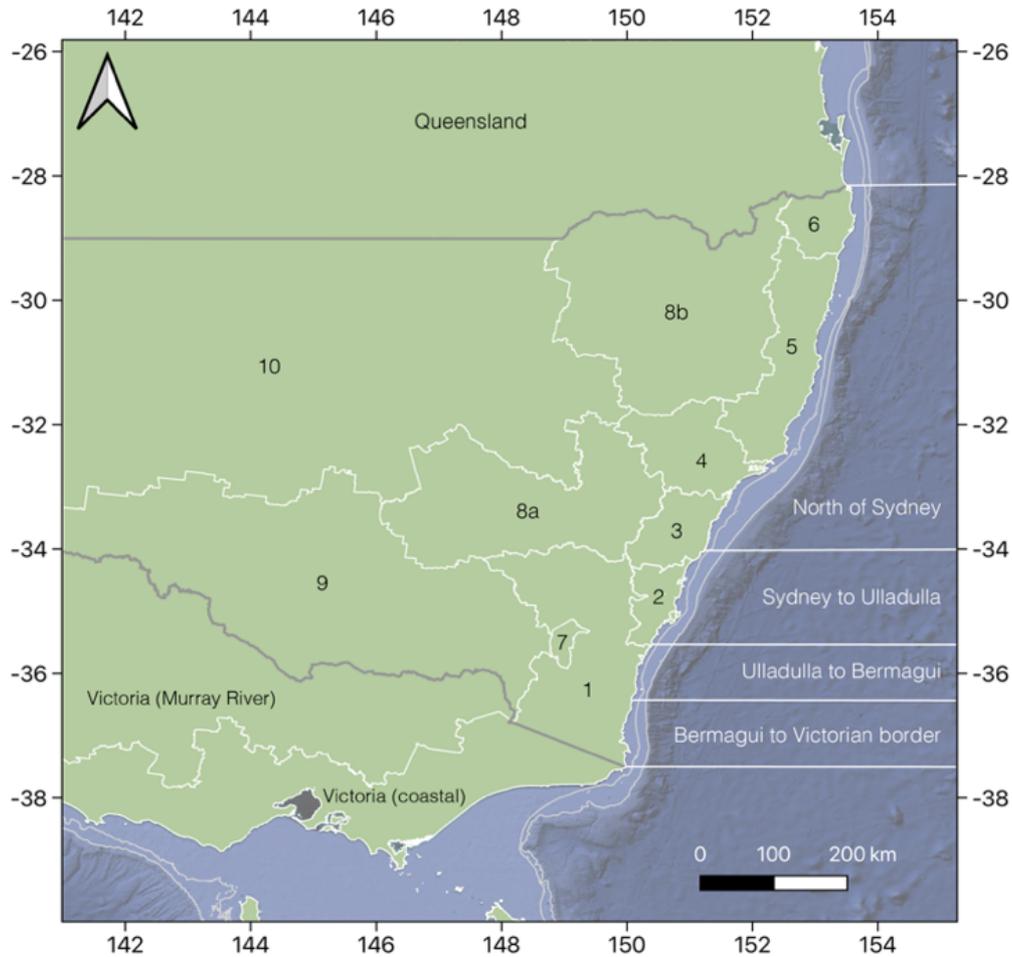


Figure 22. New South Wales map showing geographic regions used for sample stratification on land and coastal regions, to spatially categorise Southern Bluefin Tuna effort and catch during survey period. 1 = South East, 2 = Illawarra, 3 = Sydney, 4 = Hunter, 5 = Mid North Coast, 6 = Richmond/Tweed, 7 = Australian Capital Territory (ACT), 8 = Central West/North, 9 = South West, 10 = North West.

4.2.2 Interview structure

The survey involved a two-phase design. The first phase involved an initial interview (Part A) which was functionally a screening survey to identify in-scope (game fishing) activity. This was followed by a more in-depth interview (Part C) targeted at SBT fishers. However, due to concerns about some respondents potentially misinterpreting key game fishing questions, a supplementary interview was undertaken (Part B) to verify and, where confirmed by the respondent, correct and adjust key information reported in Part A.

The Part A interview was delivered as a structured questionnaire to identify whether the respondent had fished in the preceding 12-months, the water type(s) fished, and whether they had done any game fishing in New South Wales during that period. Respondents who identified as game fishers were asked to give a 'best estimate' of the number of days spent game fishing in the preceding 12 months and whether they had been on trips that had either targeted and/or caught fish from a list of key game fish species. Interviews were carefully scripted to confirm that reported catches had occurred adjacent to New South Wales in the 12-month period preceding the interview, and that it was personal catch.

All respondents, whether they had fished or not in the survey period, were asked whether they had caught any SBT in the preceding five-year period, and whether they were a current member of a club affiliated with the Game Fishing Association of Australia or Australian National Sportsfishing Association and, if so, which one.

Part A interviews were conducted by a large commercial call center using a computer-assisted telephone interviewing (CATI) system, with the audio of all interviews recorded. Daily updates on call metadata and survey responses were provided for scrutineering by project staff. Respondents who indicated they had targeted or caught SBT were asked if they would be willing to participate in a more in-depth follow-up interview about game fishing. To reduce potential subject relevancy bias, it was not disclosed at this time that the follow up interview was specific to SBT.

The primary objective of this survey was to quantify the catch of SBT. Accordingly, commencement Part A interviews was designed to occur as soon as possible after the run of SBT in New South Wales concluded. Starting the calls soon after the season would reduce the potential for recall bias for the primary species. The end of the 2019 SBT run was identified based on social media reports and discussions with regional experts, with a buffer of approximately one month added to ensure that there was no 'late run' of SBT that may have been missed but was still within the survey period (finishing on 30 November). Part A calls commenced on 19 September 2019 and concluded on 18 November 2019.

It became evident, from a review of responses relating to the number of fish reported caught by individuals during Part A interviews, that there had been a potential misinterpretation of the question relating to 'personal catch', the possible inclusion of 'out of scope' fishing that had occurred in other States or prior to the 12-month survey period and potential reporting of 'boat catch' rather than 'personal catch'. A review of 85 audio recordings was conducted to assess whether the interview script had been delivered correctly or whether respondents had obviously misinterpreted the questions, or whether any other nuances might have suggested erroneous reporting. The recordings were primarily selected for respondents who reported particularly large game fish catches.

In all cases it was identified that the script had been delivered correctly, with the interviewer clearly asking if the catch was '...caught in New South Wales in the last 12-months...' and '...how many did you personally catch...'. However, there were indications that some respondents may have been reporting catch for the whole boat rather than those that they had personally reeled in. In this respect it was hypothesised that some respondents may have interpreted 'personal catch' as 'boat catch', since game fishing is often seen as a team effort, with the skipper and crew all playing an important role in landing a fish along with the fisher on the rod actually reeling the fish to the boat. This identified the need to consider a supplementary screening survey phase to verify catch reports.

The supplementary phase (Part B) involved calling all respondents who had reported game fishing for target species during Part A, to verify that their reported catch was within the scope of the survey (i.e. in New South Wales and in the 12 months prior to their Part A interview) and, most importantly, to clarify whether they had originally reported catches for the boat rather than fish they had reeled in and landed themselves.

Catches reported during the Part A interview were adjusted according to respondent clarification if required. This was important, as the primary sampling unit (PSU) is the licence-holder, and it was crucial to ensure that reported catch data was person rather than fishing-party based to avoid over-estimation of catches. Part B calls commenced in October and continued into December 2019.

Respondents who identified as having fished for SBT during the Part A interview and confirmed as in-scope during the Part B verification interview were deemed eligible for the second phase (Part C). The Part C interview was to gain additional detail on fishing for SBT in New South Wales during the survey period, in particular the spatial and temporal distribution of catch and effort. The questions were designed in a matrix framework to ascertain the number of trips (days) targeting SBT by month and region, where regions were defined as North of Sydney to the Queensland border, Sydney south to Ulladulla, Ulladulla south to Bermagui, and Bermagui south to the Victorian border (Figure 22). SBT catches were allocated to this spatiotemporal framework. Part C calls commenced in late September and continued into December 2019. Part C interviews completed prior to the catch verification interview (Part B) were also corrected during the Part B interview, where necessary.

Part B and C interviews were conducted by a smaller commercial company with a team of interviewers experienced in delivering interviews related to recreational fishing and specifically trained to verify catch details. They were specifically trained to break the pattern of reporting for the whole boat, by using an introductory statement relating to other important roles in the capture of game fish such as the skipper or deckhand.

4.2.3 Analysis

The phone recall data was analysed by applying a two-phase model-based approach utilising the survey package (Lumley 2004, Lumley 2010) in R version 3.6.1 (R Core Team 2019). A calibrated, stratified two-phase design was used to expand the sample data to generate estimates of total effort and catch for the 12-month survey period. The first phase was comprised of all fully responding licence-holders. The second phase subset was comprised of licence-holders who had fished for SBT in the preceding 12 months and had also completed the Part C interview, where spatial and temporal information was reported for their catch and effort information.

A generalised regression (GREG) calibration model (Särndal et al. 1992, Lumley 2010) was used to obtain expansion weights for each licensed fisher in the second phase subset. This subset was calibrated simultaneously to:

- (i) known number of New South Wales licence-holders by Stratum group
- (ii) known number of adult New South Wales Gamefish Club Memberships in 2018/19 by gender (M = 2,530; F = 286) – note that gender is not recorded in the New South Wales licence database, so gender was assigned to licence-holders using the Package ‘gender’ (v 0.5.3) (Mullen 2019) in R
- (iii) the first phase sample by eligibility for second phase survey, i.e. whether they had done in-scope fishing for SBT – essentially this component counter-parts fishers from the screening survey for whom we do not have detailed information (catch and effort) with those that we do, i.e. completed Part C.

The 14 original sample strata were merged into 11 to ensure there was at least one eligible fisher in the Part C sample for each stratum. Specifically, the north coast stratum of Richmond/Tweed and Mid North Coast were combined into a single stratum and three inland strata were grouped as well – Central West/North, Far West/North West and Murray/Murrumbidgee (Table 38).

4.2.4 Fisher-independent size information

Creel clerks were deployed to target boat ramps in New South Wales to measure retained catch. These deployments were opportunistic and the selection of boat ramps to attend was guided by reports on social media of where and when SBT were being landed. Creel clerks measured fish fork length (FL) to the nearest centimetre, which were converted to weight using the CCSBT length-weight parameters (Edwards et al. 2016).

4.3 Results

A total of 433,589 licence-holders held a current one or three-year licence at the time of download, representing the survey population. There was no valid address for 582 or 0.1% of the population. These could not be attributed to a geographic stratum and were excluded from the population, as the effect of removal would be negligible. A gross sample of 37,661 licence holders was randomly drawn from the licence database according to the sample weights reported in Table 38. Of these, 34,813 licence holders had at least one valid phone number associated with their record. The timing of this survey overlapped with the screening phase of the 2019/20 New South Wales state-wide survey. To reduce respondent burden, a decision was made to remove respondents from this survey that were randomly selected to participate in both surveys. This equated to 301 licence holders across the residential strata, representing less than one percent of the valid sample (Table 38). The resulting net sample was 34,512 licence holders, equating to 8% of all licence holders (Figure 23).

4.3.1 Response rates

A total of 19,153 or 55% of the net sample were contacted during Part A of the survey. The remaining 45% could not be contacted, with 79% of non-contacts resulting from no answer after 10 call attempts, and the other 21% either disconnected or the licence holder was not on the number provided in the database (Figure 23). Response profiles by stratum groups are presented in Table 39.

Of the licence holders contacted during Part A, 16,452 or 86% provided a full-response, with the remaining 14% declining to participate (Figure 23). Of those that declined to participate, 34% were 'full uninformed refusals', which means that they terminated the call prior to hearing any dialogue relating the call to a fishing survey, 52% were 'informed refusals', meaning they had heard the introductory statement identifying the call as relating to fishing prior to terminating it, and the remaining 14% were 'partial refusals', meaning they commenced the survey but terminated the phone call prior to the survey interview being completed.

Overall, fully responding licence holders represent 4% of one and three-year licence holders at the time the database was downloaded (the population). A total of 668 licence holders indicated they had participated in game fishing in New South Wales for species such as billfish, tunas or pelagic sharks during the survey period, referred to as 'in scope'.

In total, 98% of those identifying as participating in in-scope game fishing during Part A were contacted to verify reporting of personal catches (Part B). The remaining 2% could not be contacted, either because their number had become disconnected or was not answered after 10 call attempts. Of those that were contacted, 94% provided a full response, with the remainder declining to participate (Figure 23).

For those that provided a full response, 86% were verified as in-scope game fishers, that is, they had fished for at least one of the target species in New South Wales in the survey period, whether they caught anything or not. For the remainder, 5% confirmed that they had not done any in-scope game fishing at all during the survey period and 9% indicated that, while they had not fished for the target species, they had fished for other species of game fish, in particular Yellowtail Kingfish or out-of-scope pelagic sharks such as Bronze Whalers, Tiger Sharks and others.

As a result of the verification interview, it was identified that 4% of respondents had reported some out-of-scope catch, that is, they had fished for the target species but not in New South Wales or in the survey window. Species misidentification was reported by a further 1%. For the remainder it was identified that almost half (47%) reported personal catch during the initial Part A interview, but the remaining 48% had reported boat catch for all or some of the target species during the Part A interview. In these cases, the respondents provided a revised estimate of their in-scope catch, with a clear understanding of what was deemed in-scope, that they were on the rod and personally reeled the fish to the boat.

During the Part A interview, 204 respondents indicated they had been involved in 'in scope' fishing for SBT. Of these, 174 (92%) completed the verification interview, 119 or 68% of whom confirmed that their fishing was 'in scope' for SBT whether they had caught any or not. The remaining 55 had not fished 'in scope' for SBT, a common response being that they had fished for SBT in previous seasons but not during the survey period. The status of the remaining 30 respondents who indicated they had fished for SBT during the Part A interview could not be resolved (Figure 23).

The 119 verified SBT fishers also provided a response to Part C of the survey, which was to provide further details about their fishing for SBT, including catch of SBT (numbers) and targeted effort (days fished) by month and fishing region. These fishers comprised the second phase subset for all expanded total effort estimates. For expanded total catch estimation an additional 22 unverified fishers were included in the second phase subset. These were fishers which indicated that although they had fished for SBT they had caught no SBT during the survey period, and it is assumed that while their effort could not be verified, their zero-catch response provided in Part A was reliable. This assumption is based on the fact that none of the 614 verification interviews resulted in respondents increasing their reported catches.

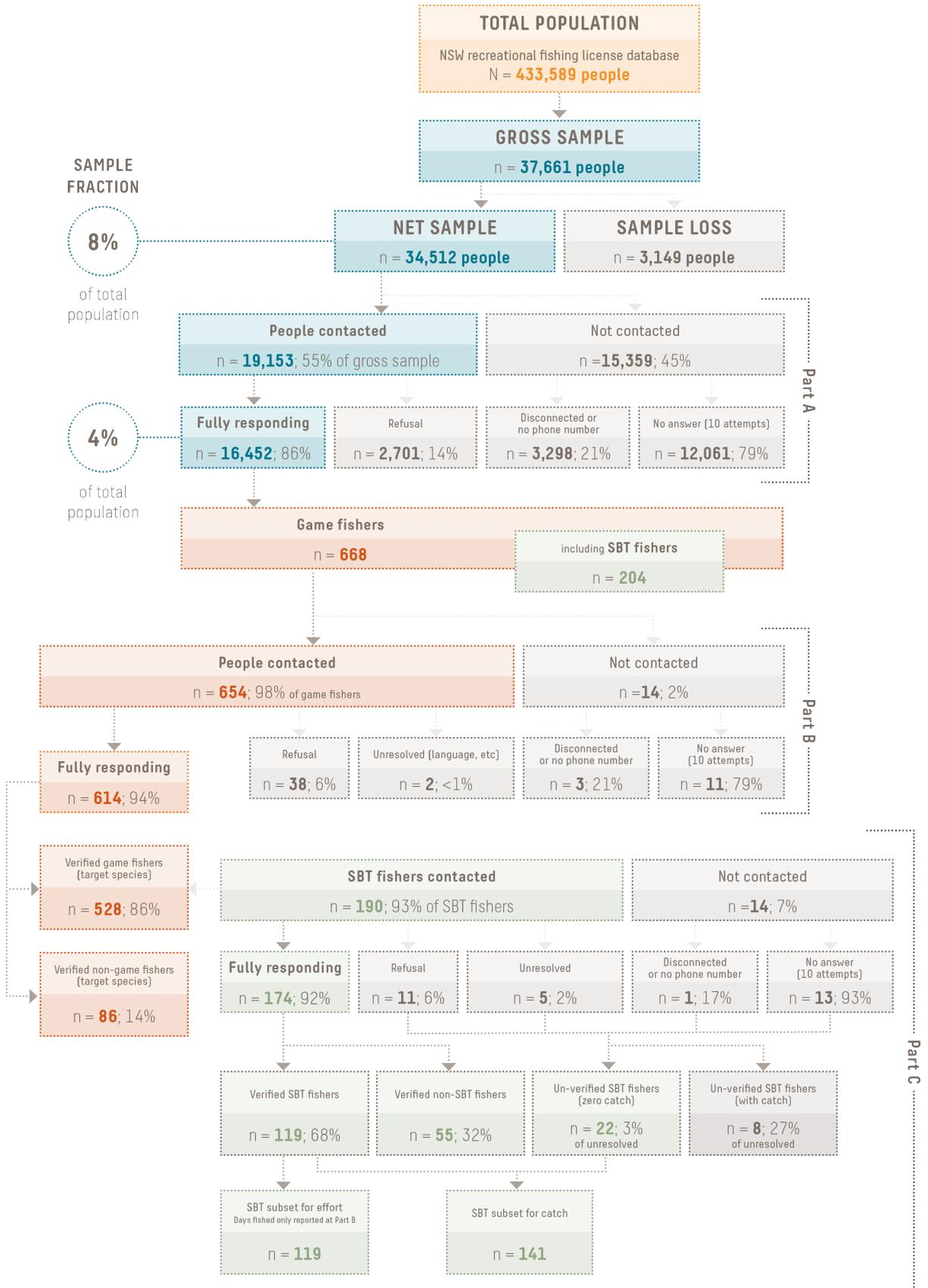


Figure 23. Sample selection and Part A, Part B and Part C response profiles.

4.3.2 Estimates of participation in recreational fishing and game fishing in New South Wales

An estimated 330,214 ($\pm 1,612$ SE) or 76% of licence holders participated in some form of recreational fishing in New South Wales in the 12-month survey period. Of these, an estimated 63,921 ($\pm 1,288$ SE) fished in freshwater only, 184,793 ($\pm 1,582$ SE) fished in saltwater only, with the remaining 81,500 ($\pm 1,582$ SE) fished in both water types. Accordingly, saltwater fishing was the dominant water body fished in by licence holders, conducted by 81% of fishers who identified fishing activity in the survey period. Of those that fished in saltwater, 130,338 ($\pm 1,585$ SE) or approximately 50% indicated they had fished in ocean waters off New South Wales during the survey period, defined as coastal waters, not embayments, estuaries or similar.

An estimated 13,661 (± 593 SE), or 3.2% of licence holders reported participating in game fishing in New South Wales during the survey period. This number includes some licence holders that reported species that were out of scope. When the analysis was limited to the target groups, it was estimated that 12,375 or 2.9% of all licence holders participated in game fishing in New South Wales during the survey window. Of these game fishers, 1,888 (± 199 SE) or 15% indicated they were a member of a New South Wales game fishing club.

4.3.3 Estimates of effort targeting tuna and catch of Southern Bluefin Tuna

During 2018/19, an estimated 2,680 (± 271 SE) licence holders fished for SBT in New South Wales, of which 12% were members of a game fishing club. An estimated 854 (± 143 SE) or 32% of fishers targeting SBT reported being on a successful trip. The estimated number of person days fished for SBT was 10,670 ($\pm 1,301$ SE), but this is likely to be an over-estimate of effort directly for SBT as it likely also included fishing for Yellowfin Tuna during the months SBT are commonly available in New South Wales.

Seventeen percent of fisher days were reported north of Sydney, 47% were between Ulladulla and Sydney, 27% were between Bermagui and Ulladulla, and the remaining 9% occurred between Bermagui and the Victorian border. Twenty-four percent of the fisher days occurred in June, 38% in July, 23% in August and 9% in September. The remaining 8% occurred in other months and is likely to be associated with 'trolling for tuna' rather than specifically targeting SBT.

An estimated 720 (± 141 SE) SBT were reported caught and kept, equating to 29.8 t (± 7.0 SE). The SBT available to the fishery in New South Wales are significantly larger on average than the school fish caught along the south coast of Australia, and comprise a much broader range of sizes. The average size of fish measured by creel clerks at boat ramps during the survey period was 41 kg (± 5.4 SE) $n = 22$, and ranging in length converted weight from approximately 19 to 139 kg. A further 763 (± 219 SE) were released, revealing a release rate of 51%.

Two percent of the total SBT catch was reported north of Sydney, 37% were caught between Ulladulla and Sydney, 36% were between Bermagui and Ulladulla, and the remaining 23% occurred between Bermagui and the Victorian border (Figure 24). Thirty-four percent were caught in June, 38% in July and 21% in August, with three and four percent reported in May and September respectively (Figure 25).

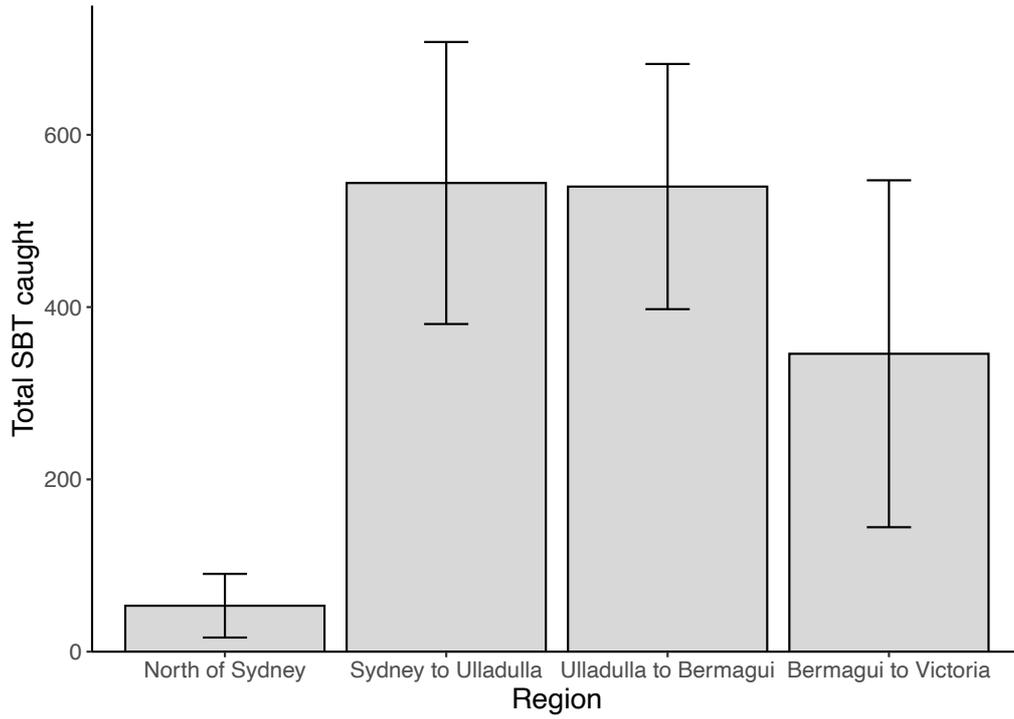


Figure 24. Estimated total catch (kept + released) of Southern Bluefin Tuna (\pm standard error) by region in New South Wales in 2019.

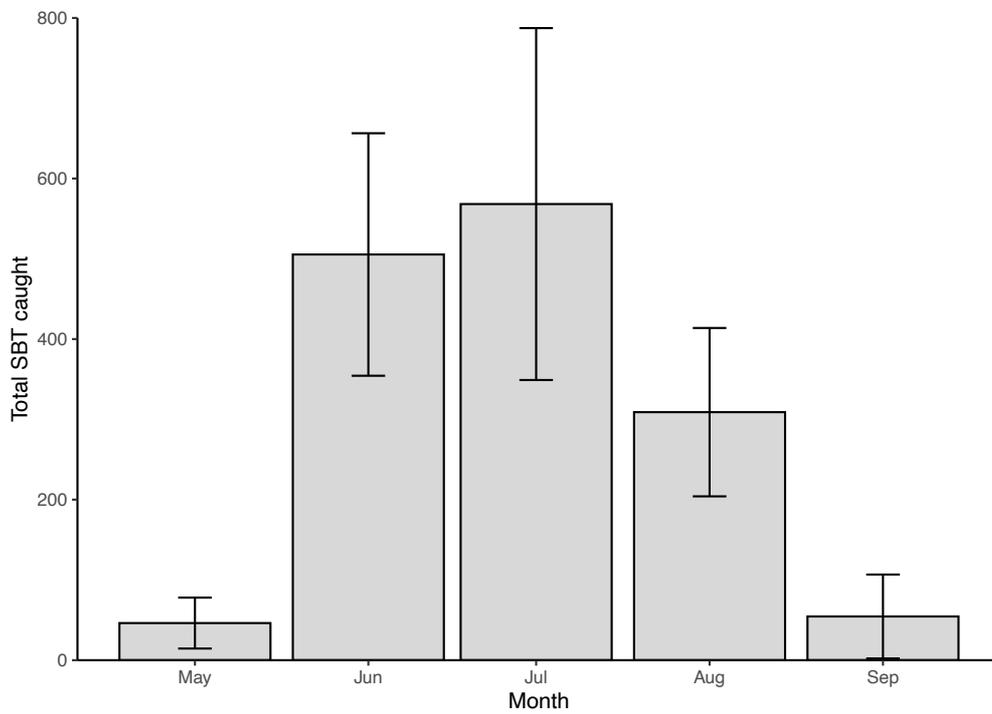


Figure 25. Total catch (kept + released) of Southern Bluefin Tuna (\pm standard error) by month in New South Wales in 2019.

4.4 Consideration of survey coverage and potential biases

New South Wales represented a methodological challenge in terms of providing robust catch estimates for what is a very minor component of the State's overall recreational fishery. This challenge was exacerbated by the large number of potential access points that the SBT fishery could be accessed from, particularly around the large metropolitan region of Sydney, coupled with the large number of registered recreational fishers (over 400,000) in New South Wales. This led to a 'wicked problem' as to what would be the most effective survey method given logistical and cost considerations in the State. While the results resulted in a reasonable relative standard error of 0.23, we acknowledge that the estimates from this State are the least robust of each of the States surveyed, and that under-coverage and bias may have affected the results.

An onsite access-point survey method was considered for New South Wales by Moore et al. (2015) with regional experts indicating that there were 21 boat ramps south of Sydney that would need to be included to provide adequate coverage of private recreational trailer-boats accessing the SBT fishery along the south coast. It was noted however, that locations around Sydney and further north were excluded due to the difficulty in sampling with adequate coverage the many access-points present in this region. Furthermore, while the game fishery is dominated by trailer vessels, the east coast of Australia does have a relatively large and active big game boat fleet compared to the southern states. These would be excluded if a boat-ramp access-point method was used leading to significant under-coverage.

The risk of significant under-coverage of large vessels, and particularly the potential of large catches to be missed if the SBT became available to vessels adjacent to Sydney as has happened in previous years, led us to move away from implementing an on-site method. The alternate was to apply an off-site methodology using the recreational fishing licence database in New South Wales. This was the method chosen as it was decided it would have a lower risk of under-coverage. It was recognised, however, that a very large number of individuals would need to be surveyed to achieve an adequate sample of active SBT fishers.

4.4.1 Recreational fishing licence types and exemptions

Using the New South Wales licence frame for one and three-year licence holders accounts for the majority of recreational fishing harvest (West et al. 2015), and is likely to be particularly the case for a highly specialised activity such as game fishing. However, as the primary sampling unit is the licence holder, it is important to consider potential under-coverage arising from fishers who are exempt from licensing or held short-term licence categories.

There are several exemptions for New South Wales recreational fishing licences³, including:

- a person under the age of 18 years
- an adult helping a person under the age of 18 to take a fish using a single rod, or to take prawns using a single dip or scoop net
- a person fishing in a private dam with a surface area of 2 hectares or less
- a First Nations person, or
- the holder of any of the following:
 - Centrelink Pensioner Concession Card

³ Sourced from <https://www.dpi.nsw.gov.au/fishing/recreational/recreational-fishing-fee/exemptions>

- Pensioner Concession Card issued by the Department of Veterans' Affairs (DVA)
- DVA Gold Card endorsed 'Totally and Permanently Incapacitated'
- DVA Gold Card endorsed 'Extreme Disablement Adjustment'
- a letter from the Commonwealth DVA stating a disability pension of 70% or higher, or an intermediate pension, is received
- holders of Seniors Cards, Health Care Cards and Repatriation Health Cards are not exempt from paying the fishing fee.

With no ability to assess the potential under-coverage that may result from these exemptions, some assumptions are required. We assume that the catch of SBT is likely to be low for persons under 18-years of age, First Nations persons, and holders of pension or disability concession cards, along with short-term licence holders, and therefore will not have a significant effect on the overall harvest. We base this assumption partly on the prohibitive cost of game fishing and the physicality required to participate, and that those who do participate in game fishing are generally more avid anglers so more likely to invest in the longer-term licence categories.

An analysis of the age demographic of survey participants identifying as participating in game fishing somewhat supports the assumption that the age exemptions are unlikely to have a substantial effect on the catch of SBT. The median age of survey respondents who indicated they had participated in game fishing during the survey period was 41-years of age, with a reasonably broad peak from age 30 to 50 (Figure 26). The number of people reporting game fishing drops away rapidly for those younger than 30 years of age and, while at a slower rate, for respondents older than 50.

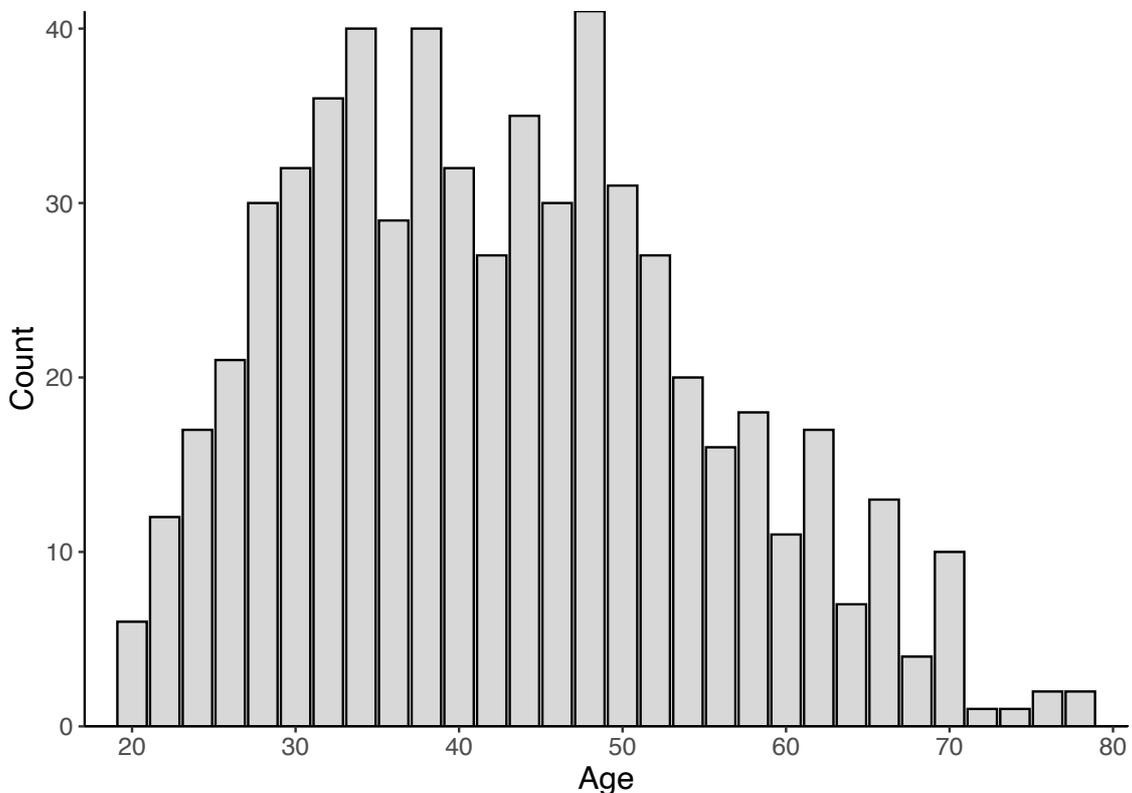


Figure 26. Age profile of respondents reporting participation in game fishing.

4.4.2 Non-response bias

Given the large number of one and three-year licence holders in the database, and the likely low number of participants in the target activity of fishing for SBT, a large net sample of 34,512 was required to provide a reasonable sample fraction. The logistics of contacting this many people over a relatively short time-frame required engaging a large call centre.

A total of 45% of the net sample could not be contacted, with almost 80% of these not answering the telephone for an interview after 10 call attempts, and the remaining approximately 20% either not at the phone number provided or the number was disconnected. While there is potential here for a non-response bias to occur, such bias is unlikely to be linked to salience bias, that is, whether or not the non-respondent was more or less likely to be a game fisher. It is more likely that non-response bias may be linked to demographic characteristics, such as age, gender, ethnicity and other factors.

Conversely, there is potential for demographic and salience bias from respondents who answered the call but declined to participate. A total of 14% of the respondents contacted declined to participate in the survey. Of these, 34% declined before hearing that the survey was about fishing, so this non-response could not be linked to the subject matter. For the remaining 66%, it is possible that a combination of demographic, content and other factors were at play.

While it is difficult to assess and correct for potential non-response bias, there is confidence in the reliability of the sample as the overall responding sample was large and demonstrated considerable consistency in key behavioural metrics (e.g. fishing participation rates) across the various regional strata.

4.4.3 Recall bias

In Tasmania, the telephone-diary design was implemented because SBT are caught throughout the year, and the potential for recall bias when reporting catch and effort is reduced through the use of the diary method and regular contact by interviewers. In New South Wales, the fishing season for SBT is much more truncated, typically only lasting between one to three months, and thus a recall-based survey implemented shortly after the completion of the season was deemed to be a feasible option, with low potential for recall bias. In addition, as the capture of SBT is considered a 'memorable event', any recall bias effects were expected to be low, particularly around reported catch numbers, noting that the daily bag limit in New South Wales is one fish. Therefore, the short recall period and low total individual catches (i.e. maximum reported catch being seven fish, with most respondents reporting two or fewer SBT for the season) strongly suggest that recall bias effects are unlikely to have been a significant issue in this case.

In summary, there is potential for survey-coverage and bias to have affected the catch estimate for New South Wales. However, given the harvest estimate from New South Wales represents only 11% of the National estimate, it is unlikely these considerations would have a significant affect overall. Future surveys should carefully consider if an opportunity exists to identify new sampling frames, or to discuss with the State agencies the potential for adjustments to existing frames to accommodate developing robust survey estimates for key, niche species.

5 Catch and effort estimation from the recreational fishery for Southern Bluefin Tuna from the charter boat sector in Australia

5.1 Introduction

Charter boats offer a fee-for-service operation for recreational fishers to access fisheries they may not be able to access otherwise. The service provides fit-for-purpose vessels and experienced operators, generally with a good knowledge of the species they are targeting. Vessel charter for game fishing trips is common in all States of Australia as larger vessels are required to venture offshore, and more expensive fishing equipment suitable to catch large fish and skipper and crew experience are important components of a successful and safe fishing trip. Charter vessels are likely to be an important and significant contributor to the catch of Southern Bluefin Tuna (SBT) in South Australia, Victoria, Tasmania and New South Wales. In this study, fishing for SBT from charter vessels has been treated separately from private-vessel survey methods.

The South Australian Charter Boat Fishery (SACBF) is managed by the South Australian State Government's Fisheries and Aquaculture Division of Primary Industries and Regions South Australia (PIRSA) in accordance with the legislative framework provided within the *Fisheries Management Act 2007*, *Fisheries Management (Charter Boat Fishery) Regulations 2005*. Like the commercial fishery in South Australia, the SACBF is subject to compulsory catch reporting. This information is reported through a mandatory logbook. Specific details recorded for each trip include port of operation, start and end dates of charter, departure and return times, number of clients and their corresponding postcodes, type of fishing activity, number of specific fishing gear, Marine Fishing Area (MFA) fished, fishing time, target species and number retained. Although additional information on the number and estimated weight of fish released, both legal and undersize, is required if King George Whiting or Pink Snapper are reported, this information is not recorded for SBT (Steer and Tsolos 2016, Rogers et al. 2017).

In New South Wales, the charter boat fishery is managed by the New South Wales Department of Primary Industries (DPI). The marine and estuarine recreational charter fishing boat sector in the State is separated into four categories: estuarine fishing, nearshore bottom fishing and sportfishing, deep sea bottom fishing and gamefishing. Each category is licensed separately, and individual operators may hold multiple licence categories.

In Victoria and Tasmania, there is no general licensing or requirement for mandatory catch reporting from the charter boat sectors. The only exception applies to a small number of Tasmanian operators. These operators are required to complete a mandatory logbook, as a condition permitting the take of a higher boat limit for SBT than provided for under the State's recreational fishing regulations.

In Western Australia, charter boat operators can hold one of several categories of Fishing Tour Operators Licences. As part of the licence conditions, operators are required to complete monthly logbook records of all catches from the vessel and submit these to the Western Australian Recreational Fishing Surveys and Statistics Branch (Moore et al. 2015).

5.2 Methods

Charter logbook data were available from mandatory logbook programs, and through a voluntary logbook program implemented in States where mandatory logbook programs were not in place.

5.2.1 South Australia

A data request was submitted to PIRSA for provision of SACBF data related to the harvest of SBT and other tuna and pelagic shark records for the period 1 December 2018 through to the 30 November 2019. To avoid breaching confidentiality requirements (at least five vessels in a reporting block), data were pooled for the 12-month survey period and grouped into three regions: Eyre Peninsula and the Marine Fishing Areas (MFAs) west to the Western Australian border, the Yorke and Fleurieu Peninsula combined with Kangaroo Island, and the Limestone coast including Port MacDonnell.

Charter operators in South Australia are not required to report the number of released fish or the size of SBT caught. Therefore, information on the number of SBT released by the charter sector in South Australia is not available. In the absence of size information for the charter boat catch, size composition of fish measured during the access-point survey of private trailer vessels (Section 2) was used to convert catch numbers to an estimate of harvested biomass. The size data reported by the regions, defined in the on-site survey, were pooled to match the coarser resolution of the three regions identified above and the average weight calculated for each, multiplied by the number of SBT reported retained in the region.

It was not possible to directly assess the number of large fish greater than 135 cm fork length (FL) taken by the charter sector. However, with the exception of three fish greater than 135 cm FL reported from Victor Harbor during the access-point survey, the only other location in South Australia where large fish were recorded during the surveys was Port MacDonnell. Fortunately, the creel clerk based at Port MacDonnell was able to maintain regular contact with all local charter operators on both survey and non-survey days, to provide an estimate of the total number and size of large SBT (43 fish) landed by the charter sector operating out of Port MacDonnell.

For large fish weighed whole, this measurement was used preferentially. For large fish weighed gill-gutted, the weight was multiplied by 1.15 to convert to whole weight. All other large SBT were measured for fork length and a length-weight conversion was applied (Edwards et al. 2016). The remainder of charter catch was converted to weight using the average length converted weights for small fish within the three reported regions. While the number of fish are provided as an absolute total, the harvested weight is reported with a standard error based on the variance in the size of school fish used to convert numbers to weight.

5.2.2 New South Wales

The New South Wales DPI provided the New South Wales Charter Monitoring Logbook Program data. The data requested for the survey period was for target game fish species, including SBT, Yellowfin Tuna, Bigeye Tuna, Longtail Tuna, Albacore, Mako Shark, Striped Marlin, Blue Marlin, Black Marlin and Swordfish. No SBT were reported in the catches, so it is assumed the harvest of SBT from this sector was zero.

5.2.3 Victoria

Victoria does not have a mandatory logbook program for charter operators. Operators providing game fishing charters were identified through discussions with local experts and internet searches. These operators were contacted and invited to participate in the study by completing a voluntary logbook of their game fishing catch and effort. As an incentive for completing their logbook, operators were advised they would receive a fuel voucher at the end of the study, if they completed the logbook and accurately recorded their catch for the 12-month survey period. In addition, creel clerks met with charter operators regularly to assist with and encourage them to complete their logbooks accurately, and also to assist with measuring fish. Creel clerks were also tasked to identify any charter operators providing game fishing trips that may have been overlooked. No overlooked trips were identified at the main access points at Portland, Port Fairy, Warrnambool or Apollo Bay.

All charter operators identified as being likely to fish for SBT agreed to participate and were provided with a logbook. Data to be recorded in the logbook included date and time of departure, time of return, location of departure, number of clients, primary fishing location, total number of fishing lines used, total fishing time, species targeted, total number of SBT kept, fork length of SBT kept, total number of SBT released, number of other game fishing species kept and released, and number of fish impacted by wildlife depredation interactions (seals, orcas or sharks preying on catch).

Numbers of school fish kept were converted to biomass by multiplying the number by the monthly average length-converted weight of measured fish (as recorded in charter logbooks). For large fish weighed whole, this measurement was used preferentially. For large fish weighed gill-gutted, the weight was multiplied by 1.15 to convert to whole weight. All other large fish were measured for fork length and a length-weight conversion was applied (Edwards et al. 2016). While the number of fish are provided as an absolute total, the harvested weight is reported with a combined standard error based on the variance in the size of school and large fish separately.

5.2.4 Tasmania

Tasmania does not have a mandatory charter logbook program across the sector. However, five operators are required to complete mandatory logbooks as a condition of a permit from the Department of Primary Industries, Water and the Environment (DPIPWE), which allows them to take more SBT than the boat limit stipulated in the recreational fishing regulations. Other operators providing game fishing charters were initially identified through an internet search, and by asking identified operators if they knew of any other operators in their region.

All operators identified were invited to complete a voluntary charter boat logbook reporting their game fishing and offshore fishing activities. The same incentives and data fields required were applied as for the Victorian logbook program but with the inclusion of other species of interest related to a survey of offshore fishing in Tasmania.

Since only a small proportion of SBT caught were measured by charter operators, the average length converted weight of school fish recorded by the creel clerk (Section 3.2.5) was used to estimate the weights of retained and depredated fish within this size class. It is assumed all

large SBT captured were flagged by the charter operators, with all but one large fish weighed-in. This single exception was assigned the average weight of the other large fish reported.

While the number of fish are provided as an absolute total, the harvested weight is reported with a standard error based on the variance in the size of school fish used to convert numbers to weight.

5.2.5 Western Australia

In Western Australia, it is a licensing requirement for all tour operators (charter boats) to provide daily logbook records of all fish caught by clients. The results of the charter logbook data are presented together with private recreational boat-based fishing survey results on a biennial basis in this State (Ryan et al. 2017). The results presented in this study are from the latest edition, reporting on the 2017/18 season which runs for the financial year for the logbook data (Ryan et al. 2019).

5.3 Results

Based on charter boat logbook returns, a total of 5,138 SBT, equating to 61.9 t (± 1.1 SE), were harvested by the charter boat sector across South Australia, Victoria, Tasmania and New South Wales between 1 December 2018 and 30 November 2019 and including the charter boat catch from 2017/18 reported from Western Australia (Table 14).

Table 14. Summary of recreational charter boat tuna fishing effort and catch of Southern Bluefin Tuna in Australia during the survey period. Nd = no data, † = only days where SBT were reported caught, * = minimum estimate due to missing data and non-reporting of zero catch days.

State	Effort (days fished)	Catch retained (n)	Catch estimated weight (t)	Catch released
South Australia	465 [†]	1,918	26.6	Nd
New South Wales	Nd	0	0	0
Victoria	463	2,640	27.0	189
Tasmania	240	505	7.9	354
Western Australia ¹	Nd	75	0.3	0
National total	1,168^{*†}	5,138	61.9	543

¹Data from 2017/18 logbook returns (West Australia DPIRD, unpublished data)

5.3.1 South Australia

There were 57 charter boat licences issued in South Australia during the survey period. Of these, 29 reported 465 trips where SBT were caught (Table 15). A total of 1,918 SBT were reported retained, equating to 26.6 t (± 1.1 SE) (Table 15). Over half of these were reported from the Yorke and Fleurieu Peninsulas and Kangaroo Island regions, while the Eyre Peninsula and western region contributed over one-third of the retained catch by numbers. The remainder was caught on the Limestone coast (Table 15).

Although the Limestone coast had the lowest catch by number, it contributed almost a third of the State's charter boat catch by weight. This was due to the number of large SBT caught from Port MacDonnell (Table 15).

Table 15. Summary of recreational charter boat sector harvested catch in South Australia for the survey period. Size data collected during on-site access-point survey of private trailer vessels were used to convert number of fish to weights. Length to weight conversions were conducted using parameters defined by the CCSBT (Edwards et al. 2016).

Region	Number of trips	Number of fish retained (small / large)	Estimated average weight of small fish (kg)	Estimated average weight of large fish (kg)	Estimated harvested biomass (t)
#Eyre/western region	129	538 / 0	11	–	5.9
#Kangaroo Island/Fleurieu/Yorke	224	1002 / 0	12	–	12.0
*Limestone coast	112	335 / 43	9	126	8.7
State total	465	1,875 / 43	11	126	26.6

5.3.2 Victoria

In Victoria, 21 operators completed the logbook, reporting a total of 471 tuna fishing trips, equating to 22 trips a year per operator on average. A total of 402 or 85% of trips were successful with at least one SBT caught. Five charter operators who did not participate in the logbook program, but had been identified as potentially providing game fishing charters prior to the start of the survey, confirmed they had not engaged in any game fishing activity during the survey period.

The total number of SBT retained by the charter sector in Victoria was 2,640, equating to 27.0 t (± 0.2 SE) (Table 16). A further 189 SBT were released, equating to a release rate of 7%. In addition, 28 SBT were reported lost to predators during retrieval to the boat, 27 to seals and one to a shark. This equates to 0.2 t, assuming 100% mortality. A further 39 SBT were reported to have been damaged by seals during the capture event, but were retained and included in the reported retained catch.

There was clear seasonality in the fishery, with low numbers caught between February and April 2019, and a steep increase in catch through May, before peaking in June and then tailing off in July (Table 16, Figure 27). The seasonality is likely to be driven by both the availability of fish and the dynamics of the fishing fleet, as many operators are based around Melbourne and relocate to western Victoria for a set period of time to provide a charter service focusing on SBT.

The vast majority of fish were caught in the waters off Portland with lower catches also reported from waters adjacent to Port Fairy and Warrnambool (Figure 28). Two operators reported a combined total of nine trips out the front of Port Phillip Bay with a total of 24 SBT reported caught in their logbook, in most cases these catches were incidental to the targeting of Yellowtail Kingfish.

Table 16. Summary of recreational charter boat sector harvested catch during the survey period.

Month	Retained catch (n)	Sum of fish measured <130 cm FL	Sum of fish measured >=130 cm FL	Percent of retained catch measured	Estimated average weight of small fish (kg)	Estimated average weight of large fish (kg)	Estimated harvested biomass (t)
Dec	–	–	–	–	–	–	–
Jan	6	5	–	100	21	–	0.12
Feb	108	90	–	88	14	–	1.54
Mar	92	70	1	86	12	56	1.15
Apr	125	108	17	100	13	106	3.24
May	712	661	3	93	8	114	6.18
Jun	1,383	1,212	9	88	8	121	11.95
Jul	198	182	3	93	7	119	1.66
Aug	3	2	1	100	17	135	0.17
Sep	9	1	8	100	29	117	0.97
Oct	–	–	–	–	–	–	–
Nov	4	4	–	100	6	–	0.02
TOTAL	2,640	2,335	42	89	9	112	27.0

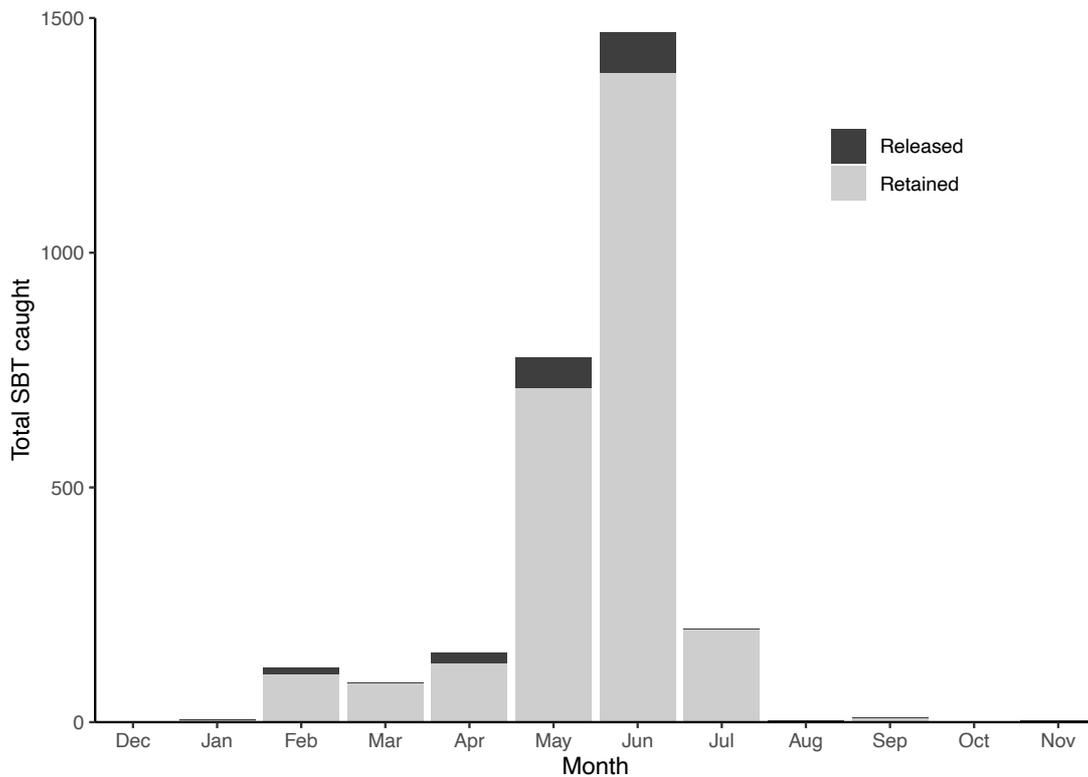


Figure 27. Catch of Southern Bluefin Tuna reported by charter boat sector in Victoria by month during the survey period, including retained and released components of catch.



Length measurements were available for 2,335 (89%) of SBT retained (Table 16). The size distribution of the catch varied throughout the 12-month period, with evidence of several modal size classes migrating seasonally through the area of the fishery. Only a small number of fish were measured during January 2019, most being larger than 100 cm fork length (FL).

Between February and July catches were higher and the monthly data are likely to be more representative of the size classes available to the fishery. From February through to July 2019, the size of school fish decreased steadily from an average of 14 kg to 7 kg (Table 16, Figure 29). These smaller fish dominated the catch throughout this period (Figure 29), with very few fish school fish caught by the charter sector after July (Table 16, Figure 27).

While caught in low numbers, large SBT were present off Portland for much of the study period, with the greatest number of fish landed in April ($n = 17$), followed by reports of a low but consistent number of fish being caught from May through to September (Table 16, Figure 29). The average weight of these fish was 112 kg, with the heaviest fish weighed in at 169 kg (Table 16).

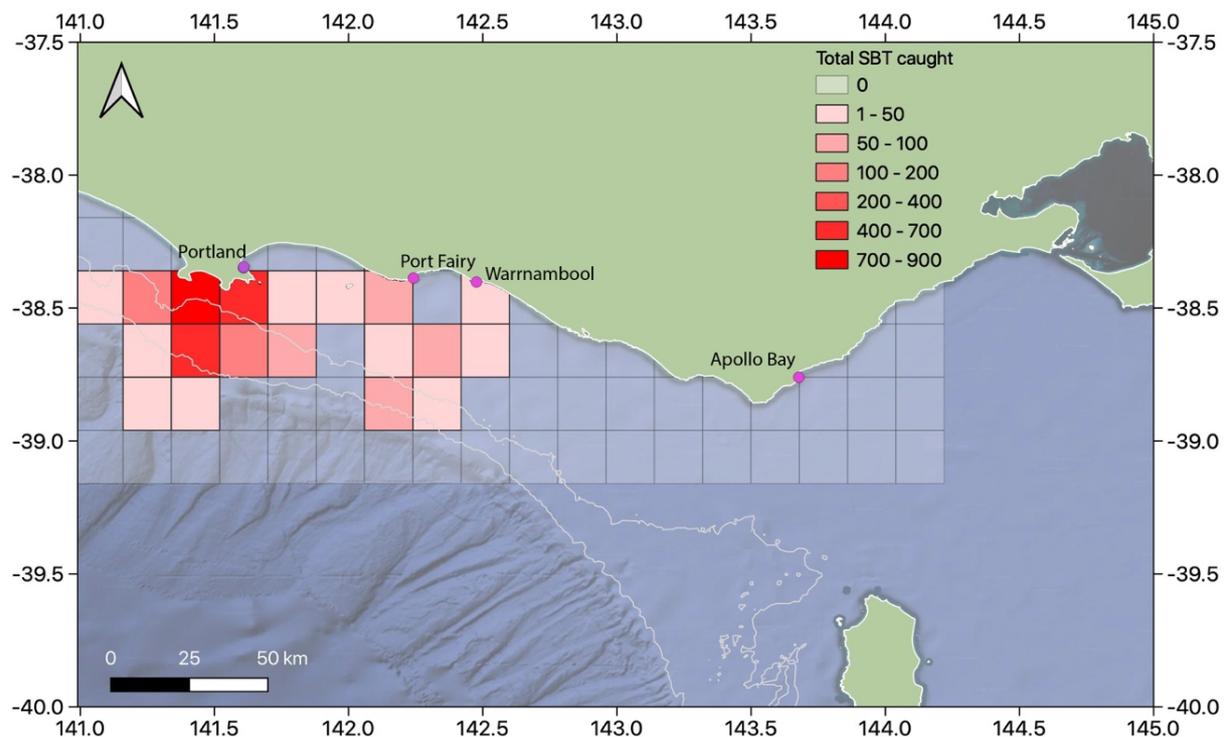


Figure 28. Spatial distribution of the charter boat catches of Southern Bluefin Tuna in Victoria during the survey period. Coloured dots indicate surveyed boat ramps.

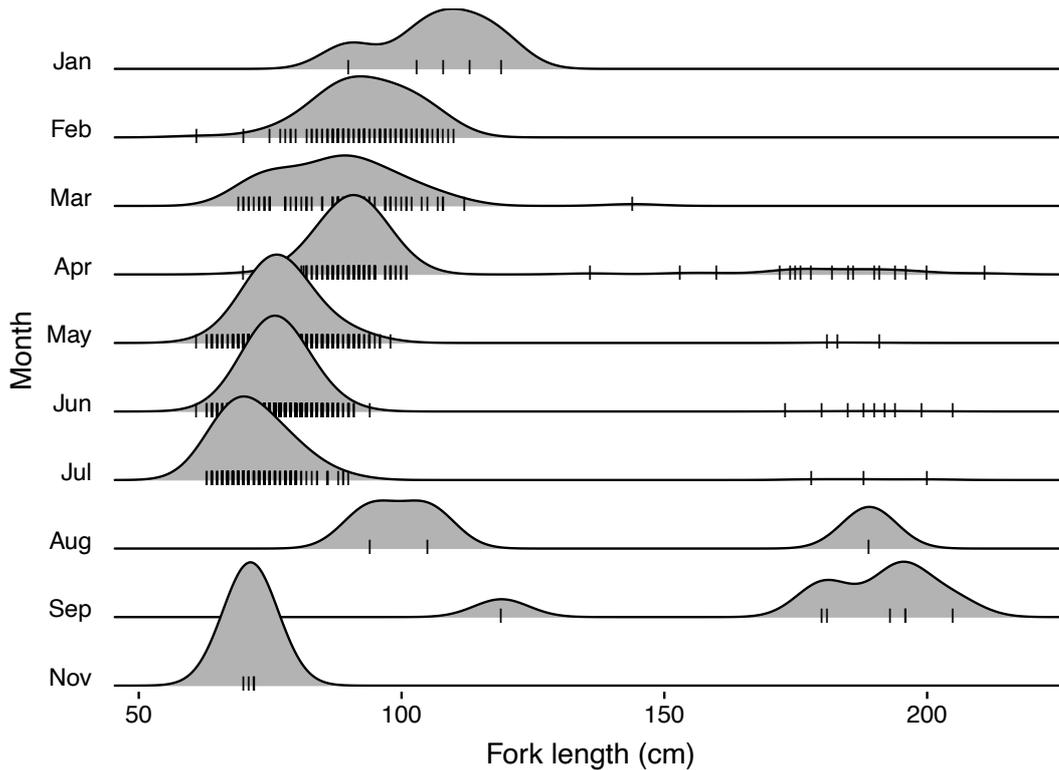


Figure 29. Relative size composition of Southern Bluefin Tuna caught by recreational charter boats in Victoria during the 12-month survey period, shown using density plots. Rugs indicate individual fish measurements contributing to density functions.

5.3.3 Tasmania

Sixteen charter boat operators were identified as likely to provide game or offshore fishing trips in Tasmania. Of these, nine reported a combined 240 game fishing trips for SBT, with fish caught on 160 of these trips. Four of the remaining operators confirmed they did not fish for SBT during the survey period while one operator, who declined to participate in the logbook program, confirmed at the end of the season that he had done two trips targeting SBT during the survey period. As the catch on these trips was unknown, Tasmania’s boat limit of four fish was assigned to each trip.

A further two operators declined to participate in the logbook program and no information was obtained from them directly. However, anecdotally, it is highly unlikely they conducted many, if any, charters for SBT. Therefore, any uncertainty surrounding the overall charter boat catch estimate is considered negligible.

A total of 505 SBT were reported retained, resulting in a harvest weight of 7.97 t (± 0.3 SE). A further 354 were released, equating to a release rate of 41%. The vast majority of retained SBT were school fish, with only four large fish reported.

The monthly trend in total catch of SBT by charter boats in Tasmania reflected the private boat sector catch. The exception was a sustained peak in charter boat sector catches in May (Figure 30), whereas the private boat sector experienced a drop in catches during that month, linked to a decline in effort.

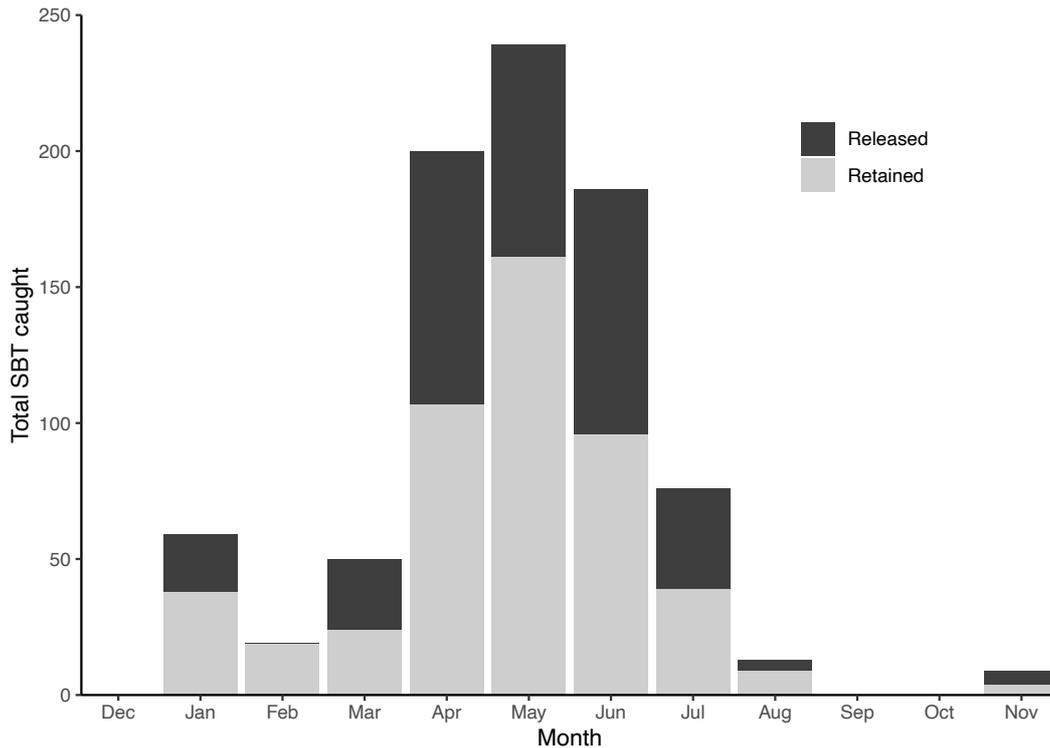


Figure 30. Total catch of Southern Bluefin Tuna reported by charter boats in Tasmania by month during the survey period, including retained and released components of catch.

A total of 43 SBT were reported as being depredated by seals, equating to 0.65 t of fishery-related mortality. A further 19 fish were damaged by seals during the capture process, but were retained and are included in the retained catch amount. However, it is likely these are underestimates as predator interactions were reported on 74 trips, but the number of fish lost was only defined for 31 of those trips. Ninety-nine percent of charter catch was caught off the Tasman Peninsula on the southeast coast of Tasmania.

5.4 Consideration of logbook coverage and compliance

While charter logbooks are mandatory in South Australia and New South Wales, completeness of data requires 100% compliance to completion of logbook records for each fishing trip. There is no evidence to suggest there is non-compliance in South Australia but, as this cannot be guaranteed, there is the possibility of under-reporting. In New South Wales, there is known non-compliance, with a report on the 2012 charter season indicating the reporting rate was 62% (McIlgorm and Pepperell 2014). This lends to a reasonable probability of under-reporting in New South Wales.

A cursory search on social media found that there were a small number of SBT caught by some charter boats in New South Wales during the survey period. However, it is not possible to quantify this information and we have reported zero catch as per the logbook database. Given the small amount of SBT catch reported from the charter sector in previous years (see Table 26 in Section 8), and considering an under-reporting rate of approximately 38%, it is highly likely that no more than 100 SBT were retained by the charter sector in New South Wales during 2019, and likely to be significantly fewer based on discussions with regional experts who indicated that 2019 was a 'quiet' year for SBT.



The voluntary charter boat logbooks used in Victoria and Tasmania may also be subject to under-reporting. However, beyond the insignificant amount of catch discussed above relating to non-participation by a couple of operators in Tasmania, compliance is likely to be relatively high.

In Victoria, the regional manager and creel clerks were in regular contact with all charter operators, encouraging completion of logbooks. Similarly, regular contact was made with charter operators in Tasmania to encourage participation. Logbook returns were routinely received and operators were reminded that, to receive the fuel voucher incentive, accurate and complete records were required for the full 12 months.

In summary, it is likely there is some under-reporting of charter boat catch, particularly from New South Wales, but in relation to the National harvest estimate this is likely to be insignificant.

6 Catch and effort estimation from sanctioned game fishing competitions

6.1 Introduction

Tournament fishing is an important part of fishing for many anglers. Tournaments may have different motivations, such as fundraising or economic gain (Curtis et al. 2017), but many come from years of tradition and many major game fishing tournaments are run at the same time each year (Park 2007). These annual fishing events often draw visitors to the regional areas where the competition is taking place, boosting tourism in the host town and bringing benefits to the local economy (Curtis et al. 2017). Tournaments can also provide an important component of data for recreational fisheries research, with dedicated programs collecting and synthesising this valuable time-series information.

Game fishing tournaments in eastern Australian have been organised since 1938 (Knight et al. 2006), with thousands of individuals participating annually. Participation in individual competitions ranges from a handful of boats to hundreds of vessels (Ward et al. 2012). Different species are targeted depending on the timing and location of the tournament, and this is often reflected in the prizes or trophies offered (Park 2007). For example, many tournaments in New South Wales target billfish due to both their presence in the subtropical waters off the coast and the challenge they present to recreational anglers. In South Australia, Victoria and Tasmania where the waters are much cooler, tuna and especially SBT are targeted, along with pelagic sharks.

Catch and release angling has become a significant component of game fishing tournaments. Since the introduction of tag and release fishing in the 1970s, there has been a shift towards increased release rates, with less fish being weighed-in during tournaments in Australia (Murphy et al. 2002, Ward et al. 2012). Most tournaments have point scores for tagged and released fish as well as retained fish, with prizes and trophies to be won for both categories (Ward et al. 2012).

Tournaments can provide an important source of data for recreational fishing research. As tournaments are generally run over short timeframes, they represent a pulse in fishing effort and, with many fishers in one place, data can be collected from many anglers over a short period of time. Catch, effort and biological data can come from targeted monitoring programs or from reports provided by local fishing clubs, councils or individuals. For example, New South Wales has run the Gamefishing Tournament Monitoring Program since the early 1990s (Pepperell and Henry 1997, Knight et al. 2006). This program collects data via multiple methods on the catch, effort, size and spatial distribution of tournament catches (Knight et al. 2006). For other States that do not run dedicated monitoring programs, data is often collected by the clubs organising the tournaments, and include information on number of participants, numbers of retained and released species, and sizes of individual fish retained and measured at the weigh station.

While tournament fishers may only make up a small proportion of recreational anglers, tournament provide an important source of recreational fishing catch and effort information. This study investigates tournament data for SBT available from South Australia, Victoria, Tasmania and New South Wales fishing competitions undertaken between December 2018 and November 2019.

The objective of this section was to document catches of gamefish species taken during game fishing competitions in South Australia, Victoria, Tasmania and New South Wales during the survey year. However, tournament catches of SBT have effectively been accounted for in the survey methodologies reported in the preceding sections, with the exception of the Riviera Port Lincoln Classic and the Port Lincoln Bluewater Classic which primarily involve large non-trailer vessels (refer Section 2.4).

6.2 Methods

Game fishing tournaments run in South Australia, Victoria, Tasmania and New South Wales that were likely to encounter SBT were identified using local expert knowledge and internet searches for tournaments and competitions run by Game Fishing Association of Australia (GFAA) affiliated clubs. While most tournaments are run by local GFAA affiliated clubs, some targeted competitions are also run by individuals such as the Coast2Coast Tuna Competition at Victor Harbor in South Australia, or by local councils such as the Portland Hooked on Tuna tournament run by the Glenelg Shire in Victoria. Appendix V (Table 37) provides a full list of the game fishing tournaments from which data was requested for the period 1 December 2018 through to 30 November 2019.

6.2.1 South Australia

In South Australia, five tournaments targeting SBT were identified. Two GFAA-affiliated clubs were identified as organising these tournaments and were asked to provide information about the event, including the number of boats and anglers participating, total number of SBT retained, total number of SBT released, total number of other gamefish species retained, total number of other game fish species released, and any length or weight data recorded for the tournament. In addition, two tournaments not affiliated with the GFAA but specifically targeting SBT were identified. These were the Coast2Coast Tuna Tournament run out of Victor Harbor, and the Riviera Port Lincoln Tuna Classic run out of Port Lincoln. Organisers of these events were contacted and asked to provide information on the tournaments as above.

6.2.2 Victoria

A total of three tournaments targeting gamefish or SBT were identified in Victoria – two run by local GFAA-affiliated clubs and one by a local government shire. The organisers of these tournaments were asked to provide information on the number of boats and anglers participating in the tournament, total number of SBT retained, total number of SBT released, total number of other gamefish species retained, total number of other game fish species released, and any length or weight data recorded for the tournament.

6.2.3 Tasmania

In Tasmania, a total of 12 tournaments targeting gamefish or SBT were identified, run by five different GFAA-affiliated clubs. All clubs provide tournament reports to the Tasmanian Game Fishing Association (TFGA). The TGFA was contacted and asked to provide information on the number of boats and anglers participating in each tournament, total number of SBT retained, total number of SBT released, total number of other gamefish species retained, total number of other game fish species released, and any length or weight data recorded for each tournament.

6.2.4 New South Wales

New South Wales has a dedicated Gamefish Tournament Monitoring Program (GTMP) which has operated since the early-1990s (Pepperell and Henry 1997, Knight et al. 2006). The GTMP collects data via mandatory radio schedules at regular intervals during tournament events. Data includes number of persons on the vessel, location, and any species of fish caught (Knight et al 2006). This is also supplemented with data from observers at ramps.

6.2.5 Results

South Australia recorded five major game fishing tournaments, of which four were specifically focussed on tuna. During these events, 560 SBT were reported caught, with 218 retained and 342 released. However, released fish were not reported for some competitions (Table 17). The Port MacDonnell Tuna and Sportfish tournament was the only competition that recorded other species captured, with three Albacore and two Mako sharks kept during the five-day event. Most participating vessels in the two Port Lincoln tournaments were cruisers rather than trailer vessels, so were out of scope for the on-site survey. Accordingly, the results from these two tournaments have been considered additional to effort and catch estimates for South Australia.

In Victoria, only two game fishing tournaments were recorded as having targeted tuna (Table 17). From these two events, only five SBT were caught, with four retained and one released. No other large game species were caught during these tournaments.

Tasmania had 12 major game fishing tournaments during the survey period. Of these, six recorded catches of SBT, with a total of 223 SBT caught, of which 89 were retained and the remainder released (Table 17). The remainder of the reported tournament catch for Tasmania included 12 Albacore retained and 38 released, 43 Mako shark retained and 42 released, and a single Swordfish released as part of the Tasmanian Easter Competition.

In New South Wales, Game Fish Tournament Monitoring Program data was available for 21 game fishing tournaments during the survey period. No SBT were caught in any New South Wales tournament in the 2018/2019 season (Table 17). A large number of billfish were caught as part of the tournaments but the vast majority were released, with Striped, Black and Blue Marlin having release rates of 99, 98 and 73%, respectively. New South Wales was the only surveyed State to record captures of Yellowfin Tuna as part of a tournament during the survey period, with 42 retained and 19 released.

Table 17. Number of game fish species kept and released during tournaments in Victoria (Vic), South Australia (SA), New South Wales (NSW) and Tasmania (Tas). Species recorded included Southern Bluefin Tuna (SBT), Yellowfin Tuna (YFT), Albacore (ALB), Striped Marlin (STR MAR), Black Marlin (BLK MAR), Blue Marlin (BLU MAR), Mako sharks (MAKO) and Swordfish (SWO). Dashes (–) indicate incomplete data.

State	Tournament name	Number of vessels	SBT kept/released	YFT kept/released	ALB kept/released	STR MAR kept/released	BLK MAR kept/released	BLU MAR kept/released	MAKO kept/released	SWO kept/released
Vic	Total	–	4 / 1	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
	Portland Hooked on Tuna	–	4 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
	Southwest Victorian Game Fishing Competition	11	0 / 1	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
SA	Total	–	218 / 342 [†]	0 / 0	3 / 0	0 / 0	0 / 0	0 / 0	2 / 0	0 / 0
	Coast 2 Coast Tuna Tournament	75	110 / –	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
	Wirrina Tuna Tournament	13	35 / –	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
	Port Lincoln Blue Water Classic	5	12 / 100	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
	Riviera Port Lincoln Tuna Classic	22	3 / 177	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
	Port MacDonnell Tuna and Sportfish Tournament	30	58 / 65	0 / 0	3 / 0	0 / 0	0 / 0	0 / 0	2 / 0	0 / 0
NSW	Total	–	0 / 0	42 / 19	1 / 4	6 [†] / 213 [†]	3 [†] / 165 [†]	23 / 61	13 [†] / 31 [†]	0 / 0
	Jervis Bay White Sands	16	0 / 0	2 / 0	1 / 1	0 / 1	0 / 0	0 / 0	1 / 0	0 / 0
	Port Macquarie Golden Lure	53	0 / 0	0 / 0	0 / 0	0 / 1	0 / 86	1 / 12	0 / 1	0 / 0
	Port Macquarie Golden Lure Ladies & Juniors	25	0 / 0	0 / 0	0 / 0	0 / 0	0 / 11	1 / 0	0 / 0	0 / 0
	Batemans Bay Tollgate Island Classic	45	0 / 0	0 / 0	0 / 0	2 / 37	1 / 9	0 / 0	0 / 8	0 / 0
	Botany Bay Bill Heyward Memorial Tournament	60	0 / 0	0 / 0	0 / 0	0 / 9	0 / 5	0 / 0	0 / 0	0 / 0
	Bermagui Bluewater Classic	78	0 / 0	0 / 0	0 / 0	0 / 27	0 / 0	0 / 0	0 / 2	0 / 0
	Ulladulla Jess Sams	43	0 / 0	0 / 0	0 / 0	0 / 26	0 / 23 [*]	0 / 0	0 / 4 [*]	0 / 0
	Lake Macquarie Big Fish Bonanza	39	0 / 0	0 / 0	0 / 0	0 / 1	1 / 2	1 / 5	0 / 0	0 / 0
	Garmin Billfish Shootout	167	0 / 0	4 / 2	0 / 0	0 / 9 [*]	0 / 9	4 / 26	1 / 0	0 / 0
	Eden Open Tournament	20	0 / 0	0 / 0	0 / 0	1 / 20	0 / 0	0 / 0	1 / 6	0 / 0
	Alliance Tag & Release Tournament	35	0 / 0	0 / 0	0 / 0	0 / 2	0 / 1	0 / 0	0 / 0	0 / 0
	Newcastle East Coast Classic	60	0 / 0	1 / 0	0 / 0	0 / 2	0 / 14	3 / 14	0 / 2	0 / 0

State	Tournament name	Number of vessels	SBT kept/released	YFT kept/released	ALB kept/released	STR MAR kept/released	BLK MAR kept/released	BLU MAR kept/released	MAKO kept/released	SWO kept/released
	Broken Bay Invitational	41	0 / 0	0 / 0	0 / 0	0 / 2	0 / 0	0 / 0	0 / 0	0 / 0
	Merimbula Billfish Tournament	14	0 / 0	0 / 0	0 / 0	0 / 7	0 / 0	0 / 0	0 / 0	0 / 0
	Central Coast Garmin Blue Water Classic	33	0 / 0	0 / 0	0 / 0	0 / 3	1 / 1	3 / 3	0 / 0	0 / 0
	Kiama Blowhole Bigfish Classic	48	0 / 0	13 / 4	0 / 0	1 / 28	0 / 2*	5 / 2	2 / 0	0 / 0
	Peter Goadby Memorial Tournament	64	0 / 0	12 / 0	0 / 0	2 / 29*	0 / 1	3 / 0	3 / 0	0 / 0
	Port Hacking 100	48	0 / 0	4 / 12	0 / 0	0 / 3	0 / 0	2 / 0	3 / 2	0 / 0
	Merimbula Open	18	0 / 0	2 / 1	0 / 0	0 / 0	0 / 0	0 / 0	0 / 2	0 / 0
	Canberra Tuna Tournament	34	0 / 0	3 / 0	0 / 3	0 / 0	0 / 0	0 / 0	0 / 1	0 / 0
	Sydney Geoff Woolley Memorial Mako Tournament	19	0 / 0	1 / 0	0 / 0	0 / 0	0 / 0	0 / 0	2 / 3	0 / 0
Tas	Total	–	89 / 154	0 / 0	12 / 38	0 / 0	0 / 0	0 / 0	43 / 42	0 / 1
	Shark Competition	41	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	14 / 11	0 / 0
	Australia Day Shark & Gamefish Challenge	18	0 / 0	0 / 0	0 / 2	0 / 0	0 / 0	0 / 0	5 / 5	0 / 0
	Tasmania Light Line Shoot Out	15	0 / 0	0 / 0	0 / 8	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
	St Helens Game Fishing Classic	52	0 / 0	0 / 0	5 / 20	0 / 0	0 / 0	0 / 0	14 / 12	0 / 0
	East Coast Classic	14	0 / 0	0 / 0	2 / 0	0 / 0	0 / 0	0 / 0	5 / 4	0 / 0
	Broadbill Championships	13	2 / 8	0 / 0	1 / 8	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
	Easter Competition	17	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	4 / 10	0 / 1
	Tom Jenkins Tuna Competition	64	26 / 12	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
	Peninsula Challenge	26	9 / 20	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
	Far South Classic	20	20 / 25	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
	Winter Windup	15	30 / 71	0 / 0	4 / 0	0 / 0	0 / 0	0 / 0	1 / 0	0 / 0
	Tuna Competition Opener	13	2 / 18	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0

* Indicates species with fate unknown. All unknown fates were of one individual except the NSW Ulladulla Jess Sams Tournament where two black marlin had unknown fates.

† Indicates numbers may be underestimated due to incomplete data.

7 Attitudinal survey

7.1 Introduction

The wash-up survey was intended to explore the experiences and perspectives of fishers in relation to the recreational SBT fishery, including trends in the availability of SBT, recreational fishing effort and overall fishery quality. Questions were focused on the State in which the respondent had done most of their SBT fishing rather than their State of residence. The questionnaire also included questions about fish handling practices and the Tuna Champions program, but these aspects will be reported elsewhere.

7.2 Method

The wash-up survey was administered by telephone as a structured questionnaire and was conducted between January and February 2020. Recruitment of respondents varied in each State, as follows:

- Tasmania – respondents who had completed the phone-diary survey and had fished for SBT during the survey period were deemed eligible for inclusion in the wash-up survey
- New South Wales – phone survey respondents who had indicated they had fished for SBT in the survey period were deemed eligible
- Victoria and South Australia – SBT fishers interviewed as part of the access-point survey were invited to provide contact details if they wished to be included in a follow-up phone survey, and all who provided phone numbers were deemed eligible for inclusion in the wash-up survey.

Since a probability-based sample design was applied to the initial selection of respondents for the Tasmanian and New South Wales surveys, and assuming no major non-response bias effects, respondents eligible for inclusion in the wash-up survey are likely to be representative of the fisher populations in either State.

By contrast, eligibility for South Australian and Victorian participants was based on self-selection (fishers agreeing to provide contact details), and thus respondents are less likely to be representative of the fisher populations targeting SBT in these States. These differences in wash-up survey recruitment mean that comparisons between States or generalisations within States will need to be made with caution.

7.3 Results

Of 535 potential respondents identified through the recruitment process, 477 (89%) were contacted, the remaining 11% could not be contacted, either due to a non-valid phone number or no answer despite multiple call attempts. Of those persons contacted, 456 (96%) fully responded to the questionnaire and a further 10 (2%) partially completed the survey. In the latter case, responses to answered questions have been included in the analyses. Overall survey non-response was low (2%).

7.3.1 Respondent profiling

Respondents were asked to identify the Australian States in which they had fished for SBT in the previous 10 or so years and then identify the State in which they had done most of their

SBT fishing. The response to this question was used to allocate respondents to a ‘home fishing State’ in which they were assumed to have greatest knowledge of the SBT fishery.

The vast majority of Tasmanian respondents indicated that they had exclusively fished for SBT in Tasmania (Figure 31). A similar situation applied for NSW/ACT respondents, although approximately 10% of respondents indicated that they had fished for SBT in Victoria. While the majority of Victorian and South Australians surveyed had fished in their home States, the proportion of those who had also fished in other States was much greater than for Tasmanian or New South Wales residents. For instance, 30% of Victorian respondents reported fishing for SBT in South Australia and 28% fished in New South Wales. Among South Australian respondents, 31% reported that they had fished for SBT in Victoria.

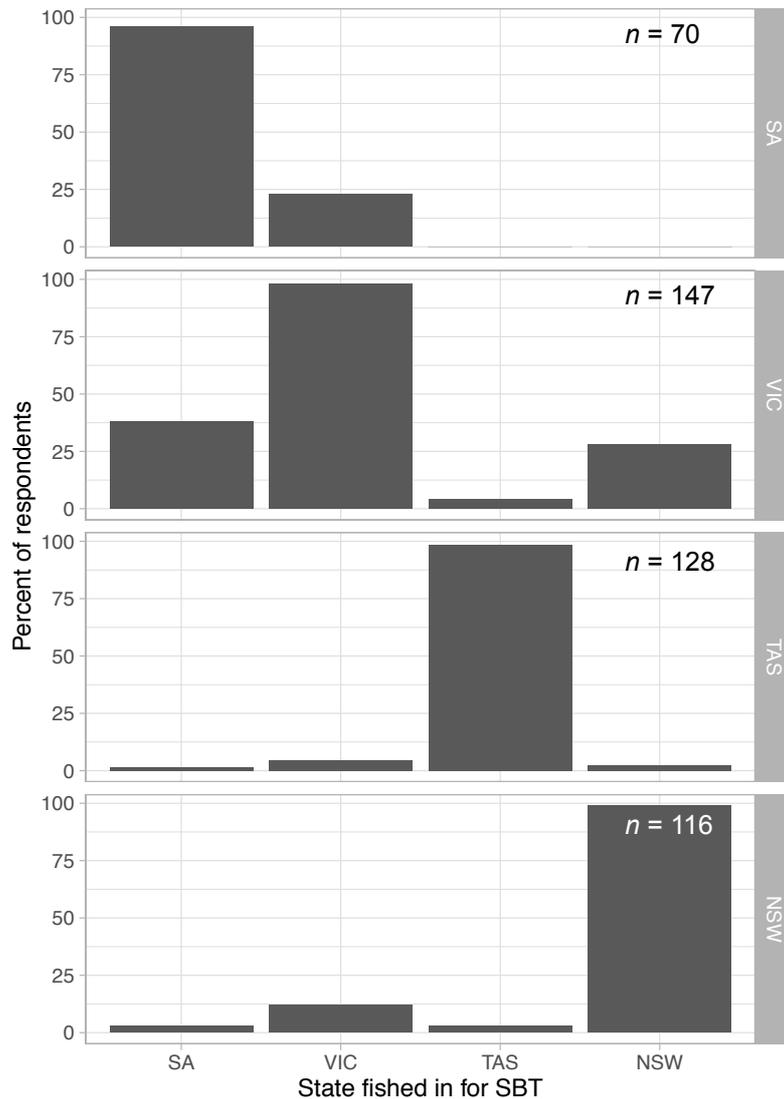


Figure 31. Proportion of respondents having fished for SBT in the various Australian States, based on the State of residence (grey labels).

Based on reported fishing experience for SBT, it was evident that there was a substantially higher proportion of respondents with more than 20 years of experience in the Tasmanian fishery (29%) as compared with fisheries in the other States (Figure 32). There was considerable similarity between the South Australian and Victorian fisheries in terms of fisher

experience profiles, with between 53–58% of respondents reporting less than 10 years of experience, and less than 20% in South Australia and 10% in Victoria with more than 20 years of experience. By contrast, experience in the New South Wales fishery tended to be less extensive amongst respondents, with 84% reporting fewer than 10 years of experience fishing for SBT. However, since there are some provisions for exemptions for pension card holders for licensing in New South Wales (the basis for sample selection), it is possible that sampling licence holders will have under-represented older and potentially more experienced fishers.

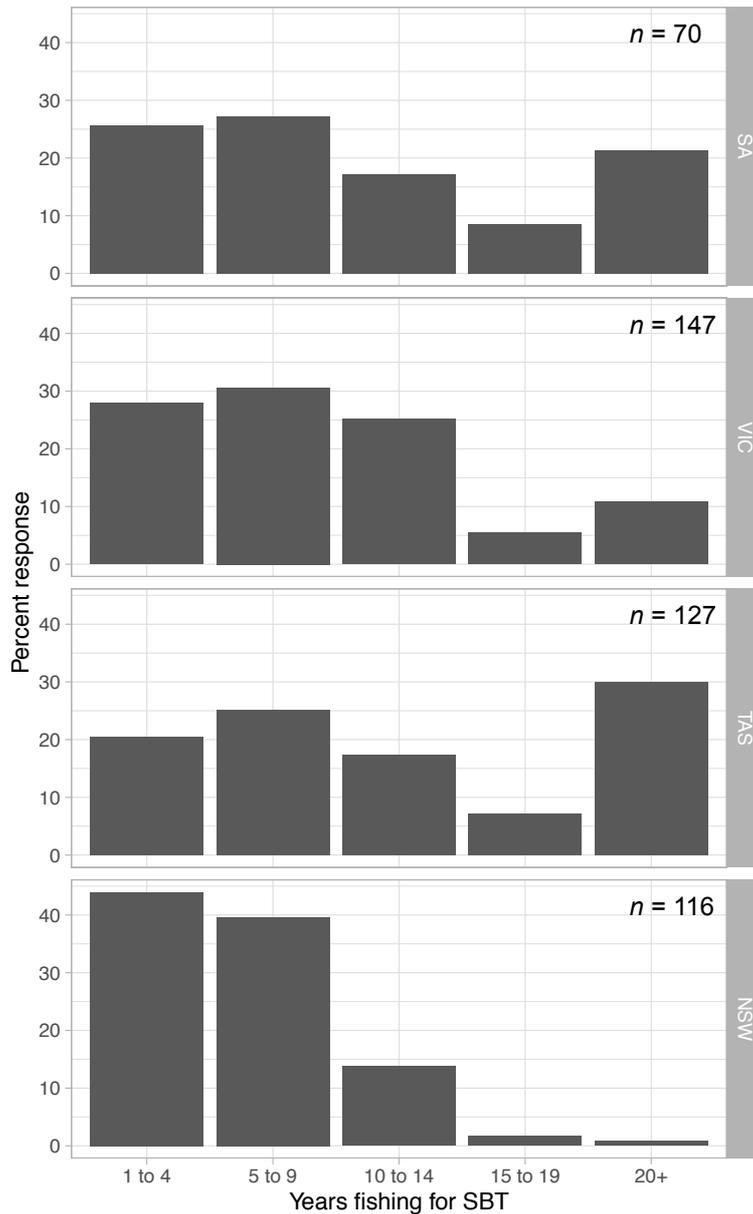


Figure 32. Experience fishing (years) for SBT as reported by survey respondents and based their main fishing State (n = sample size).

Respondents who had fished for SBT in two or more years were asked to estimate the number of days they usually fished for SBT per year, the number of days fished during the survey period and whether they considered that they had fished more, less or about the same during 2018/19 compared with previous years.

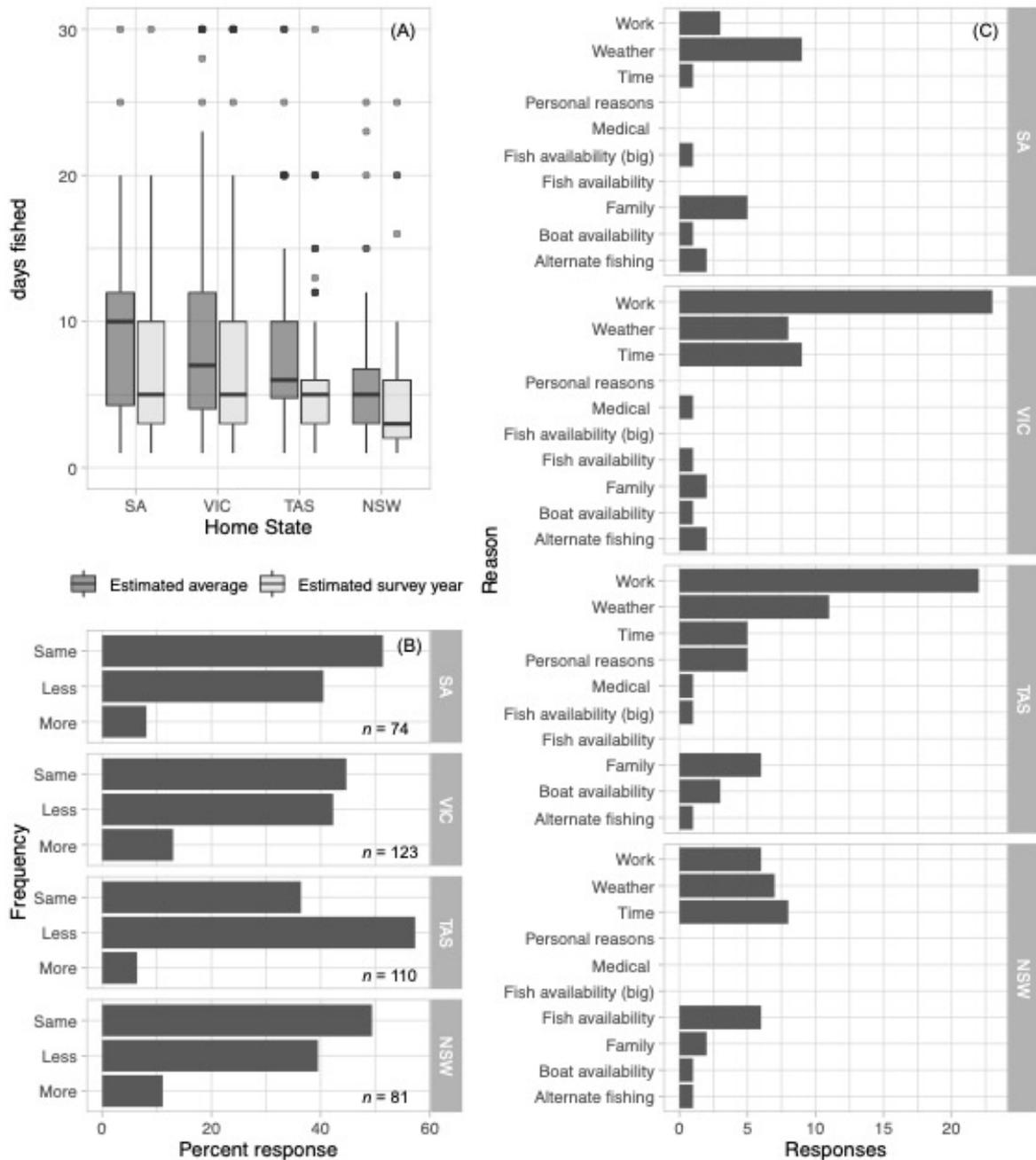


Figure 33. (A) Comparison of usual (average) days fished per year and days fished for SBT during the 2018/19 survey period by main State fished (median indicated by bold horizontal line) – Y-axis truncated to a maximum of 30 days to aid visualisation; (B) Responses to comparison of fishing effort in survey year relative to previous years by main State fished; (C) Main reasons given for fishing less in survey year based on main State fished.

A comparison between ‘usual’ or average days fished for SBT and days fished during 2018/19 suggests that overall the fishing effort expended by respondents was lower than average during 2018/19 (Figure 33A). At a State fishery level, the difference in median effort values were relatively greater for South Australia and New South Wales compared with Victoria and Tasmania. However, median days fished for SBT during 2018/19 were consistent between the three southern States (approximately five days) and around double that for New South Wales respondents.

At an individual level, the vast majority of respondents reported fishing less or about the same number of days for SBT during 2018/19 compared to what they usually had done in the past. Comparatively few respondents (6–13%) reported fishing more than usual during the survey year (Figure 33B). Apart from Tasmania, approximately 40% of respondents in each of the State fisheries reported fishing fewer days for SBT during 2018/19 than usual, with a further 45–51% indicating they had fished about the same number of days in 2018/19.

By contrast, in Tasmania, the proportion of respondents who reported fishing fewer days than usual was much higher (57%) than for respondents in other States, with only 36% of those responding indicating that they had fished about the same number of days as usual.

Work commitments, weather and time availability were the most commonly cited reasons for fishing less. The availability or lack of SBT did not emerge as an important factor in each of the States, other than New South Wales (Figure 33).

7.3.2 Trends in fishing effort, fish availability and fishery quality

The wash-up survey also canvassed perceptions relating to trends in recreational fishing effort and SBT availability relevant to the respondent's experience fishing for SBT. Overall, it was the perception of the majority of respondents that fishing effort for SBT had increased over time, with more than 70% of respondents reporting a general increase in effort in Victorian, South Australian and Tasmanian fisheries, while 57% of New South Wales fishers reported an increasing trend in that State (Figure 34A). Relatively few respondents (< 10%) indicated a belief that recreational effort had declined over time.

Changes in recreational fleet capability, attributed to an increase in the number of vessels suitable for offshore fishing, was suggested as a major contributor to the general increase in effort, particularly among Tasmanian respondents. Social media and 'popularity' were also identified as factors influencing the growth in effort, especially in the Victorian and New South Wales fisheries. Increased availability/accessibility of SBT to the recreational sector was also flagged as an important factor contributing to the general increase in fishing effort (Figure 34B).

It is possible that the perceived increase in effort may in fact be more related to an increased visibility of the fishery, through an increase in the reporting of successful fishing trips over the last decade on social media platforms. The increased visibility of the fishery on social media can lead to significant cognitive biases including confirmation bias where people tend to be exposed more to subject matter they are interested in within their social networks.

This reinforces perceptions of a general 'increase' in these subjects in their news feeds. This is further exacerbated by recall bias when considering trends over long periods. Considering that 46% of fishers reported that they had personally fished less in the survey year than on average, and only 10% feeling that they had fished more than on average (Figure 33B), supports the assumption that there may be significant biases in the perceptions of increased effort.

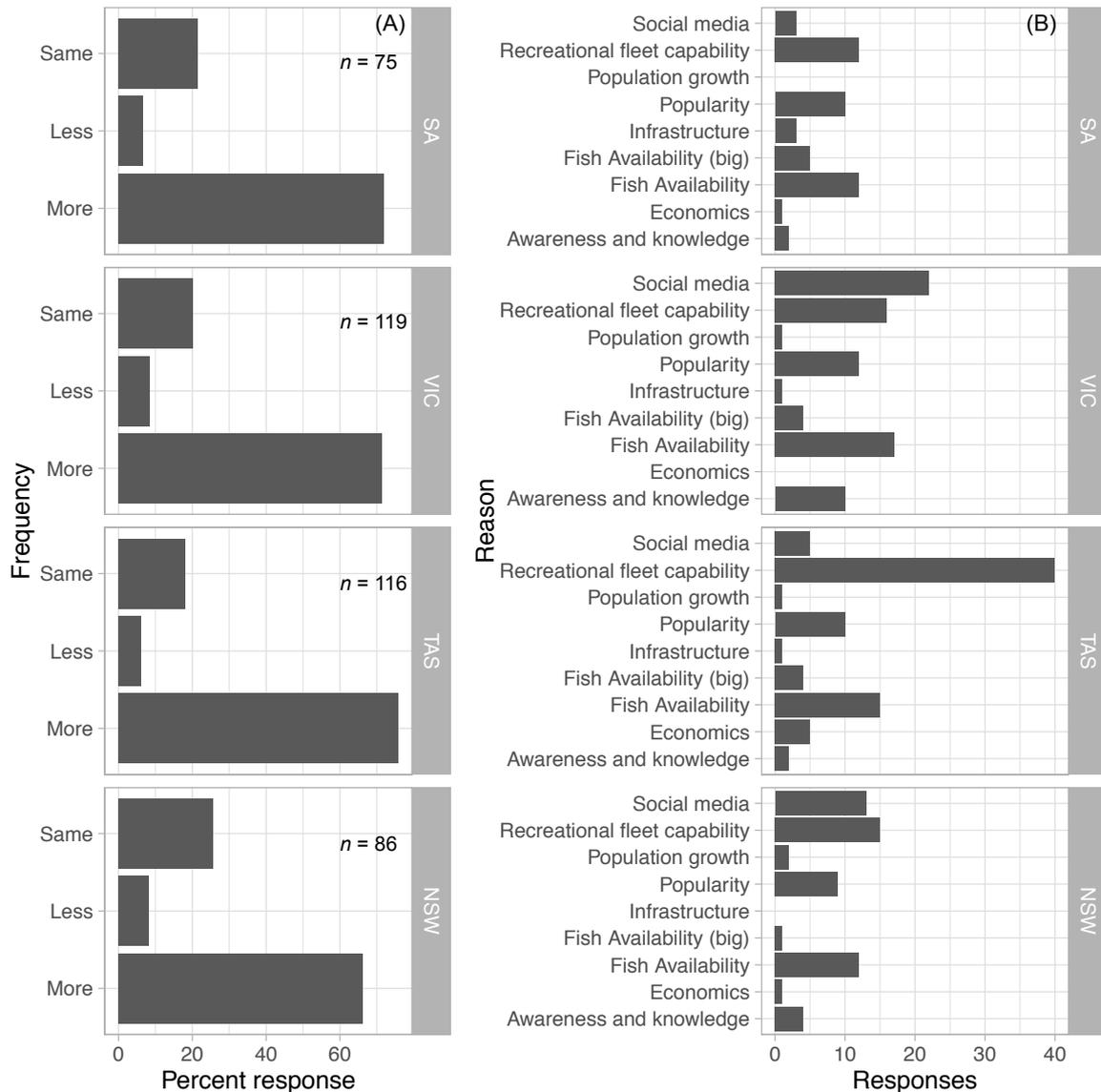


Figure 34. (A) Trends in recreational fishing effort for Southern Bluefin Tuna based on fisher perception and relevant to the main State in which the respondent fished. (B) Suggested reasons for effort increases, based on main State where respondent fished.

Most respondents considered that the availability of SBT to the recreational fisheries had either remained unchanged or increased over time, with fewer than 10% of respondents in each of the States other than New South Wales suggesting that availability had declined (Figure 35). There was a stronger perception that the availability of SBT to the Victorian fishery (60% of respondents) had increased when compared with the other States (typically less than 50% respondents) (Figure 35A). Twenty percent of respondents in New South Wales suggested that the availability of SBT had decreased, a response possibly reflecting what was regarded as a relatively ‘poor’ 2019 season for the species in New South Wales.

In each State, respondents identified management efforts as important factor contributing to increased availability (presumably linked to management efforts to rebuild SBT stocks), while environmental drivers were also identified as important contributing factors in the fisheries off Tasmania and New South Wales (Figure 35B).

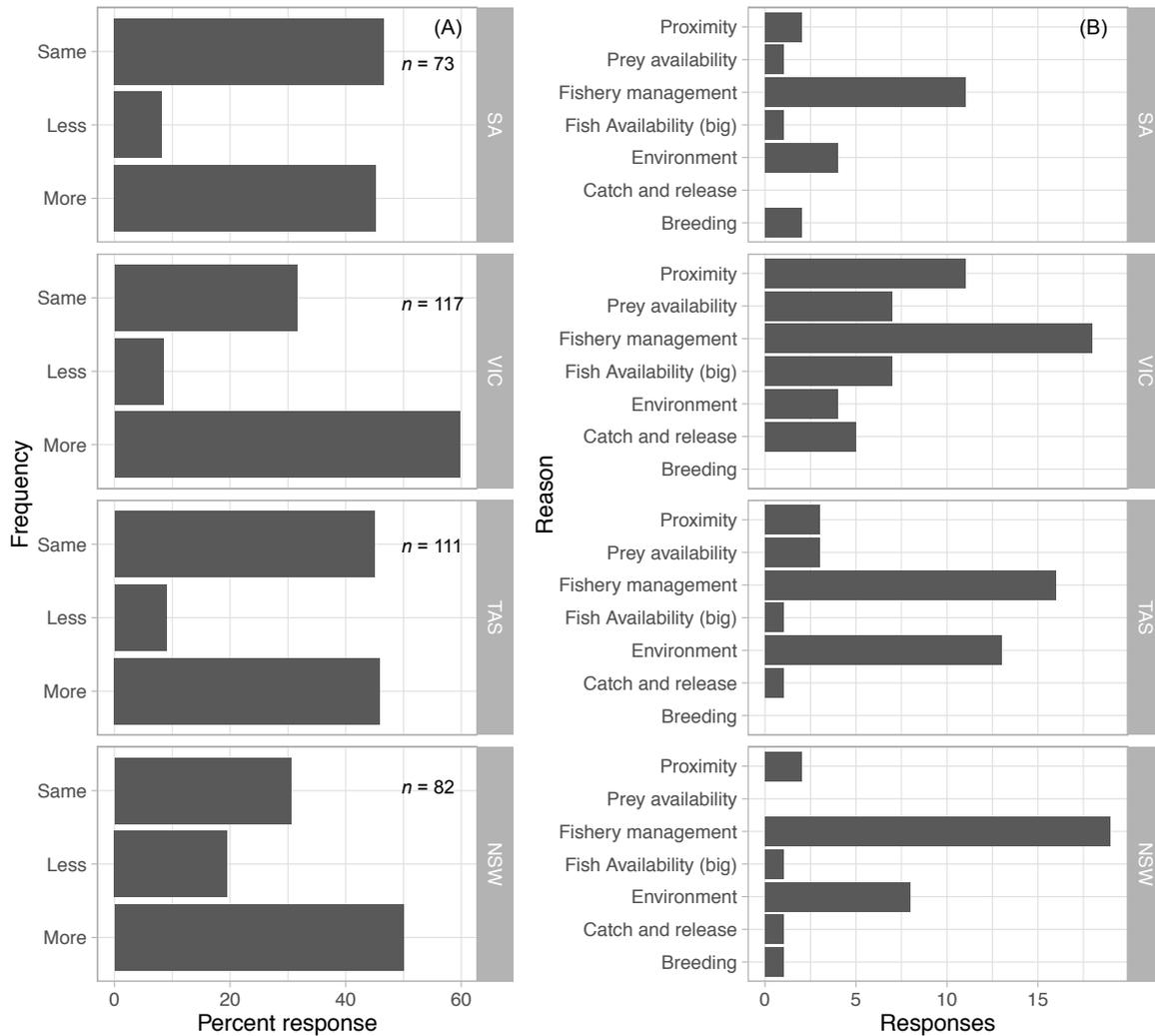


Figure 35. (A) Trends in availability of Southern Bluefin Tuna based on fisher perception and relevant to the State in which respondents had done most of their recreational fishing. (B) Suggested reasons for availability increase, based on main State where the respondent fished.

Overall, there was a general consensus from respondents that the quality of the recreational fishery for SBT had either improved (better) or at least not changed (same) in recent years (Figure 36A). Most Victorian fishers (61%) indicated that they considered that the quality of their fishery had improved, compared to just under half of the fishers from other States.

Relatively few respondents suggested that the quality of their fisheries had declined, with less than 8% of respondents in South Australia, Victoria and Tasmania and 15% in New South Wales. Not surprisingly, these results align closely with fishers’ perceptions regarding trends in SBT availability, highlighting the link between fish availability and fisher satisfaction (here expressed as fishing quality).

Availability of SBT (including availability of big fish) was in fact commonly mentioned as a reason for the improved quality of the fishery in all States (Figure 36B). Other experiential factors related to fishing were also mentioned, such as improved boat ramp facilities (especially in Victoria and Tasmania), improvements in fishing gear and fishing practices (especially in South Australia), general knowledge and respect for the fish and promotion of

catch and release. Interestingly, fisheries management, as a contributor to improved fishing quality was the most commonly mentioned factor by New South Wales respondents but only occasionally mentioned by fishers from the other States.

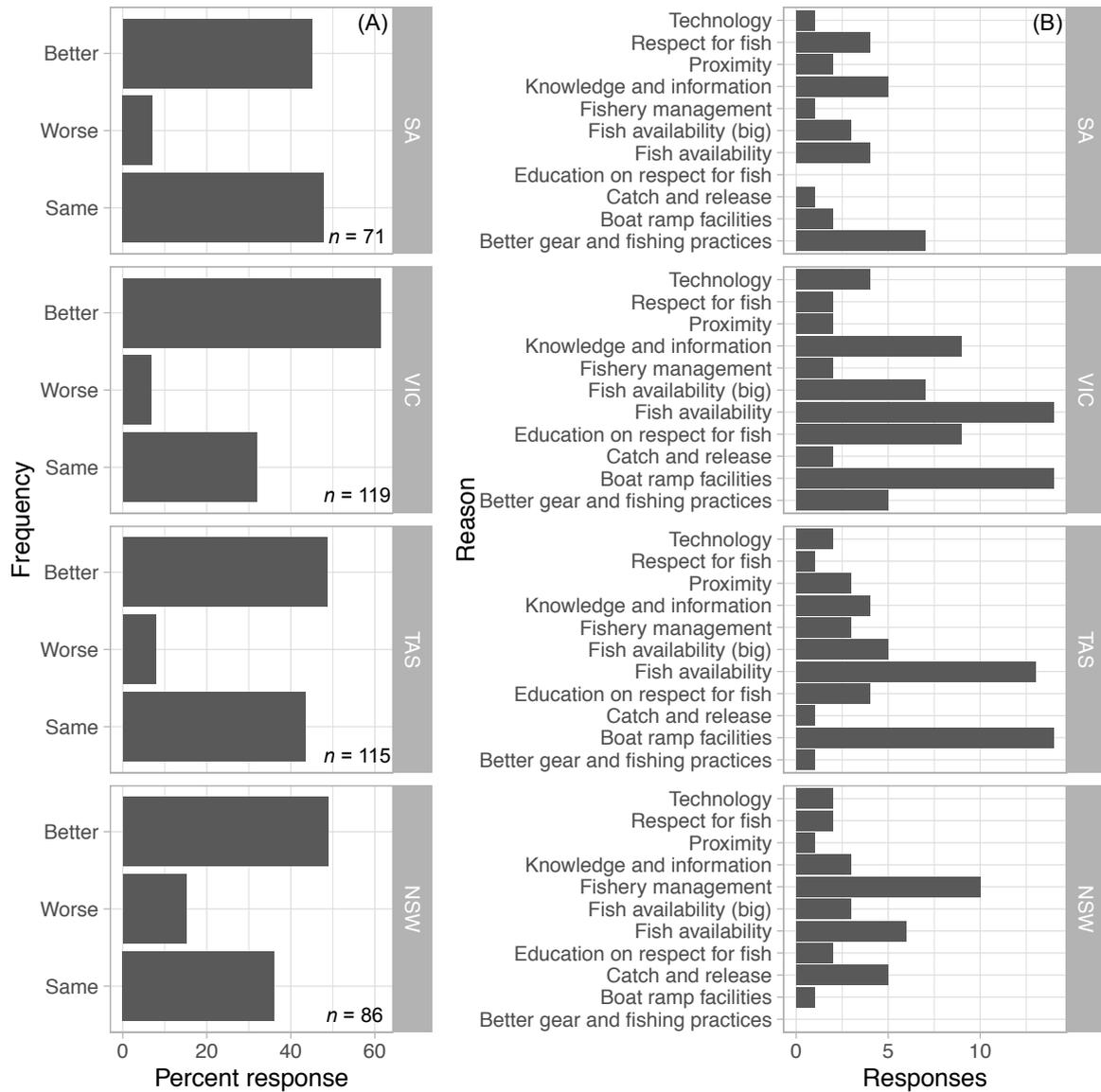


Figure 36. (A) Trends in recreational fishing quality for Southern Bluefin Tuna based on fisher perception and relevant to the main State where the respondent fished. (B) Suggested reasons for improvement in fishing, based on main State where the respondent fished.

8 Discussion

8.1 Historical context of the recreational fishery for Southern Bluefin Tuna in Australia and earlier relevant surveys

The history of recreational fishing for Southern Bluefin Tuna (SBT) in Australia dates back to the early 1900s (Roughley 1937, Roughley 1951, D’Ombrain 1957, Palmer 1984). Historical catches are thought to have peaked in the late 1970s before declining during the 1980s, although the quantity of catch is not reported (Caton 1994). The decline was most likely related to significant commercial overfishing in the decade preceding this period, which reduced the availability of fish in proximity to access points used by recreational fishers. During the last decade or so, the popularity and availability of trailer vessels suitable for fishing offshore, significant advances in fish finding and navigation equipment, and heavy fishing tackle coincided with an increasing availability of fish closer to the coastline. A resurgence in targeting SBT for a new generation of recreational fishers had begun.

8.1.1 Western Australia

The only known spawning area for SBT is in the north-eastern Indian Ocean between Indonesia and northern Western Australia (Caton 1991, Farley and Davis 1998). Adult fish are thought to forage in the temperate waters of the southern hemisphere during winter, before migrating to the tropical spawning grounds in spring/summer (Farley and Davis 1998, Patterson et al. 2008).

Juveniles leave the spawning grounds within a few months of hatching and move south along the continental shelf of Western Australia, appearing in the Great Australian Bight as one-year-olds in summer (Farley and Davis 1998). The zero-plus juveniles moving down the west coast of Australia are small fish, but their growth rate is fast attaining a size of approximately 50–60 cm fork length (FL) after one year, and between 70–90 cm FL after two years (Itoh and Tsuji 1996, Gunn et al. 2008).

In recent years, there have been no accounts of the large adults migrating to and from the tropical Indian Ocean spawning grounds being encountered by recreational fishers in Western Australia. Historically, there are reports of these larger specimens occurring off Albany in Western Australia during the summer months (Serventy 1941, D’Ombrain 1957, Parrott 1959), but these fish generally refused to take a hook, reportedly due to being in spawning condition (Parrott 1959).

Biennial monitoring of recreational catch from private boats in Western Australia began in 2011 (Ryan et al. 2013, Ryan et al. 2015, Ryan et al. 2017, Ryan et al. 2019). The biennial cycle means there is no estimate of recreational catch of SBT from Western Australia that aligns with the timing of the other States assessed as part of this survey. Considering this factor, the most recent estimate is used to represent the catch from Western Australia in the national total.

Since the first survey in 2011/12, the recreational catch of SBT has more than doubled, but has remained under approximately 10 t (Table 18). The most recent survey began in September 2017 and ran for 12-months (Ryan et al. 2019). A total of 1,823 SBT were retained, resulting in a harvest estimate of 7.66 t, with a further 872 released (Table 18). These juvenile fish are likely dominated by the zero-plus cohorts moving down the coast from the spawning grounds, with

the average weight reported as 4.2 kg (Ryan et al. 2019) based on reported lengths (converted to weights) in Tour Operator returns from 2002 to 2018. It is also worth noting that SBT were the second most frequently caught pelagic species by number and the fourth by weight for the recreational fishery in Western Australia in 2017/18 (Ryan et al. 2019).

Table 18. Retained catch of Southern Bluefin Tuna from Western Australia from state-wide boat-based surveys.

Survey Year	Estimated retained (n)	Estimated released (n)	Estimated harvest (t) ± SE	Charter retained catch (n)	Charter estimated harvest (t)
2011/12	889 ± 147	341 ± 117	4.95 ± 0.82	20	<0.1
2013/14	461 ± 93	202 ± 101	2.41 ± 0.49	8	<0.1
2015/16	2,009 ± 344	524 ± 159	9.76 ± 1.68	65	0.25
2017/18	1,823 ± 542	872 ± 264	7.66 ± 2.28	75	0.28

Most of the catch in Western Australia occurs along the southwest and south coasts, up to 62 and 30%, respectively. However, there is also a small catch reported from further north. Interestingly, there appears to be a gradual shift in the timing of peak catches in Western Australia. The majority of catches occurred in the autumn months from March to May in 2011/12 (71%) and 2013/14 (58%), but occurred earlier in the summer months from December to February in 2015/16 (44%) and 2017/18 (51%). The retained catch of SBT reported from the charter boat sector in Western Australia has not exceeded 0.5 t since reporting began in 2001/02 (Table 19).

Table 19. Catch of Southern Bluefin Tuna from the charter boat sector in Western Australia, as reported in Tour Operator Logbook Returns (West Australia DPIRD, unpublished data).

Financial Year	Retained catch (n)	Released catch (n)	Harvest weight (t)
2001/02	12	3	0.05
2002/03	5	4	0.02
2003/04	10	0	0.04
2004/05	21	1	0.08
2005/06	22	7	0.08
2006/07	28	2	0.11
2007/08	10	0	0.04
2008/09	83	3	0.31
2009/10	107	14	0.41
2010/11	90	24	0.34
2011/12	20	6	0.08
2012/13	56	5	0.21
2013/14	8	4	0.03
2014/15	13	0	0.05
2015/16	65	2	0.25
2016/17	42	0	0.16
2017/18	75	0	0.28

8.1.2 South Australia

The first SBT reported caught on rod and reel in South Australia was in 1936 by Jack Arthur, with the catch sent to the Melbourne Museum for species verification (Palmer 1984). In his game fishing memoirs, Messr Palmer A.O (1984) recalls seeing SBT swimming past the Glenelg and Brighton jetties in the Gulf St Vincent and numerous schools on a crossing to Kangaroo Island, presumably around the turn of the 19th century. Large adult fish were reportedly caught off Port Lincoln in the past (D’Ombrain 1957).

In more recent history, Port Lincoln became known as the main centre of recreational tuna fishing in South Australia, but by a small fleet due to the exposed waters and weather conditions (Caton 1994). Prior to the 1980s, there was some limited recreational fishing activity from Cape Jervis on the Fleurieu Peninsula, but progressive contraction of fish aggregations westwards led to recreational fishing for SBT ceasing in this area at the time. The population contraction also affected a small number of vessels fishing in the south east of the State, where an Easter fishing tournament targeting SBT occurred with approximately 20–30 trailer vessels participating (Caton 1994). A qualitative assessment of the recreational fishery in South Australia is reported by Caton (1994), with the catch thought to be no more than 20 t during this period and dominated by school fish of between 5–20 kg.

Since this time, information on the recreational SBT fishery is scarce. There have been intermittent surveys, but these were predominantly general recreational fishing surveys and not designed to provide robust results for niche species such as SBT. Some information is also available from the South Australian charter logbook monitoring program (Steer and Tsolos 2016, Rogers et al. 2017). South Australian recreational charter boat fishery operators have been required to be licensed since 2005. Retained catch data from the charter boat sector is reported from the 2007/08 financial year (Table 20). Charter catch of SBT in South Australia has increased from 2007/08, peaking at 2,393 retained SBT in 2015/16 (Table 20). SBT is reported to be increasing in importance as a catch for the charter sector in South Australia, particularly around the Fleurieu Peninsula and the southeast region (Steer and Tsolos 2016). In 2016/17, SBT was ranked the eighth most common species caught by number retained from the charter boat sector in the State (Rogers et al. 2017).

Table 20. Retained catch of Southern Bluefin Tuna from the South Australian Charter Boat Fishery. Data from 2007/08 to 2016/17 reported by Rodgers et al. (2017). ND = no data.

Financial Year	SBT retained
2007/08	554
2008/09	736
2009/10	1,035
2010/11	1,144
2011/12	1,552
2012/13	1,739
2013/14	1,824
2014/15	2,320
2015/16	2,393
2016/17	1,866
2017/18	ND
2018/19	1,918

The National Recreational and Indigenous Fishing Survey (NRIFS) in 2000/01 (Henry and Lyle 2003, Jones and Doonan 2005) was the first quantitative assessment of broadscale recreational fishing in South Australia, and provided an estimate of 'tuna' catch. Since then, two state-wide recreational fishing surveys have been conducted in South Australia, fundamentally repeating the method and coverage of the NRIFS. One was conducted in 2007/08 (Jones 2009) and most recently in 2013/14 (Giri and Hall 2015).

These surveys were conducted as off-site telephone-diary surveys using the whole population of the State as the sample frame. State-wide surveys delivered in this format provide statistics on participation in recreational fishing, and reliable estimates of catch for species frequently caught by the general recreational fishing population. For species caught less frequently, catch estimates tend to be less precise, as reflected in large relative standard errors associated with estimates (Beckmann et al. 2019). Game fishing species, such as SBT, are often poorly resolved in general fishing surveys due to the relatively rare nature of this mode of fishing (Tracey et al. 2013).

A re-analysis of the 2000/01 data estimated a total of 3,386 ($\pm 1,545$ SE)⁴ 'tunas' were retained in South Australia (Jones 2009), although the relative standard effort (RSE) was high at 0.46. As noted above though, state-wide surveys are not designed to provide precise catch estimates of niche fisheries such as game fishing. A further 2,778 ($\pm 2,656$ SE)² tuna were estimated to have been released, with an RSE of 0.96.

In 2007/08, the state-wide survey reported a total of 2,425 ($\pm 1,305$ SE)² 'tunas' harvested (RSE = 0.54), which is reported as a combined catch of SBT, Yellowfin Tuna (YFT) (*Thunnus albacares*) and Albacore (*Thunnus alalunga*) (Jones 2009). Given the distribution of these species in Australia, it is likely that these would be limited to SBT or Albacore. A further 2,988 ($\pm 1,792$ SE)² 'tunas' were released (RSE = 0.60). In the same year, the charter boat sector reported landing 554 SBT (Table 20), which would equate to a total harvest weight of approximately 10 t. Based on the survey method used in that year, the charter catch would be included in the recreational catch estimate provided by Jones (2009).

In 2013/14, there were an estimated 10,427 ($\pm 4,833$ SE) SBT retained (RSE = 0.46), equating to 151 t, based on an average individual weight of 14.5 kg. There was also 2,609 ($\pm 2,250$ SE) YFT reported retained (RSE = 0.86). It is highly likely that this expanded estimate is based on a species misidentification, since YFT are not known to inhabit the waters of South Australia, so are most likely to be SBT. A further 5,834 ($\pm 4,147$ SE) SBT were reported released (RSE = 0.71), and 251 (± 231 SE) YFT were reported released (RSE = 0.92). A total of 1,824 SBT were reported from the charter boat sector in the 2013/14 financial year (Table 20) which, based on the reported average weight from the survey, would equate to approximately 26 t. As discussed previously, the general population telephone-diary design used for the 2013/14 survey would include catch reported from the charter boat sector.

There has been one previous study specifically designed to estimate the recreational catch of SBT in South Australia, which was reported as 'a study to test a methodology for estimating

⁴ Errors are presented as 95% confidence limits in Jones (2009), they have been converted here to standard error (by dividing by 1.96) to aid comparison.

the recreational catch of SBT' (Moore et al. 2015). The seven-month on-site access-point study ran from 1 January to 2 August 2014. Of the estimated 61,989 recreational fishing trips conducted at the surveyed boat ramps during the survey period, only 0.7% of the trips were targeting SBT. It was estimated that 1,808 (± 690 SE) SBT were retained (RSE = 0.38), the equivalent of 29 (± 12 SE) tonnes (RSE = 0.41). In addition to this retained catch, 1,021 (± 230 SE) SBT were estimated to have been released (RSE = 0.22), resulting in a release rate of 36%. This survey mostly overlapped with the 2013/14 financial year and, as discussed above, the reported charter boat retained catch in this year was 1,824 individual SBT.

The relative precision of the estimates reported in Moore et al. (2015) represents an improvement from those reported during the state-wide surveys but nonetheless are still relatively high, rendering the results statistically unreliable (Table 21). It is reported that the imprecision arose due to very few anglers targeting SBT during the survey period. However, the reported charter boat catches for this year, and the upward trajectory of the charter catch across the years before and after that year, would suggest this may not be the case. Furthermore, based on the seasonality of SBT available to the recreational fishery in South Australia, this on-site survey was recording data from the same 'peak' season as the 2013/14 general fishing which began in December 2013 and ran for 12 months (Giri and Hall 2015). The latter survey, despite uncertainty in the catch estimates for SBT, reported a significantly higher catch (Table 21).

It is more likely that the low catch reported by the on-site access-point survey was due to limitations of the survey design. It is likely the sample fractions in some regions were too low to provide a reasonable probability of encountering a sufficient number of fishers targeting SBT. The large number of ramps surveyed, meant that resources were dispersed across the survey region, limiting the number of survey days covered in each spatiotemporal stratum combination. A simulation model, to assess the number of sample days required to increase the precision to a statistically acceptable level, indicated that at least 500 survey days would be required, an increase of 334 from those conducted (Moore et al. 2015).

These findings led to consideration of significantly increasing the number of sample days (751 conducted) as well as careful refinement, in consultation with regional experts, of the number of ramps that were included in this current study (reduced from 43 to 17). The objective was to optimise resources to ensure adequate sampling occurred in each survey region.

As a result, the precision of the estimates reported here are significantly lower for South Australia, with RSE values of 0.14, 0.13 and 0.19 for the number of SBT retained, the weight of SBT harvested and the number of SBT released respectively (Table 21). It is also worth noting that the variance around the average size of fish is integrated into the precision estimate of the weight of SBT harvested.

Table 21. Estimated catch, including a measure of precision (SE = standard error, RSE = relative standard error of estimate) of mixed tuna¹ and Southern Bluefin Tuna (SBT) from the recreational fishery in South Australia, as reported in five separate surveys.

Year	Number retained ± SE	Number retained (RSE)	Harvest weight (t)	Harvest weight (RSE)	Number released ± SE	Number released (RSE)
2000/01 ¹	3,386 ± 1,545	0.46	–	–	2,778 ± 2,656	0.96
2007/08 ¹	2,425 ± 1,305	0.54	–	–	2,988 ± 1,792	0.60
2013/14 ²	10,427 ± 4,833	0.46	151	–	5,834 ± 4,147	0.71
2014	1,808 ± 690	0.38	29 ± 12	0.41	1,021 ± 230	0.22
2018/19	5,203 ± 708	0.14	75.1 ± 9.7	0.13	1,458 ± 275	0.19

¹Catch in these years were reported generically as ‘tuna’. Given the distribution of tuna species found around Australia it would be reasonable to assume that the vast majority would be SBT and Albacore.

²Yellowfin tuna were reported caught in this survey but, given their distribution around Australia, this is most likely a species misidentification. They are most likely to be SBT, which would increase the total estimates reported for this year.

The NRIFS conducted in 2000/01 and the state-wide survey conducted seven years later, indicate the number of tuna estimated to have been harvested in South Australia in each of those years did not differ significantly (Table 21). However, the state-wide survey in 2013/14 indicated that the estimated catch of SBT had increased significantly by about three to four-times the retained estimate from the 2000s (Table 21). As discussed previously, general recreational fishing surveys such as these are not designed to provide precise estimates for niche fisheries or for species caught by a small proportion of recreational fishers. This is reflected in the high RSE values for each of these estimates, which would render them statistically unreliable.

The on-site access-point survey conducted in 2014 reported the lowest estimate of SBT harvested of all previous surveys, but was in the realm of reported estimates from 2007/08, assuming that all tuna reported in that survey were SBT (Table 21). The results reported in this study indicate a retained catch of approximately half of the largest catch reported in the 2013/14 state-wide survey (Table 21), considering the results of each would indicate significant inter-annual variability. However, it is important to recognise that the results of the earlier studies are statistically imprecise, and the variability could be an artifact of this uncertainty in the estimates.

8.1.3 Victoria

The game fishery in Victoria for SBT is possibly younger than in other southern States, although some of the earliest records of SBT are from Victoria including specimens caught in Bass Strait and adjacent to Portland, Queenscliff and Hobson’s Bay which is within Port Phillip Bay and close to the metropolitan centre of Melbourne (McCoy 1885).

There are early records of Victorian anglers venturing to the south coast of New South Wales to chase tuna in 1936, inspired by the exploits of famed fisher and writer, Zane Grey, who visited Bermagui in the same year (Lyne 1947). More recently, interest by anglers in fishing for SBT saw the formation of the Game Fishing Association of Victoria in 1976 and the Victorian Game Fishing Club shortly thereafter.

At the time the main fishery was operating out of Warrnambool, Port Fairy and especially Portland, focusing on school fish around 7–15 kg, with catch also reported from Mallacoota, on the far southeast coast of Victoria (Anon. 1981, Anon. 1983). Abalone divers operating out of Mallacoota were known to target and catch school-sized tuna in summer from the mid-1970s through to the early 1980s (*G. Booth, Pers. comm.*).

However, in 1984 SBT apparently disappeared from Victorian waters (*G. Booth, Pers. comm.*), likely due to the westward contraction reported by Caton (1994) that affected the availability of SBT in southeast South Australia. This scarcity of SBT lasted for close to 20 years, with only small episodic schools of SBT encountered during the 1990s and early 2000s, although few anglers were fishing out along the shelf break at this time due to limitations in electronic navigation equipment (*S. Gray, pers. comm.*). This anecdote was somewhat supported by the findings of the National Recreational and Indigenous Fishing Survey in 2000/01, where none of the Victorians participating in the survey reported any SBT catch from Victorian waters during the survey period. However, these Victorians did report some fishing for SBT in other States (Henry and Lyle 2003).

The recreational fishery for SBT in Victoria had a contemporary increase in popularity during the mid-2000s. The fishery again focused along the west coast of Victoria, particularly the main port of Portland (Gray 2006, Hobsbawn et al. 2007, Roswell et al. 2008). This resurgence in interest was sparked by the presence of large SBT in adjacent waters, with some high catch rates reportedly creating a spectacle in the regional town of Portland (Gray 2006).

In the same year a similar phenomenon was noted on the far south coast of Tasmania, including the remote rocky outcrops around Pedra Branca (*S. Tracey, pers. obs.*). Hobsbawn et al. (2007) report this 'good' season off Victoria in 2005/06 but do not quantify it in terms of catch. Around the same time, the maximum indicative estimate of national recreational catch was 85 t (Hobsbawn et al. 2007). With pelagic shark the primary gamefish target species in any abundance off Victoria during the previous decade, this SBT event invigorated the recreational game fishing community in Victoria.

This interest was also indicated by a number of recreational fishers from Victoria traveling to South Australia to target SBT, with a particularly large proportion of Victorian anglers fishing out of Port MacDonnell (Roswell et al. 2008). The trend was also identified in this study, with over 40% of the tuna fishing trips reported from Port MacDonnell in the survey period conducted by vessels from Victoria. Most of these trips occurred during August and September, a reasonably protracted period when large SBT were present in a defined area off Port MacDonnell.

From 2007 to 2009 there was a relatively consistent run of school fish off the southwest coast of Victoria in autumn months (*N. Dance, pers. comm.*). Then in 2010, in addition to the school fish, another run of very large SBT became available off Lady Percy Island, close to shore and not far from the Portland boat ramp. This run of fish again piqued the interest of game fishers in Victoria with large numbers of fishers traveling to Portland to get involved (Cooper 2016). In 2011, the very large fish returned but this time further east off Cape Otway, with fishers accessing the fish from Apollo Bay (Cooper 2016).

In 2011, an on-site access-point survey was conducted to estimate the recreational catch of SBT in Victoria (Green et al. 2012). A total of 1,924 interviews were conducted on 162 survey days. The survey ran for five months from March to July. During this period, an estimated 6,200 fishing trips were conducted, with an estimated 19,737 ($\pm 2,796$ SE) SBT kept, equating to 243 (± 31 SE) tonnes.

The design of the present study was fundamentally consistent with 2011 VFA survey, with both using on-site access-point methods across the same boat ramps. The differences relate to the survey duration, with the 2011 survey conducted over five months while the current survey ran for 12 months, as well as several nuances in the survey design. The 2011 survey applied secondary sampling units (SSU) as partial day shifts, with unequal probabilities weighted towards afternoon shifts relative to morning shifts. In contrast, the current survey applied whole-day shifts starting at 9:00 am and finishing when most, if not all, vessel trailers were accounted for.

On busy days during the 2011 survey, time constraints prevented the creel clerks from interviewing every returning boat, so they were instructed to systematically sub-sample every second or third boat for interview, and trailer counts were used as a proxy for the number of completed trips during the shift. In the current study, an additional creel clerk would assist on busy days to eliminate the potential for missed interviews. In addition, creel clerks were instructed to forego collecting ancillary information such as region fished, owner postcode and the measuring of fish and to prioritise, as a minimum, collecting information from every boat on whether the trip was a tuna fishing trip, how many they had caught and released and the number of fishers on board. These modifications reduce the degree of extrapolation of primary survey data.

Finally, the 2011 survey applied a modified access-point survey design with characteristics similar to a bus route survey for Port Fairy and Warrnambool, whereas the current survey design considered ramps as individual strata within the southwest Victorian region. This modification further reduced the reliance on extrapolation to address missing data.

Table 22. Catch and effort estimates of recreational Southern Bluefin Tuna fishing in Victoria. Previous year's data (2011) reported in Green et al (2012).

Year	Number retained \pm SE	Number retained (RSE)	Harvest weight (t)	Harvest weight (RSE)	Number released \pm SE	Number released (RSE)
2011	19,737 \pm 2,796	0.14	243.0 \pm 30.7	0.13	6,942 \pm 1,483	0.21
2018/19	2,945 \pm 450	0.15	55.6 \pm 8.0	0.14	1,315 \pm 285	0.12

The estimated number of boat days decreased between the two surveys, from 6,184 (± 794 SE) boat days (RSE = 0.13) to 5,001 (± 444 SE) boat days (RSE = 0.09). The regional contribution of measured effort was consistent between the two surveys, with 83% in 2011 and 82% in 2018/19 occurring from Portland. Beyond the decrease, the greatest difference was in the estimated catch between the two surveys. A simple catch rate comparison indicates an average of 4.3 (3.2 retained) SBT were caught on each boat day in 2011, while an average of 0.86 (0.6 retained) SBT were caught on each boat day during the 2018/19 survey.

It is likely that the main reason for the significant difference between the harvest estimates in the two surveys is due to a change in the dynamic of the fishery. Discussion with a charter operator with extensive experience (since 2008) in the SBT fishery in western Victoria suggests the fishery has changed over the last 10 years.

A decade ago, the excitement of both large and school-sized SBT becoming available after a long period of absence along the west coast of Victoria created a 'buzz', but this has now subsided. The fishers that are still traveling to the west coast to catch tuna are also releasing more fish than before. This is particularly the case for fishers focusing on catching trophy size fish. These fishers now release a lot of the school fish they catch, rather than harvesting them as they would have in the past (M. Hunt, *Pers. comm.*).

While the 2011 survey did not indicate the number of 'successful' trips, defined as at least one SBT caught, it was noted that the reason for release was driven primarily (79% of reported releases) by fishers reaching the Victorian bag limit of two tuna per day per angler. Few anglers were releasing SBT because they were unwanted or because they were practicing catch and release. The resulting release rate was 25% across the surveyed boat ramps.

In this study only 5% of all tuna fishing trips reached the State catch limit. Furthermore, of the 26% of tuna fishing trips that were 'successful' in catching at least one SBT, only 19% of these trips took the State catch limit. The release rate across the surveyed ramps in Victoria increased by 6% from the previous survey to 31%. However, it was not asked so is not clear whether people were unable to catch enough fish to reach the catch limits or they chose to keep fewer fish to only accommodate their needs. While a tendency to only harvest fish to accommodate a crew's needs could partly account for the significant decline in catch rate, fish availability and catchability are also likely to play a role. Another contributing factor was that most effort conducted during the tail season was likely to be targeting large SBT at a time when school sized fish were scarce, and this resulted in a lower proportion of successful trips (11%).

Victoria does not have a mandatory logbook program in place for its charter fishing sector. However, previous surveys have provided estimates of the average number of days per operator at 55.2 and 55.6 days in 2011 and 2012 respectively, with the latter based on interviews with 18 operators reported to comprise all operators active in Portland in that year (Deloitte 2013). The decrease in private trailer-vessel effort for 2018/19 is also reflected in the charter boat sector, with the average number of charter days per operator down 50% to an average of 22 days per operator in 2018/19.

In 2014, a trial was undertaken to determine if a voluntary logbook would provide adequate information of SBT catch from charter vessels in Victoria (Moore et al 2015). While 14 operators were identified and six agreed to participate in the trial, only two operators fully completed the logbook. The time burden of completing the logbook was identified as the primary reason for lack of completion by participants. In the current study, operators were incentivised, and creel clerks were present at ramps where many operators returned for the day, enabling increased encouragement to complete the logbooks. As a result, 21 operators completed the logbooks in 2018/19, with a total of 2,640 SBT retained, equating to 27.0 t retained catch (Table 23).

Only 305 retained SBT were recorded in 2014. While the sample size for the 2014 study is small, the release rate of SBT on charter trips appeared to considerably decrease, from 28% in 2014 to 7% in 2018-19 (Table 23). Timing of peak catches was similar between studies, with catch rates high in May and June, before decreasing in July. Of all trips, 40% reported catch limits being reached in 2018/19.

Table 23. Catch estimates of recreational Southern Bluefin Tuna fishing from charter vessels in Victoria.

Survey year	Participating operators (n)	SBT retained (n)	SBT retained (t)	SBT released (n)
2014*	2	305	ND	119
2018/19	21	2,640	27.0	189

**2014 is incomplete data as only two operators participated in the voluntary logbook program.*

8.1.4 Tasmania

Recreational fishing for SBT has a long history in Tasmania, with the formation of the Tasmanian Game Fishing Association in 1956, and the formation of The Tuna Club of Tasmania in 1960 which had a membership of 110 persons by 1961 (Anon. 1961). It was reported that an estimated 100–200 SBT and striped tuna were captured by club members in 1961 and, while not clear how many were SBT, at least 23 were recorded on the official list of captures. These fish ranged from 13–70 kg with most caught off the Tasman Peninsula and some off Maria Island on the east coast (Anon. 1961).

A charter boat operator based at Eaglehawk Neck on the Tasman Peninsula in southeast Tasmania recorded his daily SBT catches from 1965. He initially recorded high catch rates of between three and 15 fish per day, rapidly declining towards the end of the 1970s, with no SBT reported caught in 1984. As the international quotas were applied around this time, he reported an increase in catch rates but at a far lower level (0.5–4.8 fish a day) than prior to the fishery collapse (Caton 1994). It was thought that around this time there about 50 boats in the recreational fishery, with the annual catch unlikely to exceed 25 t (Caton 1994).

In 1993, the estimated catch of SBT by charter operators in Tasmanian waters was 12.5 tonnes (678 fish) (Smith 1994), almost double the catch of 6.9 tonnes (295 fish) taken the following year (Evans 1995). Evans (1995) established that SBT accounted for just 2% of the tuna catch (all species) by number from north of Bicheno, compared to 26% of the catch taken to the south of Bicheno. However, charter vessels represent just one component of the recreational fishery, with a significant proportion of the catch caught by fishers from privately operated vessels.

The NRIFS in 2000/01 reported a total harvest of 12,700 tuna in Tasmania in the survey period (Henry and Lyle 2003). However as previously mentioned, National and State-based recreational fishing surveys that use broad total population frameworks are ineffective in providing precise estimates for niche fishing modes, such as game fishing. In the NRIFS case, this is reflected in the large RSE of 0.42.

Although indicative, it was reported that SBT accounted for about 12% of all tuna caught, or approximately 1,500 individuals (Table 24). A creel survey in the year preceding the NRIFS, reported the average size of SBT to be 28 kg, noting that some large fish were also measured (Lyle and Campbell 1999). This would equate to a harvest of approximately 42 t. Albacore was

the dominant species reported in the NRIFS, accounting for 74% of all tuna caught in Tasmania with Skipjack Tuna accounting for the difference (Henry and Lyle 2003).

A further three state-wide recreational fishing surveys have been conducted in Tasmania since the NRIFS. These were in 2007/08 (Lyle et al. 2009), 2012/13 (Lyle et al. 2014) and 2017/18 (Lyle et al. 2019). Catch estimates of SBT caught fluctuated between the survey years, with approximately 1,050, 450 and 2,500 fish retained in 2007/08, 2013/14 and 2017/18 respectively (Table 24). However, it should be noted that these surveys are not designed to provide precise estimates for species caught by a small proportion of all recreational fishers, which is reflected in the comparatively large relative standard error (RSE) values ranging from 0.37–0.48 for retained catch. While these estimates are not particularly robust, they do concur with the order of magnitude of catch from Tasmania reported by other survey methods.

There have been three previous studies focusing on game or offshore fishing with a focus on SBT. The first used a combination of an on-site access-point survey in April and May 2003 at the Pirates Bay boat ramp on the Tasman Peninsula in southeast Tasmania, an angler logbook provided to all game fishing club members, and a charter boat logbook (Morton and Lyle 2003).

A conservative harvest estimate of 112 SBT (approximately 2.5 t) was reported, but some limitations with the methods were noted (Table 24). It is also noted in Morton and Lyle (2003) that inferences derived during interviews suggested the SBT catch in the previous year (2002) was approximately 10 times greater (25 t) than in the survey year. The factors that may have contributed to the particularly poor season in 2003 were not reported (Morton and Lyle 2003).

Table 24. Estimated catch of SBT in Tasmania, including a measure of precision (SE = standard error, RSE = relative standard error) when provided in original source.

Year	Number retained ± SE	Number retained (RSE)	Harvest weight (t)	Harvest weight (RSE)	Number released ± SE	Number released (RSE)
2000/01 ¹	1,500	0.42*	42.0	–	–	–
2003	112	–	2.5	–	–	–
2007/08 ³	1,076 ± 400	0.37	–	–	409 ± 369	0.90
2008 ²	480 ± 62	0.13	17.9 ± 1.8	0.10	77	–
2011/12 ²	3,242 ± 498	0.15	59.9 ± 9.2	0.15	1,035 ± 325	0.31
2012/13 ³	484 ± 232	0.48	–	–	0	–
2017/18 ³	2,511 ± 925	0.37	–	–	830 ± 554	0.67
2018/19	2,975 ± 328	0.11	40.4 ± 5.4	0.11	1,223 ± 230	0.19

¹Catch in this survey was reported generically as 'tuna', the estimated number retained is based on SBT accounting for 12% of tuna catch in the report (Henry and Lyle, 2003). *The RSE is for all tuna caught. The harvest weight is calculated on the average weight of SBT reported during a creel survey in the previous year (Lyle and Campbell 1999).

²Error around the estimates in these survey years were modelled unequal 95% confidence intervals (CI). To aid comparison with other survey years, they were converted to standard error by calculating the average CI for each estimate then dividing by 1.96.

³Results from state-wide surveys conducted at 5-year intervals in Tasmania (Lyle et al. 2009, Lyle et al. 2014, Lyle et al. 2019). Note that the data presented in this table specific to retained and released catch of SBT is unpublished results.

The second targeted survey was conducted in 2008, also implementing an on-site access-point survey. Sampling was conducted between April and June, inclusive, at both the Pirates Bay boat ramp in southeast Tasmania and Southport in the south of the State (Forbes et al 2008). A charter boat logbook was also used in the survey year. It was estimated that 347 SBT were retained by private boats, equating to a harvest weight of 10.1 t. A further 133 (3.9 t) were retained by the charter boat sector (Table 25), but it was noted that not all operators participated, so catch from this sector is a minimum estimate. The total estimate from this survey period was 14.0 t (95% CI = 10.6 – 17.7) (Forbes et al. 2009). A total of 77 SBT were estimated to have been released across both sectors, resulting in a release rate of 14%.

Table 25. Catch effort estimates of Southern Bluefin Tuna fishing from charter vessels in Tasmania.

Financial Year	Operators reporting SBT	Number of trips (n)	SBT retained (n)	SBT harvest (t) ± SE	SBT released (n) & (release rate)
2008	6	78	133	3.9	29 (18%)
2012/13	8	272	937	17.8	153 (14%)
2018/19	14	240	501	8.0	354 (41%)

The third targeted survey was the Tasmanian offshore recreational fishing survey conducted in 2011/12, which used multiple survey methods, but based overall results on a 12-month longitudinal survey (November 2011 to October 2012) (Tracey et al 2013). The current survey fundamentally replicated this method. A voluntary charter boat logbook was also distributed to all operators likely to do game fishing charters. The 12-month telephone-diary survey estimated 3,243 (95% CI = 2,321–4,272) SBT were retained by private vessels, equating to 59.9 t (95% CI = 42.8–78.9).

The charter sector reported a further 937 SBT retained, equating to 17.8 t and a total harvested catch from the recreational sector of 77.7 t. A further 1,035 (95% CI = 486–1,762) were estimated to have been released by private vessels (release rate = 24%) and 153 from charter vessels (release rate = 14%). This survey was also the first to assess predation on SBT by fur seals during the fish capture event, with depredation resulting in fishing-related mortality for 1,325 (95% CI = 749–1,978) SBT equating to 24.9 t (95% CI = 13.9–38.0) (Tracey et al. 2013).

Since the NRIFS in 2000/01, there appears to have been significant variability in the estimated catch of SBT in Tasmania in the years an estimate has been produced (Table 24). However, it is important to note that the methods used vary greatly, with the NRIFS not designed to provide robust estimates of SBT and the on-site surveys in 2003 and 2008 conducted at a limited number of access points and only over part of the year. It is highly likely that those two years were poor relative to more recent estimates, with anecdotal reports corroborating this.

The two most recent surveys are the most comparable, indicating a downturn in retained harvest of approximately 30 tonnes. Release rates increased considerably in the most recent study, from 14% in 2012–13 to 41% in 2018–19. It is likely that this change may have been driven, in part, by the introduction in 2015 of a boat-limit of four SBT, and a maximum of only two SBT over 1.5 m in length allowed in Tasmania.

Interactions with fur seals as a source of mortality of SBT while being retrieved during a fishing event in Tasmania was first quantified in the 2011/12 study (Tracey et al. 2013). The

percentage of total fishery-induced mortality accounted for by depredation between the 2011/12, and this study is remarkably consistent at 29% and 31% by number respectively, or 29% for both by weight. Records of interactions between fur seals and the SBT recreational fishery in Tasmania are available from 1980, with charter boat logbooks specifically distributed to assess 'seal interference' by the Tasmanian Fisheries Development Authority (IMAS, unpublished records). The logbooks indicate that seal interactions, including damaged landed fish and fish taken by the seals, occurred reasonably regularly at the time.

8.1.5 New South Wales

The first tuna caught on rod and line in New South Wales was reported from 1900 in Sydney's Middle Harbour (Harpur 1902). The fish was originally called a Bonito, but Dr Julian Pepperell later identified it as a Longtail Tuna (*Thunnus tonggol*) (McIntyre 2011). In 1907, large schools of SBT ranging in length from five to seven feet were present in the immediate vicinity of Port Hacking and Port Jackson, with one taken by harpoon by a party in pursuit of porpoises (Stead 1908).

From as early as 1936, the southern coast of New South Wales has been an important recreational fishing area for SBT (Roughley 1937, Roughley 1951, D'Ombraïn 1957). Early records describe 'second season' fish appearing adjacent to Bermagui where they remained abundant until November (D'Ombraïn 1957). Troll fishing generally occurred on the Continental Shelf, with fish ranging in size from 7–15 kg across the season from July/August to January (Caton 1994). Caton speculated that the recreational catch in New South Wales may have been in the order of 50–100 tonnes in the 1970s. Gamefishing clubs then report a near cessation of catches after 1980, with the absence persisting until at least 1991, when small scattered catches were taken again by recreational angler in some of the traditional areas (Caton 1994).

A review and compilation of game fishing club annual records identified that the first SBT was weighed and recorded by a club in New South Wales in 1937 (J. Pepperell, *unpublished data*). Until 2009, the number of SBT recorded each year rarely made it over double-digits, with a peak of 32 fish reported in 1977. The size of fish recorded was generally less than 10kg up to 1998, with the odd fish between 20–25 kg. From 2001 to 2008, most fish were greater than 20 kg, and then in 2009 there was a jump to most fish weighing greater than 60 kg. At the same time, the number of fish reported each year increased, with approximately 30 fish weighed in 2009 and again in 2010, and a peak of 78 weighed in 2011. This is likely to have been when the contemporary resurgence of SBT fishing commenced in New South Wales, with vessels traveling further to sea and often beyond the continental shelf when the larger fish congregate.

This fishery in New South Wales continues to occur much further offshore than in other States, with fishers often having to travel up to 100 km offshore to access SBT (Moore et al. 2015). This has only been the case for approximately the last decade or two, and has been made possible by the vast improvements in navigation equipment available for use on recreational fishing vessels. Fishing for SBT predominantly occurs in the southern half of the State from the southern port of Eden, with some fish occasionally caught as far north as Newcastle. Other major points of access along the coast include Bermagui, Batemans Bay, Narooma, Ulladulla, Jervis Bay, Wollongong and Kiama (Moore et al. 2015).

A re-analysis of the NRIFS data for fishing in 2000/01 indicated a total tuna catch of 108,445 ($\pm 47,962$ SE) (West et al. 2015). Of these, 94,281 ($\pm 47,496$ SE) were reported retained, resulting in a release rate of 13%. While there is no indication of the species composition, based on the results of the 2013/14 survey reported below it is likely that a large proportion are small sub-tropical/tropical tunas which are often caught in large numbers and used as bait for a range of other fishing activities, including targeting larger game fish species.

A state-wide survey conducted in 2013/14, using a similar phone-diary off-site survey methodology to the NRIFS, reported 46,333 ($\pm 24,191$ SE) tuna caught and kept, resulting in an RSE of 0.52 with a further 10,714 ($\pm 4,953$ SE) released, RSE = 0.46 (West et al. 2015). The catch was dominated by Bonito (*Sarda spp.*), accounting for 84% of all tuna caught. Albacore (*Thunnus alalunga*) and Mackerel Tuna (*Euthynnus affinis*) accounted for about 8% and the remainder were reported as Longtail Tuna (*Thunnus tonggol*) and Skipjack Tuna (*Katsuwonus pelamis*).

All these species are considered sub-tropical or tropical species. The smaller species are abundant in New South Wales waters and often used as bait for targeting larger gamefish species. This may explain the relatively low release rate of approximately 19%. No SBT were reported during this state-wide survey (West et al. 2015).

Charter boat records were provided by New South Wales DPI for 2016–2019, only a small number of SBT have been reported by the charter sector over this period (Table 26).

Table 26. Number of Southern Bluefin Tuna reported retained by the charter sector in New South Wales, in charter boat logbook returns.

Year	Retained catch (n)
2016	1
2017	31
2018	65
2019	0

The release rate of SBT reported in this current survey was particularly high relative to the other States. New South Wales has the lowest personal catch limit in Australia, at one SBT per person per day. This factor is likely to contribute to the high release rate of SBT in New South Wales.

8.2 Other sources of mortality

Previous surveys have estimated release rates of SBT at 24% for Tasmania (Tracey et al. 2013) and 26% for Victoria (Green et al. 2012). Comparatively, release rates in 2018/19 were slightly higher, at 26% and 30% for the Tasmanian and Victorian fisheries, respectively. Nationally, and including catch from both private vessels and charter boats, the overall release rate was 28%. Note that this estimate excludes South Australian charter catches, since no estimate was available for released catch.

Post-release mortality represents an additional source of fishery-related mortality (Bartholomew and Bohnsack 2005, Arlinghaus et al. 2007, Cooke and Schramm 2007). In Australia, post-release survival (PRS) associated with catch and release of recreationally-caught

SBT has been estimated to be at least 83% (95% confidence interval: 75.9–90.7%) (Tracey et al. 2016). For that study, released fish were removed from the water to obtain a blood sample, to assess physiological condition, and to apply a satellite tag to the musculature. This additional handling is likely to have resulted in further stress and potentially impacted survival, so the reported PRS rate is considered to represent a minimum value.

Studies assessing PRS of recreationally-caught juvenile Atlantic Bluefin Tuna (*Thunnus thynnus*) that were brought onboard and rapidly tagged and released, reported 100% survival (Marcek and Graves 2014). A further study assessing PRS of very large Atlantic Bluefin Tuna caught using recreational fishing methods and tagged boat-side rather than on-board reported a survival rate of 97% (Stokesbury et al. 2011). These results suggest a high survival rate of released bluefin tuna, particularly if the fish are left in the water and handled with care.

Depredation by predators appears to be a very minor contribution to recreational fishery-related mortality in each of the mainland States reporting catches of SBT. However, in Tasmania predation by fur seals appears to be a significant contributor to mortality (Tracey et al. 2013, Cummings et al. 2019). In this study depredation accounted for an estimated 17.8 t (\pm 3.8 SE) nationally, of which the vast majority was from seal predation in Tasmania.

9 References

- Abbott, J. K. (2015). Fighting over a red herring: The role of economics in recreational-commercial allocation disputes. *Marine Resource Economics* **30**(1): 1 – 20.
- Anon. (1961). The Tuna Club of Tasmania Newsletter.
- Anon. (1981). Victorian Game Fishing Club Annual report 1980-81.
- Anon. (1983). Victorian Game Fishing Club Annual report 1982-83.
- Arlinghaus, R., S. J. Cooke and I. G. Cowx (2010). Providing context to the global code of practice for recreational fisheries. *Fisheries Management and Ecology* **17**(2): 146 – 156.
- Arlinghaus, R., S. J. Cooke, J. Lyman, D. Policansky, A. Schwab, C. Suski, S. G. Sutton and E. B. Thorstad (2007). Understanding the complexity of catch-and-release in recreational fishing: an integrative synthesis of global knowledge from historical, ethical, social, and biological perspectives. *Reviews in Fisheries Science* **15**(1-2): 75 – 167.
- Bartholomew, A. and J. A. Bohnsack (2005). A review of catch-and-release angling mortality with implications for no-take reserves. *Reviews in Fish Biology and Fisheries* **15**(1-2): 129 – 154.
- Basson, M., A. J. Hobday, J. P. Eveson and T. A. Patterson (2012). Spatial interactions among juvenile Southern Bluefin Tuna at the global scale: A large scale archival tag experiment. FRDC Report 2003/002. Hobart, 347pp.
- Beckmann, C., S. Tracey, J. Murphy, A. Moore, B. Cleary and M. Steer (2019). Assessing new technologies and techniques that could improve the cost-effectiveness and robustness of recreational fishing surveys. Proceedings of the national workshop, Adelaide, South Australia, 10-12 July 2018. South Australian Research and Development Institute (Aquatic Sciences). South Australia, 46pp.
- Caton, A. E. (1991). Review of aspects of southern bluefin tuna biology, population and fisheries. Inter-American Tropical Tuna Commission, La Jolla, CA. special report 7, 181-357pp.
- Caton, A. E. (1994). Commercial and recreational components of the southern bluefin tuna (*Thunnus maccoyii*) fishery. Pp 344-369. In R.S. Shomura, J. Majkowski and S. Langi (eds) Interactions of Pacific tuna fisheries. Proceedings of the first FAO Expert Consultation on Interactions of Pacific Tuna Fisheries. 3-11 December 1991, Noumea, New Caledonia. Vol. 2: Papers on biology and fisheries. FAO Fisheries Technical Paper No. 336, Vol. 2. FAO, Rome.
- CCSBT (2014). Report of the extended scientific committee for the nineteenth meeting of the scientific committee. 115pp.
- CCSBT (2019). Report of the twenty sixth annual meeting of the commission. 103pp.
- Cochran, W. G. (1977). Sampling techniques. 3rd edition. Wiley. New York, 448pp.

Cooke, S. J. and H. L. Schramm (2007). Catch-and-release science and its application to conservation and management of recreational fisheries. *Fisheries Management and Ecology* **14**(2): 73 – 79.

Cooper, S. (2016). Boiled lollies to chocolates: Victoria's tuna industry. Sportshounds.com.au.

Cox, S. P., C. J. Walters and J. R. Post (2003). A model-based evaluation of active management of recreational fishing effort. *North American Journal of Fisheries Management* **23**: 1294 – 1302.

Cummings, C. R., M. A. Lea and J. M. Lyle (2019). Fur seals and fisheries in Tasmania: an integrated case study of human-wildlife conflict and coexistence. *Biological Conservation* **236**: 532 – 542.

Curtis, J., S. Hynes, P. O'Reilly and B. Breen (2017). Recreational angling tournaments: participants' expenditures. *Journal of Sport & Tourism* **21**(3): 201 – 221.

D'Ombrain, A. (1957). Game fishing off the Australian coast. Angus and Robertson. Sydney, 230pp.

Deloitte (2013). Assessing the economic value of the 2012 Victorian recreational Southern bluefin tuna fishery in Portland. Study for the Victorian Department of Environment and Primary Industries. Melbourne, Victoria.

Edwards, C., A. Williams and S. Hoyle (2016). Updated estimates of Southern Bluefin Tuna Catch by CCSBT Non-Member States. CCSBT-ESC/1909/BGD 03.

Evans, B. S. (1995). Tasmanian tuna charter fishery - update, season 1994 Department of Primary Industry and Fisheries, Tasmania., Hobart.

Ezzy, E., H. Scarborough and A. Wallis (2012). Recreational value of Southern Bluefin Tuna fishing. *Economic Papers: A journal of applied economics and policy* **31**(2): 150 – 159.

Farley, J. H. and T. L. O. Davis (1998). Reproductive dynamics of southern bluefin tuna, *Thunnus maccoyii*. *Fishery Bulletin* **96**(2): 223 – 236.

Forbes, E., S. Tracey and J. Lyle (2009). Assessment of the 2008 recreational gamefish fishery of southeast Tasmania, with particular reference to southern bluefin tuna. Tasmania Aquaculture and Fisheries Institute, Hobart. 23pp.

French, R. P., J. Lyle, S. Tracey, S. Currie and J. M. Semmens (2015). High survivorship after catch-and-release fishing suggests physiological resilience in the endothermic shortfin mako shark (*Isurus oxyrinchus*). *Conservation Physiology* **3**: OV44 – OV44.

Georgeson, L., A. Moore, P. Ward, N. Stenekes, R. Kancans, K. Mazur, R. Curtotti, S. Tracey, J. Lyle, S. Hansen, M. Chambers, M. Finn, P. Gooday and I. Stobutzki (2015). A framework for regular national recreational fishing surveys. ABARES technical report. Canberra, 128pp.

- Giri, K. and K. Hall (2015). South Australian Recreational Fishing Survey 2013/14. Fisheries Victoria Internal Report Series No. 62. 65pp.
- Gray, S. (2006). Giant Blues. Sport fishing marine and trailer boats. Australian Fishing Network, Victoria 20 – 25.
- Green, C., P. Brown, K. Giri, J. Bell and S. Conron (2012). Quantifying the recreational catch of southern bluefin tuna off the Victorian coast., Department of Primary Industries, Victoria, Recreational Fishing Grant Program - Research Report, 29pp.
- Grewe, P., N. Elliott, B. Innes and R. Ward (1997). Genetic population structure of southern bluefin tuna (*Thunnus maccoyii*). *Marine Biology* **127**: 555 – 561.
- Gunn, J. S., N. P. Clear, T. I. Carter, A. J. Rees, C. A. Stanley, J. H. Farley and J. M. Kalish (2008). Age and growth in southern bluefin tuna, *Thunnus maccoyii* (Castelnau): Direct estimation from otoliths, scales and vertebrae. *Fisheries Research* **92**(2): 207 – 220.
- Harpur, F. M. (1902). Leaves from a Sydney angler's note book. W.M. Madgwick & Sons. Sydney.
- Hartill, B. W., M. Cryer, J. M. Lyle, E. B. Rees, K. L. Ryan, A. S. Steffe, S. M. Taylor, L. West and B. S. Wise (2012). Scale- and Context-Dependent Selection of Recreational Harvest Estimation Methods: The Australasian Experience. *North American Journal of Fisheries Management* **32**(1): 109 – 123.
- Hartog, J. R., A. J. Hobday, R. Matear and M. Feng (2011). Habitat overlap between southern bluefin tuna and yellowfin tuna in the east coast longline fishery – implications for present and future spatial management. *Deep Sea Research Part II: Topical Studies in Oceanography* **58**(5): 746 – 752.
- Henry, G. W. and J. M. Lyle (2003). The national recreational and indigenous fishing survey. Canberra, FRDC project no: 99/158, 188pp.
- Hobday, A. J. (2005). Southern Bluefin Tuna Recruitment Monitoring Program 2003/2004. Australian Fisheries Management Authority (AFMA) Final Report, Report Number R03/1429. Hobart, Tasmania.
- Hobday, A. J., J. R. Hartog, C. M. Spillman and O. Alves (2011). Seasonal forecasting of tuna habitat for dynamic spatial management. *Canadian Journal of Fisheries and Aquatic Sciences* **68**(5): 898 – 911.
- Hobsbawn, P. I., J. Hender, S. Rowcliffe and R. Murphy (2007). Australia's Annual Review of the Southern Bluefin Tuna Fishery. Working Paper CCSBT-EC/0710/SBT Fisheries-Australia presented at the Extended Commission of the Fourteenth Meeting of the Commission for the Conservation of Southern Bluefin Tuna, Canberra, October 2007. 15pp.
- Holdsworth, J. C. (2020). Recreational harvest of southern bluefin tuna in New Zealand, 2018-19. New Zealand Fisheries Assessment Report 2020/02. Wellington, NZ, 16pp.



Holdsworth, J. C., B. W. Hartill, A. Heinemann and J. Wynne-Jones (2018). Integrated survey methods to estimate harvest by marine recreational fishers in New Zealand. *Fisheries Research* **204**: 424 – 432.

Itoh, T. and S. Tsuji (1996). Age and Growth of Juvenile Southern Bluefin Tuna *Thunnus maccoyii* based on Otolith Microstructure. *Fisheries Science* **62**(6): 892 – 896.

Jones, C. M. and K. H. Pollock (2013). Recreational angler survey methods: estimation of effort, harvest, and released catch. pp. 883 – 919. in Z. A. V., P. D. L. and S. T. M. (eds). *Fisheries Techniques*. 3rd ed. American Fisheries Society. Bethesda, MD.

Jones, K. (2009). South Australian recreational fishing survey. South Australian Fisheries Management Series Paper No 54. PIRSA Fisheries, Adelaide, 84pp.

Jones, K. and A. Doonan (2005). 2000-01 National recreational and indigenous fishing survey. South Australian Information. SA fisheries management series paper No. 46. 75pp.

Knight, E., T. Park, D. Bromhead, P. Ward, S. Barry and R. Summerson (2006). Analysis of interactions between longline and recreational gamefish fisheries taking or tagging striped marlin off NSW. Canberra, 62pp.

Lohr, L. S. (2010). *Sampling: Design and Analysis*. 2nd Edition. Arizona State University. Tempe, 567-572pp.

Lumley, R. (2010). *Complex Surveys: A Guide to Analysis Using R: A Guide to Analysis Using R*. Wiley. 296pp.

Lumley, T. (2004). Analysis of complex survey samples. *Journal of Statistical Software* **9**(1): 1 – 19.

Lumley, T. (2019). *survey: analysis of complex survey samples*. R package version 3.35-1.

Lyle, J. and D. A. Campbell (1999). Species and size composition of recreational catches with particular reference to licensed fishing methods. MRFC Final Report. Tasmanian Aquaculture and Fisheries Institute University of Tasmania., Hobart.

Lyle, J. M., F. Ewing, G. Ewing and S. R. Tracey (2019). Tasmanian recreational Rock Lobster and Abalone fisheries: 2018-19 fishing season. Hobart, 36pp.

Lyle, J. M., K. E. Stark, G. P. Ewing and S. R. Tracey (2019). 2017-18 Survey of recreational fishing in Tasmania. Hobart, 123pp.

Lyle, J. M., K. E. Stark and S. R. Tracey (2014). 2012-13 survey of recreational fishing in Tasmania. Hobart, 124pp.

Lyle, J. M., S. Tracey, K. Stark and S. Wotherspoon (2009). 2007-08 survey of recreational fishing in Tasmania.

Lyle, J. M. and S. R. Tracey (2012). Recreational gillnetting in Tasmania - An evaluation of fishing practices and catch and effort. Hobart, 48pp.

Lyle, J. M., S. R. Tracey, K. E. Stark and S. J. Wotherspoon (2009). 2007-08 survey of recreational fishing in Tasmania. Hobart, 97pp.

Lyle, J. M., S. J. Wotherspoon and K. E. Stark (2010). Developing an analytical module for large-scale recreational fishery data based on phone-diary survey methodology. FRDC Final Report, Project 2007/064., 98pp.

Lyne, C. R. (1947). Tunny fishing at Bermagui. Australian Shooters and Anglers News.

MacKenzie, C. J. A. and S. P. Cox (2013). Building legitimacy of the recreational fishing sector in mixed commercial-rerecreational fisheries. *Ocean & Coastal Management* **75**: 11 – 19.

Marcek, B. J. and J. E. Graves (2014). An Estimate of Postrelease Mortality of School-Size Bluefin Tuna in the U.S. Recreational Troll Fishery. *North American Journal of Fisheries Management* **34**(3): 602 – 608.

McCoy, F. (1885). Prodomus of the Zoology of Victoria or Figures and descriptions of the living species of all classes of the Victorian indigenous animals. Melbourne. Volume I. (Decades I. to X.).

McIlgorm, A. and J. Pepperell (2014). An economic survey of the Recreational fishing charter boat industry in NSW. A report to the NSW Department of Primary Industries by Dominion Consulting Pty Ltd., 31pp.

McIntyre, J. (2011). Australia's first tuna capture on rod and reel. pp. in (eds). Sydney Game Fishing Club Tight Lines. Sydney.

Moore, A., K. Hall, G. Khageswor, S. Tracey, S. Hansen, P. Ward, I. Stobutzki, J. Andrews, S. Nicol and P. Brown (2015). Developing robust and cost-effective methods for estimating the national recreational catch of Southern Bluefin Tuna in Australia. Canberra, 123pp.

Morton, A. J. and J. Lyle (2003). Preliminary assessment of the recreational gamefish fishery in Tasmania, with particular reference to southern bluefin tuna Tasmanian Aquaquulture and Fisheries Institute. Hobart, 30pp.

Mullen, L. (2019). Package 'gender' v.0.5.3.

Murphy, J. J., M. B. Lowry, G. W. Henry and D. Chapman (2002). The gamefish tournament monitoring program—1993 to 2000. NSW fisheries final report series. Sydney, 38, 93pp.

Palmer, E. W. (1984). Fifty years of game fishing.

Park, T. (2007). NSW gamefish tournament monitoring: angling research tournament monitoring program. NSW Department of Primary Industries – Fisheries Final Report Series. Sydney, 94, 142pp.

Parrott, A. W. (1959). Sea Anglers' fishes of Australia. Hodder & Stoughton. Melbourne, 208pp.

- Patterson, H., I. Stobutzki and M. Stephan (2014). Southern bluefin tuna fishery. *Australian Fisheries Management Authority Annual Report*: 13–14.
- Patterson, H., A. Williams, B. Hennecke and D. Mobsby (2018). Fishery status reports 2018. Canberra, 542pp.
- Patterson, T. A., K. Evans, T. I. Carter and J. S. Gunn (2008). Movement and behaviour of large southern bluefin tuna (*Thunnus maccoyii*) in the Australian region determined using pop-up satellite archival tags. *Fisheries Oceanography* **17**(5): 352 – 367.
- Patterson, T. A., P. J. Eveson, J. R. Hartog, K. Evans, S. Cooper, M. Landsdell, A. J. Hobday and C. R. Davies (2018). Migration dynamics of juvenile southern bluefin tuna. *Scientific Reports* **8**: Article number: 14553.
- Pepperell, J. and G. Henry (1997). Development and implementation of a catch/effort monitoring system for the organized gamefish fishery off eastern Australia. *Report to the Australian Fisheries Management Authority: Canberra*.
- Pink, B. (2011). Australian Statistical Geography Standard (ASGS): Volume 1 - Main Structure and Greater Capital City Statistical Areas. Catalogue No: 1270.0.55.001.
- Pollock, K. H., C. M. Jones and T. L. Brown (1994). Angler survey methods and their application in fisheries management. American Fisheries Society Special Publications. 25, 371pp.
- Rogers, P. J., A. Tsolos, M. K. Boyle and M. Steer (2017). South Australian charter boat fishery data summary. Final report to PIRSA Fisheries and Aquaculture. . SARDI Research report series. Publication No. F2011/000437-2. Adelaide, No. 966, 17pp.
- Roswell, M., A. Moore, P. Sahlqvist and G. Begg (2008). Estimating Australia's recreational catch of southern bluefin tuna. Bureau of Rural Resources, Australian Government. CCSBT-ESC/0809/17. 11pp.
- Roughley, T. C. (1937). Big-game angling Australia.
- Roughley, T. C. (1951). Fish and fisheries of Australia. Angus and Robertson. Melbourne, 343pp.
- Ryan, K. L., N. G. Hall, E. K. Lai, C. B. Smallwood, A. Tate, S. M. Taylor and B. S. Wise (2019). Statewide survey of boat-based recreational fishing in Western Australia 2017/18. Fisheries Research Report No. 297. Western Australia, 195pp.
- Ryan, K. L., N. G. Hall, E. K. Lai, C. B. Smallwood, S. M. Taylor and B. S. Wise (2015). Statewide survey of boat-based recreational fishing in Western Australia 2013/14. Fisheries Research Report No. 268. Western Australia, 208pp.
- Ryan, K. L., N. G. Hall, E. K. M. Lai, C. B. Smallwood, S. M. Taylor and B. S. Wise (2017). Statewide survey of boat-based recreational fishing in Western Australia 2015/16. Fisheries Research Report No. 287. Department of Primary Industries and Regional Development, Western Australia, 205pp.



- Ryan, K. L., B. S. Wise, N. G. Hall, K. H. Pollock, E. H. Sulin and D. J. Gaughan (2013). An integrated system to survey boat-based recreational fishing in Western Australia 2011/12. Fisheries Research Report No. 249. Western Australia, 168pp.
- Särndal, C.-E., B. Swensson and J. Wretman (1992). Model Assisted Survey Sampling. Springer-Verlag New York.
- Serventy, D. L. (1941). The Australian Tunas. Commonwealth of Australia - Council for Scientific and Industrial Research. Melbourne.
- Smith, J. T. (1994). Charter fishing for tuna in Tasmania. 1. Department of Primary Industry and Fisheries Tasmania., Hobart.
- Stead, D. G. (1908). The edible fishes of New South Wales: Their present importance and their potentialities. G. P. Sydney W.A. Gullick, 296pp.
- Steer, M. A. and A. Tsolos (2016). South Australian charter boat fishery 2014/15. Report to PIRSA Fisheries and Aquaculture. . SARDI research report series. Publication No. F2007/000847-4. Adelaide, No. 932, 40pp.
- Steffe, A. S., J. J. Murphy and D. D. Reid (2008). Supplemented Access Point Sampling Designs: A Cost-Effective Way of Improving the Accuracy and Precision of Fishing Effort and Harvest Estimates Derived from Recreational Fishing Surveys. *North American Journal of Fisheries Management* **28**(4): 1001 – 1008.
- Stokesbury, M. J. W., J. D. Neilson, E. Susko and S. J. Cooke (2011). Estimating mortality of Atlantic bluefin tuna (*Thunnus thynnus*) in an experimental recreational catch-and-release fishery. *Biological Conservation* **144**: 2684 – 2691.
- Tracey, S. and J. Pepperell (2018). Understanding the movement, behaviour and post-capture survival of recreationally caught Swordfish from southeast Australia - a pilot study. Final report FRDC project 2015-022. Hobart, 69pp.
- Tracey, S. R., K. Hartmann, M. Leef and J. McAllister (2016). Capture-induced physiological stress and postrelease mortality for Southern bluefin tuna (*Thunnus maccoyii*) from a recreational fishery. *Canadian Journal of Fisheries and Aquatic Sciences* **73**(10): 1547 – 1556.
- Tracey, S. R., K. Hartmann, J. McAllister, S. Conron and M. Leef (2016). Capture-induced physiological stress and post-release survival of recreationally caught Southern Bluefin Tuna. Final report FRDC project 2013-025. Hobart, 143pp.
- Tracey, S. R., J. M. Lyle, G. Ewing, K. Hartmann and A. Mapleston (2013). Offshore recreational fishing in Tasmania 2011/12. Hobart, 98pp.
- Ward, P., K. Mazur, N. Stenekes, R. Kancans, R. Curtotti, R. Summerson, C. Gibbs, N. Marton, A. Moore and J. Roach (2012). A socioeconomic evaluation of three eastern Australian game-fishing regions. Canberra, 218pp.



West, L. D., K. E. Stark, J. M. Murphy, J. Lyle and F. A. Ochwada-Doyle (2015). Survey of recreational fishing in New South Wales and the ACT, 2013/14. Fisheries Final Report Series Sydney, 149, 150pp.

Appendix I: Boat ramp, seasonal strata and ramp weighting selection

South Australia

In South Australia, fishing for SBT is reported on social media to occur across the extent of the ocean coastline, with several focal points of access. Anecdotally, Port MacDonnell in southeast South Australia has been previously identified as the most popular area in that State for targeting SBT. Given its proximity to Portland in Victoria, it often experiences a similar run of SBT in terms of the frequency and size of fish. It is also one of the only areas in South Australia where large SBT (more than 100 kg) are known to be caught. Other areas known to be popular for targeting SBT in South Australia are around Port Lincoln on the Eyre Peninsula, the Fleurieu Peninsula particularly from Victor Harbor and, to a lesser extent, the Yorke Peninsula and the Limestone Coast. Victor Harbor is a large town and the closest access point to the metropolitan centre of the State's capital, Adelaide.

The pilot access-point survey reported by Moore et al. (2015) provided a starting point to assess which ramps were most likely to be used by recreational fishers accessing SBT. A total of 43 boat ramps out of 152 (Table 27) were identified as possible access points for the recreational SBT fishery in South Australia, and were subsequently included in the survey design implemented in Moore et al. (2015).

Before commencing this survey and based on the results and recommendations of Moore et al. (2015), several of the experts previously interviewed and some additional regional experts were consulted to refine the list of boat ramps, and also to provide advice on an appropriate sample weighting for each boat ramp based on the degree of effort for SBT that originates from the ramp. A higher sampling weight was applied for ramps that were reported to be more likely to have a greater degree of activity for SBT fishers.

The experts were also asked to confirm the timing and duration (in months) of the SBT fishing season in their region, including identifying the peak period and any trends in fish size throughout the season. The high, low and tail seasonal strata were assigned accordingly, with the high season extended both before and after (where applicable) for one month to provide a buffer for seasonal variability.

Table 27. Number of boat ramps identified in South Australia Government database by region and number of ramps surveyed to assess recreational fishery for Southern Bluefin Tuna in South Australia by Moore et al. (2015) and in this study.

Region	Total number of ramps	Number of boat ramps identified in Moore et al. 2015	Number of boat ramps sampled in this study
Western Region	13	10	2
Eyre Peninsula	14	9	3
Spencer Gulf	31	0	0
Yorke Peninsula	5	4	2
Gulf St Vincent	33	5	0
Fleurieu Peninsula	12	6	3
Kangaroo Island	7	5	3
Coorong	16	0	0
Limestone Coast*	21	4	4

* Port MacDonnell included in total number of ramps and this study but not included in Moore et al. (2015) column as it was considered separately.

Tuna trips were reported from only three of the 43 ramps surveyed in the pilot study reported in Moore et al. (2015). Subsequent discussions with local experts confirmed that many of the ramps surveyed by Moore et al. (2015) were rarely, if ever, used as launch points to fish for tuna. These observations, coupled with expert opinion relating to the identification of ramps with a moderate to high probability of use by game fishers, resulted in a reduction in the number of boat ramps to be surveyed, from 43 to 17 (Table 27). Before commencing the survey, the list of proposed survey ramps was presented to members of RecFish SA, who confirmed that those selected ramps were expected to cover the vast majority of recreational fishing for SBT in South Australia.

Victoria

Historically, the recreational fishery for SBT in Victoria has predominantly been based along the southwest coast of Victoria, from the South Australian border to Apollo Bay (Green et al. 2012). More recently, there have been limited reports of SBT being caught outside Port Phillip Bay and Western Port Bay. Given the complexity of adequately surveying these regions, due to the high number of access points and the apparent relatively low number of fish caught, this survey focuses solely on the southwest coast of Victoria.

The boat-ramps used to access offshore waters at Port Fairy, Warrnambool and Apollo Bay were considered as a unique region, with sample weighting for each ramp defined by discussions with local experts and a higher weighting applied to ramps where more SBT fishing activity was expected. Portland was considered as its own region, noting there are two independent boat ramp facilities there. Sample weighting was applied equally to both ramps.

Appendix II: Access point survey sampling protocol – South Australia

Port MacDonnell

Survey days for Port MacDonnell were selected, at random and without replacement, from within each of the six stratum cells according to the sample fractions identified in Table 28. This sampling regime allocated a total of 129 survey days at Port MacDonnell.

Table 28. Stratum design and sample sizes for supplemented stratified access-point design used to assess recreational fishing targeting Southern Bluefin Tuna at Port MacDonnell, South Australia.

Season stratum	Day stratum	Stratum size	Survey days (SF) Port MacDonnell	Auxiliary data days
Low season	Weekday	39	7 (18%)	25
	Weekend/PH	23	3 (13%)	16
High season	Weekday	124	40 (32%)	124
	Weekend/PH	57	30 (53%)	57
Tail season	Weekday	86	32 (37%)	85
	Weekend/PH	36	17 (47%)	36
	Annual	365	129 (35%)	345

*Low season = Dec 2018 – Jan 2019, High season = Feb – Jul 2019, Tail season = Aug – Nov 2019
PH = Public holiday (South Australia), SF = Sample fraction
Auxiliary data days are the number of days where traffic counter data was recorded*

Limestone Coast

A total of 78 survey days were allocated to the Limestone Coast region. Survey days were selected at random and without replacement from within each of the four stratum cells according to the sample fractions identified in Table 29. Survey days were then randomly assigned to each boat ramp based on these relative sample fractions: Beachport = 0.1, Cape Jaffa = 0.6 and Robe = 0.3. Seasonal strata were Low season = December 2018 – January 2019 and August – November 2019, and High season = February – July 2019. The seasonal strata and access-point selection probabilities were based on discussions with local anglers.

Table 29. Stratum design and sample sizes for stratified access-point design used to assess recreational fishing targeting Southern Bluefin Tuna along Limestone Coast at boat ramps located at Beachport, Cape Jaffa and Robe.

Season stratum	Day stratum	Stratum size	Survey days (SF)
Low season	Weekday	125	16 (13%)
	Weekend/PH	59	16 (27%)
High season	Weekday	124	26 (21%)
	Weekend/PH	57	20 (35%)
	Annual	365	78

*Low season = Dec 2018 – Jan 2019, High season = Feb – Jul 2019, Tail season = Aug – Nov 2019
PH = Public holiday (South Australia), SF = Sample fraction*

Kangaroo Island

A total of 90 survey days were allocated to Kangaroo Island. Survey days were selected at random and without replacement from within each of the four stratum cells, according to the sample fractions identified in Table 30. These were then randomly assigned to each boat ramp based on these relative sample fractions: Emu Bay = 0.2, Penneshaw (Christmas Cove) = 0.2, Stokes Bay = 0.6. The seasonal strata were Low season = June – November 2019 and High season = December 2018 – May 2019. Seasonal strata and access-point selection probabilities were based on discussions with local anglers.

Table 30. Stratum design and sample sizes for stratified access-point design used to assess recreational fishing targeting Southern Bluefin Tuna from Kangaroo Island at boat ramps located at Emu Bay, Penneshaw (Christmas Cove) and Stokes Bay.

Season stratum	Day stratum	Stratum size	Survey days (SF)
Low season	Weekday	128	15 (12%)
	Weekend/PH	55	15 (27%)
High season	Weekday	121	35 (29%)
	Weekend/PH	61	25 (41%)
	Annual	365	90

*Low season = June – November 2019, High season = December 2018 – May 2019
PH = Public holiday (South Australia), SF = Sample fraction*

Fleurieu Peninsula

A total of 133 survey days were allocated to the Fleurieu Peninsula. Survey days were selected at random and without replacement from within each of the four stratum cells, according to the sample fractions identified in Table 31.

These were then randomly assigned to each boat ramp based on these relative sample fractions: Victor Harbor (Encounter Bay) = 0.6, Wirrina = 0.15 and Cape Jervis = 0.25. The seasonal strata were Low season = June – November 2019 and High season = December 2018 – May 2019. Seasonal strata and access-point selection probabilities were based on discussions with local anglers.

Table 31. Stratum design and sample sizes for stratified access-point design used to assess recreational fishing targeting Southern Bluefin Tuna from Fleurieu Peninsula at boat ramps located at Victor Harbor (Encounter Bay), Wirrina and Cape Jervis.

Season stratum	Day stratum	Stratum size	Survey days (SF)
Low season	Weekday	128	25 (20%)
	Weekend/PH	55	25 (45%)
High season	Weekday	121	43 (36%)
	Weekend/PH	61	40 (66%)
	Annual	365	133

*Low season = June – November 2019, High season = December 2018 – May 2019
PH = Public holiday (South Australia), SF = Sample fraction*

Yorke Peninsula

A total of 107 survey days were allocated to the Yorke Peninsula. Survey days were selected at random and without replacement from within each of the four stratum cells, according to the sample fractions identified in Table 32. These were then randomly assigned to each boat ramp based on these relative sample fractions: Marion Bay = 0.75 and Pandalowie Bay = 0.25.

The seasonal strata were Low season = June – November 2019 and High season = December 2018 – May 2019). Seasonal strata and access-point selection probabilities were based on discussions with local anglers.

Table 32. Stratum design and sample sizes for stratified access-point design used to assess recreational fishing targeting Southern Bluefin Tuna from Yorke Peninsula at boat ramps located at Marion Bay and Pandalowie Bay.

Season stratum	Day stratum	Stratum size	Survey days (SF)
Low season	Weekday	128	20 (16%)
	Weekend/PH	55	20 (36%)
High season	Weekday	121	31 (26%)
	Weekend/PH	61	36 (59%)
	Annual	365	107

Low season = June – November 2019, High season = December 2018 – May 2019

PH = Public holiday (South Australia), SF = Sample fraction

Eyre Peninsula

A total of 109 survey days were allocated to the Eyre Peninsula. Survey days were selected at random and without replacement from within each of the four stratum cells, according to the sample fractions identified in Table 33. These were then randomly assigned to each boat ramp based on these relative sample fractions: Coffin Bay (Esplanade) = 0.4, Port Lincoln (Axel Stenross) = 0.3 and Port Lincoln (Billy Lights Point) = 0.3. The seasonal strata were Low season = May – November 2019 and High season = December 2018 – April 2019. Seasonal strata and access-point selection probabilities were based on discussions with local anglers.

Table 33. Stratum design and sample sizes for stratified access-point design used to assess recreational fishing targeting Southern Bluefin Tuna from Eyre Peninsula at boat ramps located at Coffin Bay (Esplanade), Port Lincoln (Axel Stenross) and Port Lincoln (Billy Lights Point).

Season stratum	Day stratum	Stratum size	Survey days (SF)
Low season	Weekday	151	20 (13%)
	Weekend/PH	63	20 (32%)
High season	Weekday	97	39 (40%)
	Weekend/PH	54	30 (56%)
	Annual	365	109

Low season = May – November 2019, High season = December 2018 – April 2019

PH = Public holiday (South Australia), SF = Sample fraction

Region west

A total of 105 survey days were allocated to Region west. Survey days were selected at random and with replacement from within each of the four stratum cells according to the sample fractions identified in Table 34. These were then randomly assigned to each boat ramp based on these relative sample fractions: Sceale Bay = 0.5 and Thevenard = 0.5. The seasonal strata were Low season = May – November 2019, High season = December 2018 – April 2019. Seasonal strata and access-point selection probabilities were based on discussions with local anglers.

Table 34. Stratum design and sample sizes for the stratified access-point design used to assess recreational fishing targeting Southern Bluefin Tuna from the West coast of South Australia at boat ramps located at Sceale Bay and Thevenard. Low season = May – November 2019, High season = December 2018 – April 2019, PH = Public holiday (in South Australia), SF = Sample fraction.

Season stratum	Day stratum	Stratum size	Survey days (SF)
Low season	Weekday	151	20 (13%)
	Weekend/PH	63	20 (32%)
High season	Weekday	97	30 (31%)
	Weekend/PH	54	35 (65%)
	Annual	365	105

*Low season = May – November 2019, High season = December 2018 – April 2019
PH = Public holiday (in South Australia), SF = Sample fraction*

Appendix III: Access point survey sampling protocol – Victoria

Portland

A supplemented stratified access-point design was implemented at the two boat-ramps in Portland. These two areas are large, multi-lane launching facilities and, while in close proximity, they are too far apart to survey simultaneously on a given day. Therefore, each ramp was surveyed independently, with the randomised sample days allocated in an alternating systematic way to each ramp, and the estimates of fishing effort and catch combined to obtain a total estimate for Portland.

Randomising sample days before allocation meant there was no biasing to systematic selection of samples within strata, that is, on a weekend it did not select Saturday every time at the same ramp. The survey days were then listed in chronological order, ignoring seasonal and day-type stratification. Finally, the surveys days were systematically alternated between the two boat-ramps. This sampling regime allocated a total of 209 survey days at Portland – 104 at Portland old and 105 days at Portland new (Table 35).

Table 35. Stratum design and sample sizes for supplemented stratified access-point design used to assess recreational fishing targeting Southern Bluefin Tuna at Portland, Victoria.

Season stratum	Day stratum	Stratum size	Survey days (SF) Portland old	Survey days (SF) Portland new	Auxiliary data days
Low season	Weekday	39	5 (13%)	7 (18%)	25
	Weekend/PH	23	4 (17%)	3 (13%)	16
High season	Weekday	124	36 (29%)	34 (27%)	124
	Weekend/PH	57	21 (37%)	23 (40%)	57
Tail season	Weekday	85	21 (25%)	20 (24%)	85
	Weekend/PH	37	17 (46%)	18 (49%)	37
	Annual	365	104 (28%)	105 (29%)	344

Low season = Dec 2018 – Jan 2019, High season = Feb – Jul 2019, Tail season = Aug – Nov 2019

PH = Public holiday (in Victoria), SF = Sample fraction

Auxiliary data days are the number of days where traffic counter data was recorded

Regional Southwest Victoria

A total of 213 survey days were allocated to the region. Survey days were selected at random and without replacement from within each of the six stratum cells, according to the sample fractions identified in Table 36.

The sampling effort allocated to each ramp was based on the relative use of the ramps in the 2011 survey (Green et al. 2012) and discussions with local anglers. Survey days in regional southwest Victoria were randomly assigned to each boat ramp with these relative sample fractions: Port Fairy = 0.52, Warrnambool = 0.24 and Apollo Bay = 0.24. Sampling was conducted without replacement of the sampling unit (calendar day).

Table 36. Stratum design and sample sizes for stratified access-point design used to assess recreational fishing targeting Southern Bluefin Tuna in regional southwest Victoria, at boat ramps located at Port Fairy, Warrnambool and Apollo Bay. Low season = Dec 2018 – Jan 2019, High season = Feb – Jul 2019, Tail season = Aug – Nov 2019, PH = Public holiday (in Victoria), SF = Sample fraction.

Season stratum	Day stratum	Stratum size	Survey days (SF)
Low season	Weekday	39	12 (31%)
	Weekend/PH	23	12 (52%)
High season	Weekday	124	70 (56%)
	Weekend/PH	57	41 (72%)
Tail season	Weekday	85	41 (48%)
	Weekend/PH	37	37 (100%)
	Annual	365	213

*Low season = Dec 2018 – Jan 2019, High season = Feb – Jul 2019, Tail season = Aug – Nov 2019
PH = Public holiday (in Victoria), SF = Sample fraction*

Appendix IV: Assessment of traffic counters as a proxy for game fishing effort at select boat ramps

Introduction

Traffic counters were installed at Portland in Victoria and Port MacDonnell in South Australia, during the on-site access-point survey in these States. The data collected, when validated by the survey data collected by creel clerks on sampling days, could be used as auxiliary data providing a daily proxy for fishing effort on non-survey days to improve the accuracy and precision of the survey estimates of effort and subsequently catch (Steffe et al. 2008). The traffic counter data could also be used to assess the assumption that, on days where wind speeds were in excess of 30 knots, there would be no or minimal fishing effort.

Methods

The traffic counters were deployed in accordance with the recommendations of the MetroCount[®] manufacturer's product manual. On-board setting for all units were consistent with the default settings, except for the directional movement of vehicles setting, which was disabled so all triggers were recorded. Axle sensors were set for Paired (class/speed/count) with a lockout of 20 ms (as per the multi-lane special classification).

Two pneumatic tubes (A and B) were fixed 1.0 metre apart and tensioned in accordance with manufacturer recommendations. Weekly inspections on all tubes were made to ensure tension was sufficient and tubes had not been damaged, vandalised, become loose or had holes in them. Nails and wire loops anchoring the tubes were also inspected. Regular downloads of data were made in case of theft, vandalism or electronic faults.

The raw count data from the B tube were used for subsequent analysis providing a relative measure of effort in hourly time bins. An assessment was made between Tube A and B to ensure there was no drift through time between the tubes.

Portland

Traffic counters were installed at the Portland boat ramps with placement ensuring all vehicles towing vessels that launch (or all trips) were recorded. They were located directly at the top of the boat ramp to reduce noise from other vehicles using the ramp area, and to ensure both launching and retrieval events triggered the counter.

All four logger units were deployed on Friday 21 December 2018, with the first full day of operation on 22 December, one week before any tuna were reported landed. Two units were deployed at the new Portland ramp site, one each to cover the dual lane ramps which were approximately 8.5 m wide. Two units were also deployed at the old Portland ramp site. One covered the triple lane ramp with a width of 12.5 m and the other covered the single lane ramp which was 4.5 m wide.

Port MacDonnell

The single traffic logger unit was deployed at the Port MacDonnell ramp on Saturday 19 January 2019, well before tuna were reported in the survey at this ramp. Local council restrictions meant the tubes could not be placed directly at the top of the ramp, so pneumatic tubes attached to the traffic logger were deployed across the four-lane exit from the ramp

area, at approximately 80 m from the top of the boat-ramp. This meant that only vessel retrievals would be logged, and that the traffic counter data may also be corrupted by noise from other vehicles using the car park facilities but not the boat ramp.

In addition, Port MacDonnell has a large commercial fleet (mainly for Southern Rock Lobster). Their vehicles tow small aluminium vessels and use the four-lane ramp exit exclusively, as they weigh their catch at the weigh station situated between the exit lanes, after crossing the traffic counters. Therefore, there is less confidence in the data from the Port MacDonnell traffic counter, as an accurate proxy of boat ramp usage by recreational fishing vessels. As a result, Port MacDonnell is not assessed for traffic trends at the boat ramp. However, an analysis of the relationship between the number of fishing interviews and the traffic counter was conducted. This assessed the suitability of the data to act as a proxy for fishing effort on sample days for integration into the expansion analysis for tuna fishing events.

Results

The new ramps at Portland had consistently more traffic than the older ramps across all months. The greatest amount of traffic using the boat ramps at Portland was recorded in January 2019. Traffic counts from February through June were reasonably consistent, except for a peak in traffic in April (Figure 37). July and August had the least amount of traffic, with traffic increasing again from September through to the end of the survey in November.

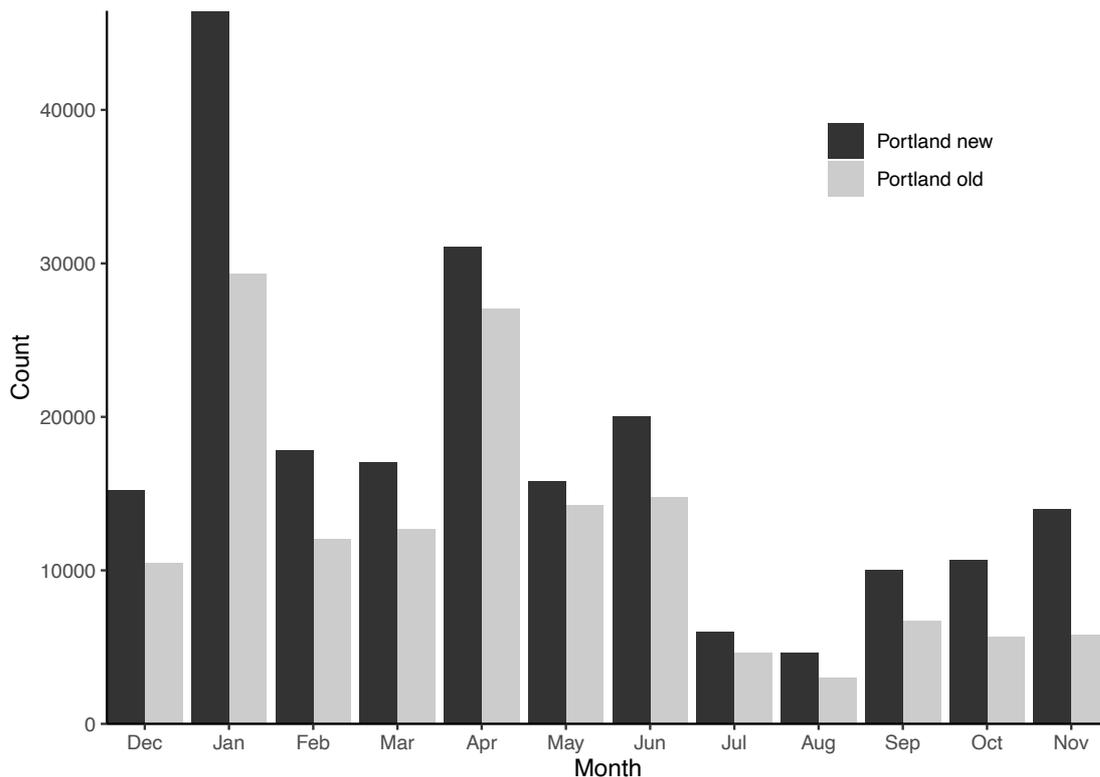


Figure 37. Monthly count data beginning in December 2018, from pneumatic traffic counters placed across the boat ramps at the two boat ramp facilities in Portland, Victoria. Note: counters were not installed in Portland until 21 December 2018, so only a partial count is available for December in Portland.

At Portland there was a pulse of activity in the morning between 6:00 and 8:00 am, then a lull before a broad pulse from midday to approximately 6:00 pm (Figure 38). Presumably this is vessels launching in the morning and retrieving in the afternoon or evening, which corresponds with the launch and retrieval times reported during the survey interviews. This trend was particularly pronounced in the peak tuna fishing months of April, May and June. From April through October, the amount of traffic on the ramps after 6:00 pm was minimal (Figure 38), which is assumed to be due to the shorter days throughout these months. There was more night-time activity in December 2018, noting that Figure 38 only represents 11 days of activity in this month, and November 2019.

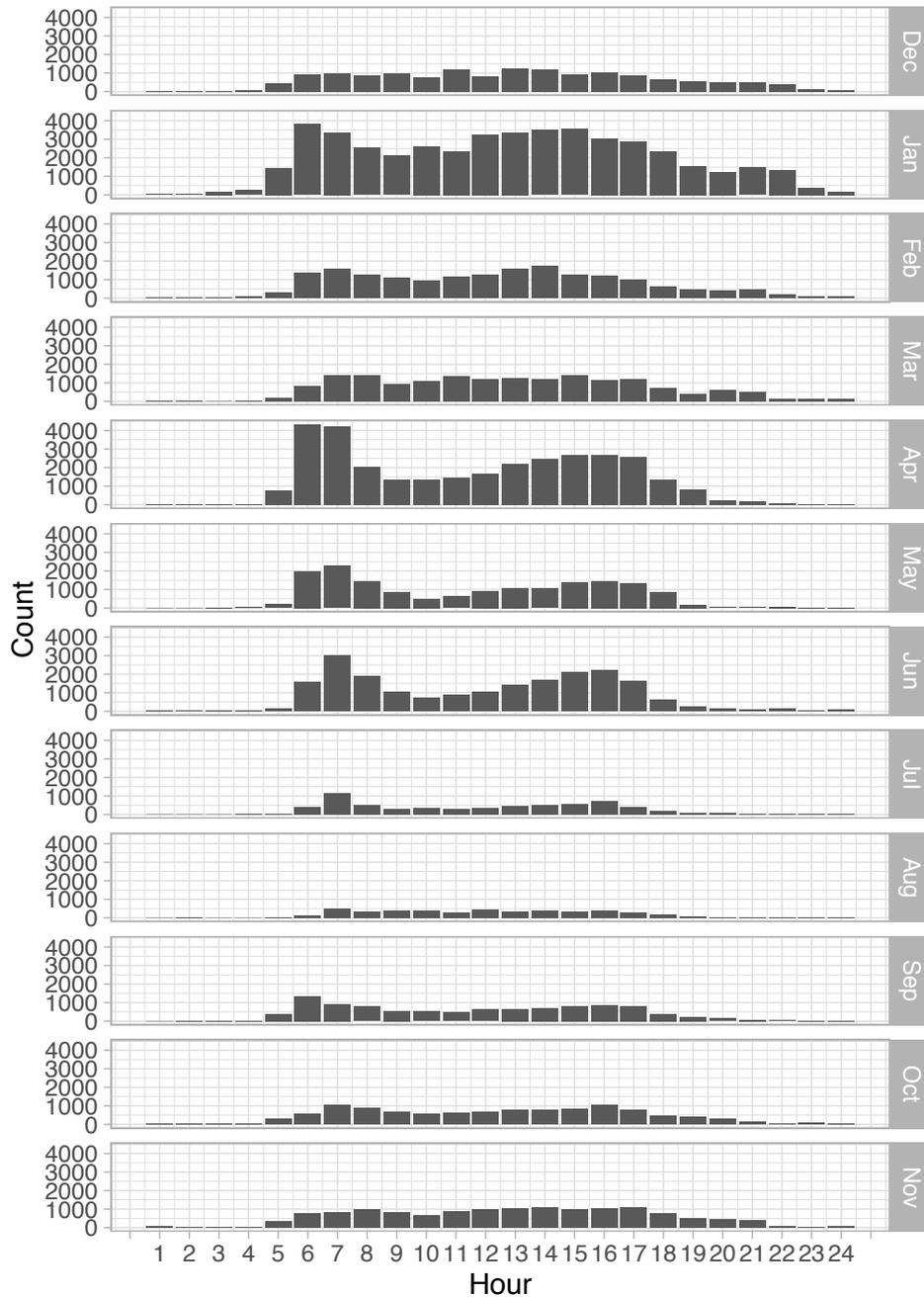


Figure 38. Traffic counter data summary counts by hour, for each month from December 2018 through to November 2019 at Portland in Victoria. Note: data from two ramps facilities at Portland are pooled.

The amount of traffic using the Portland boat ramps dropped away significantly once the daily average windspeed exceeded 15 knots, and when it was over 20 knots there was minimal traffic (Figure 39).

A similar pattern is observed when comparing the number of reported game fishing events recorded on survey days related to the daily average wind speed. Once wind speeds exceeded 15 knots, the number of vessels game fishing reduced significantly.

This supports the assumption there would be no or minimal game fishing effort or catch of SBT on those survey days cancelled due to a forecast windspeed of greater than 30 knots.

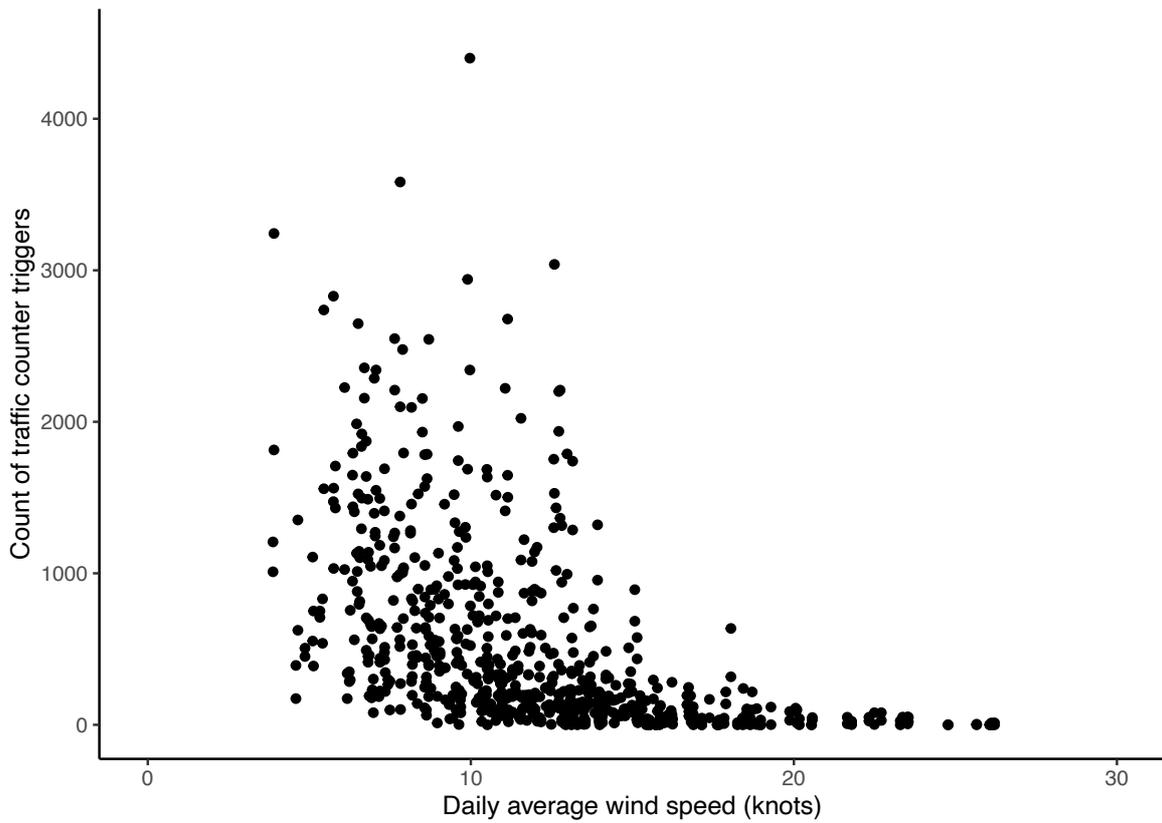


Figure 39. Relationship between number of traffic counter triggers and daily average wind speed (knots) at combined Portland boat ramp facilities, from December 2018 through to November 2019.

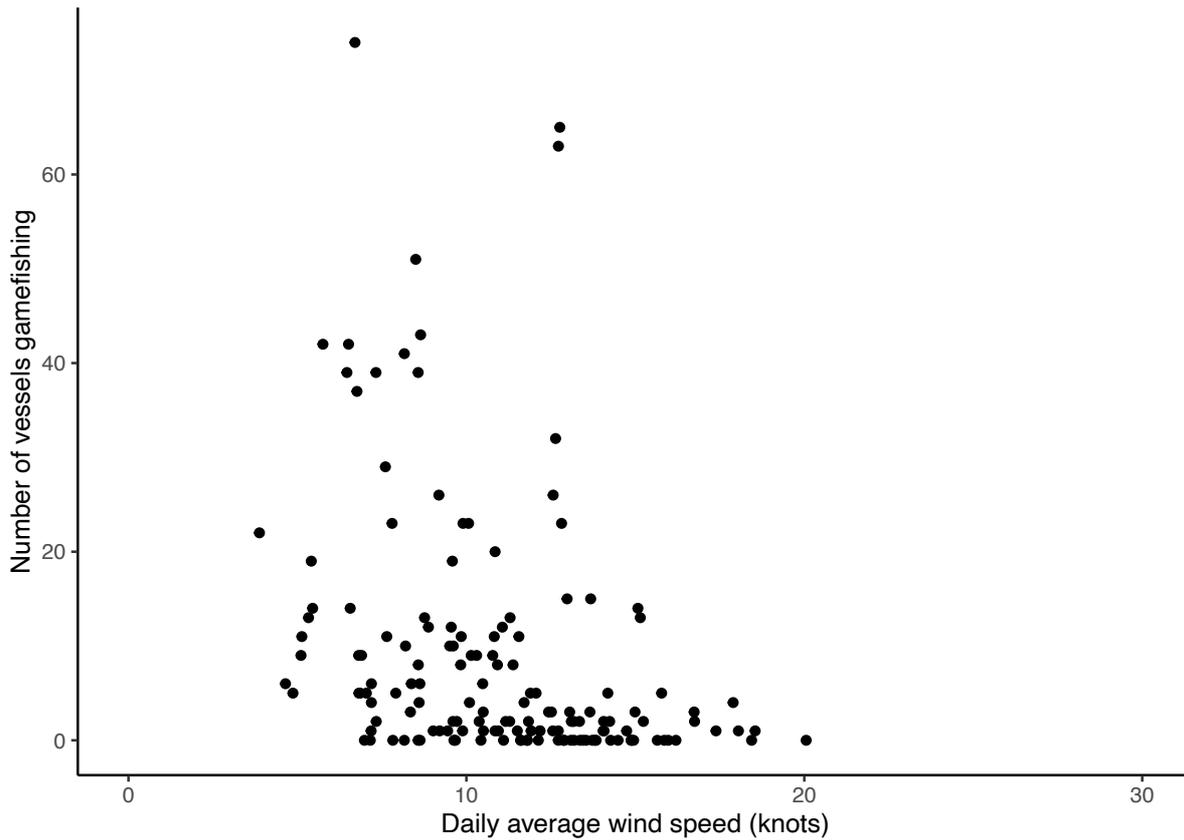


Figure 40. Relationship between number of vessels game fishing and daily average wind speed (knots) at combined Portland boat ramp facilities, reported on survey days from December 2018 through to November 2019.

There was a significant relationship between the number of fishing parties reporting they were using their vessel for recreational fishing and the number of traffic counter triggers at both Portland (ramps combined) and Port MacDonnell (Figure 41). The relationship was stronger at Portland ($R^2 = 0.93$) compared to Port MacDonnell ($R^2 = 0.68$).

This was expected, as the unit placement at Port MacDonnell meant the counter had a higher degree of ‘noise’ from vehicles using the exit road but not the boat ramp at this location. The strong relationship between the traffic count data and the number of reported fishing trips suggest using traffic counter data as an auxiliary data source, to resolve effort on non-survey days, would be warranted when assessing general recreational fishing activity. This supports the findings of Steffe et al. (2008).

However, the relationship weakens dramatically when assessed between game fishing events and traffic counts (Figure 41), with the R^2 values dropping to 0.65 and 0.21 at Portland and Port MacDonnell, respectively. These two boat ramp facilities far exceeded the greatest percentage of game fishing activity targeting SBT, relative to all types of recreational fishing of all ramps surveyed, at 45 and 35% respectively. The amount of ‘noise’ from vessels targeting other recreational fishing species severely reduces the utility of the traffic counter data to act as a proxy for game fishing effort on non-survey days. Therefore, it was decided not to use the traffic count data as auxiliary data to refine the effort and subsequent catch of SBT.

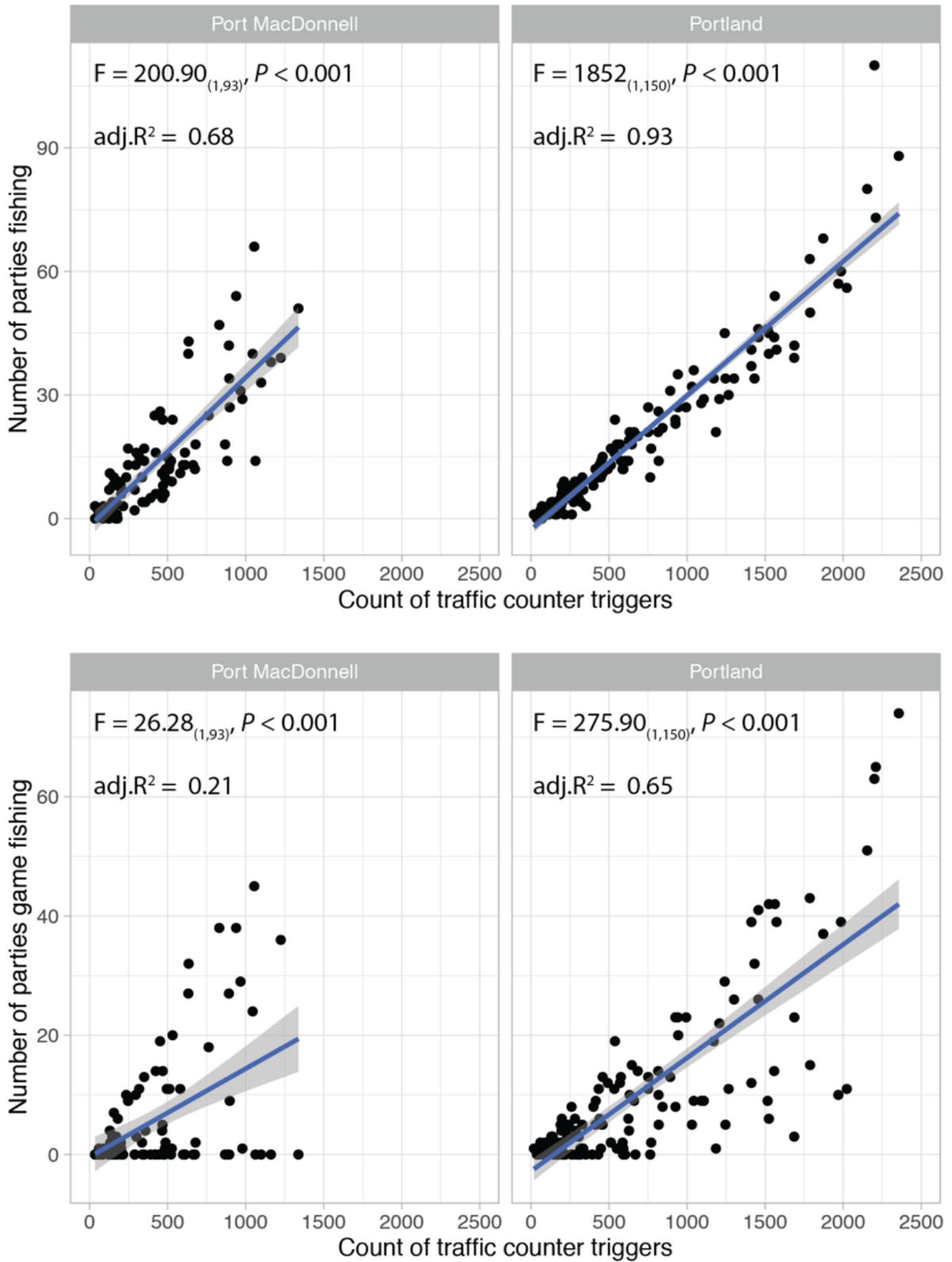


Figure 41. The top two figures show the relationship between number of vessels reportedly used for recreational fishing on survey days and number of traffic counter triggers at Port MacDonnell boat ramp in South Australia and Portland boat ramps (combined) in Victoria, respectively. The bottom two figures show the same relationship, but for parties that specifically indicated they were game fishing.

Appendix V: Game fishing tournaments – New South Wales, Victoria, Tasmania and South Australia

A list of all game fishing tournaments in New South Wales, Victoria, Tasmania and South Australia is provided in Table 37. Data was requested from these tournaments for the period of 1 December 2018 through to 30 November 2019.

Table 37. Game fishing tournaments in New South Wales, Victoria, Tasmania and South Australia.

State	Tournament	Angling Club	Location	Tournament Dates
Tasmania	Shark Competition	St Helens Game Fishing Club	St Helens	5 Jan 2019
	Australia Day Shark & Gamefish Challenge	Tuna Club of Tasmania	Eaglehawk Neck	26 Jan 2019
	Tasmania Light Line Shoot Out	Tuna Club of Tasmania	Eaglehawk Neck	16–19 Feb 2019
	St Helens Game Fishing Classic	St Helens Game Fishing Club	St Helens	9–10 Mar 2019
	East Coast Classic	Southern Gamefish Club	Bicheno	23–24 Mar 2019
	Broadbill Championships	Sport Fishing Club of Tasmania	Eaglehawk Neck	28–30 Mar 2019
	Easter Competition	Game Fishing Club of Northern Tasmania	St Helens	19–20 Apr 2019
	Tom Jenkins Tuna Competition	Tuna Club of Tasmania	Eaglehawk Neck	26–27 Apr 2019
	Peninsula Challenge	Sport Fishing Club of Tasmania	Eaglehawk Neck	18 May 2019
	Far South Classic	Southern Gamefish Club	Southport	25–26 May 2019
	Winter Windup	Game Fishing Club of Northern Tasmania	Bicheno	8 Jun 2019
	Tuna Competition Opener	St Helens Game Fishing Club	St Helens	13 Jul 2019
	Victoria	Portland Hooked on Tuna	N/A	Portland
Southwest Victorian Game Fishing Competition		Warrnambool Offshore and Light Game Fishing Club	Warrnambool	22–23 Jun 2019
South Australia	Coast 2 Coast Tuna Tournament	N/A	Victor Harbour	9 Feb 2019
	Wirrina Tuna Tournament	Game Fishing Club of South Australia	Wirrina	15–17 Feb 2019
	Port Lincoln Blue Water Classic	Game Fishing Club of South Australia	Port Lincoln	15–21 Mar 2019
	Riviera Port Lincoln Tuna Classic	N/A	Port Lincoln	22–24 Mar 2019
	Port MacDonnell Tuna and Sportfish Tournament	Port MacDonnell Offshore Angling Club	Port MacDonnell	4–8 May 2019
New South Wales	Jervis Bay White Sands	Jervis Bay Game Fishing Club	Jervis Bay	1 Dec 2018
	Port Macquarie Golden Lure	Port Macquarie Game Fishing Club	Port Macquarie	6–11 Jan 2019
	Port Macquarie Golden Lure Ladies & Juniors	Port Macquarie Game Fishing Club	Port Macquarie	8 Jan 2019
	Batemans Bay Tollgate Island Classic	Batemans Bay Game Fishing Club	Batemans Bay	18–20 Jan 2019
	Botany Bay Bill Heyward Memorial Tournament	Botany Bay Game Fishing Club	Botany Bay	19–20 Jan 2019
	Bermagui Bluewater Classic	Bermagui Big Game Anglers Club	Bermagui	26–28 Jan 2019
	Ulladulla Jess Sams	Ulladulla Game Fishing Club	Ulladulla	1–3 Feb 2019



State	Tournament	Angling Club	Location	Tournament Dates
	Lake Macquarie Big Fish Bonanza	Lake Macquarie Game Fishing Club	Swansea	1–3 Feb 2019
	Garmin Billfish Shootout	Newcastle & Port Stephens Game Fishing Club	Port Stephens	16–17 Feb 2019
	Eden Open Tournament	Eden Sport & Game Fishing Club	Twofold Bay	16–18 Feb 2019
	Alliance Tag & Release Tournament	Bermagui Big Game Anglers Club	Bermagui	9–10 Mar 2019
	Newcastle East Coast Classic	Newcastle Game Fishing Club	Newcastle	9–10 Mar 2019
	Broken Bay Invitational	Broken Bay Game Fishing Club	Broken Bay	16–17 Mar 2019
	Merimbula Billfish Tournament	Merimbula Big Game & Lakes Angling Club	Merimbula	22–24 Mar 2019
	Central Coast Garmin Blue Water Classic	Central Coast Game Fishing Club	Central Coast	23–24 Mar 2019
	Kiama Blowhole Bigfish Classic	Kiama Game Fishing Club	Kiama	6–7 Apr 2019
	Peter Goadby Memorial Tournament	Sydney Game fishing Club	Watson's Bay	13–14 Apr 2019
	Port Hacking 100	Port Hacking Game Fishing Club	Port Hacking	4 May 2019
	Merimbula Open	Merimbula Big Game & Lakes Angling Club	Merimbula	7–10 Jun 2019
	Canberra Tuna Tournament	Canberra Game Fishing Club	Bermagui	22–24 Jun 2019
	Sydney Geoff Woolley Memorial Mako Tournament	Sydney Game fishing Club	Sydney	3–4 Aug 2019

Appendix VI: Supplementary figures and tables

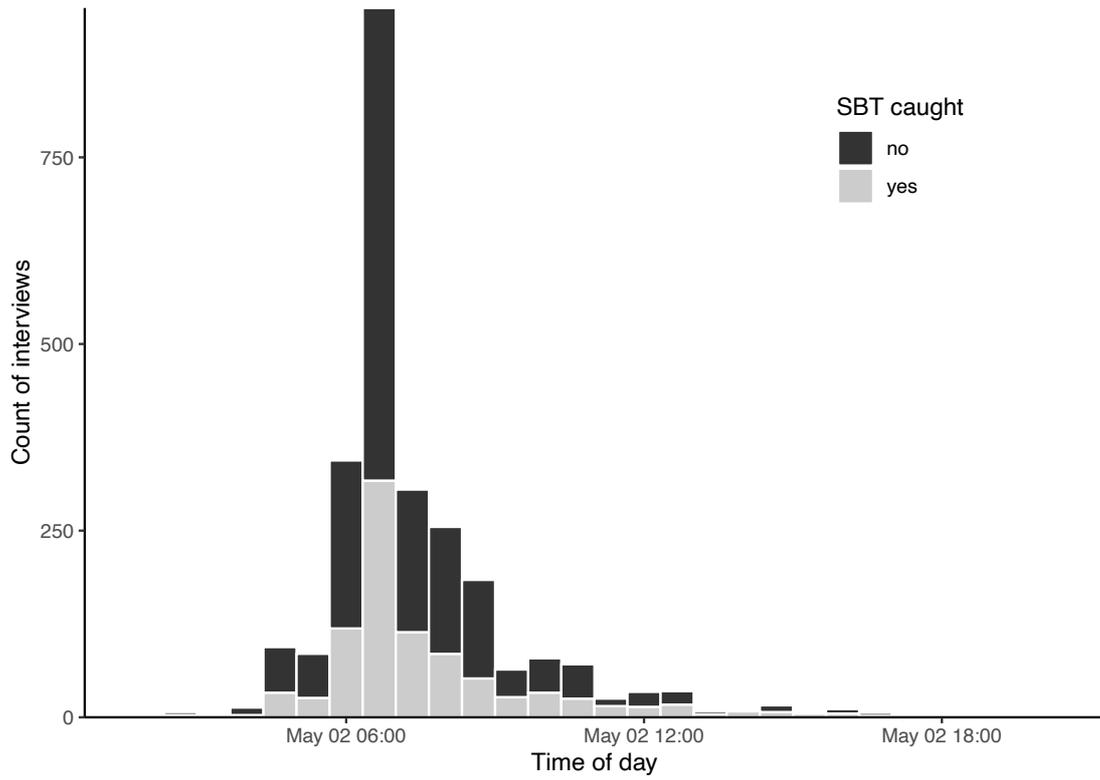


Figure 42. Frequency distribution of launch times reported for tuna fishing trips during the access-point survey of recreational game fishing in South Australia and Victoria during the survey period.

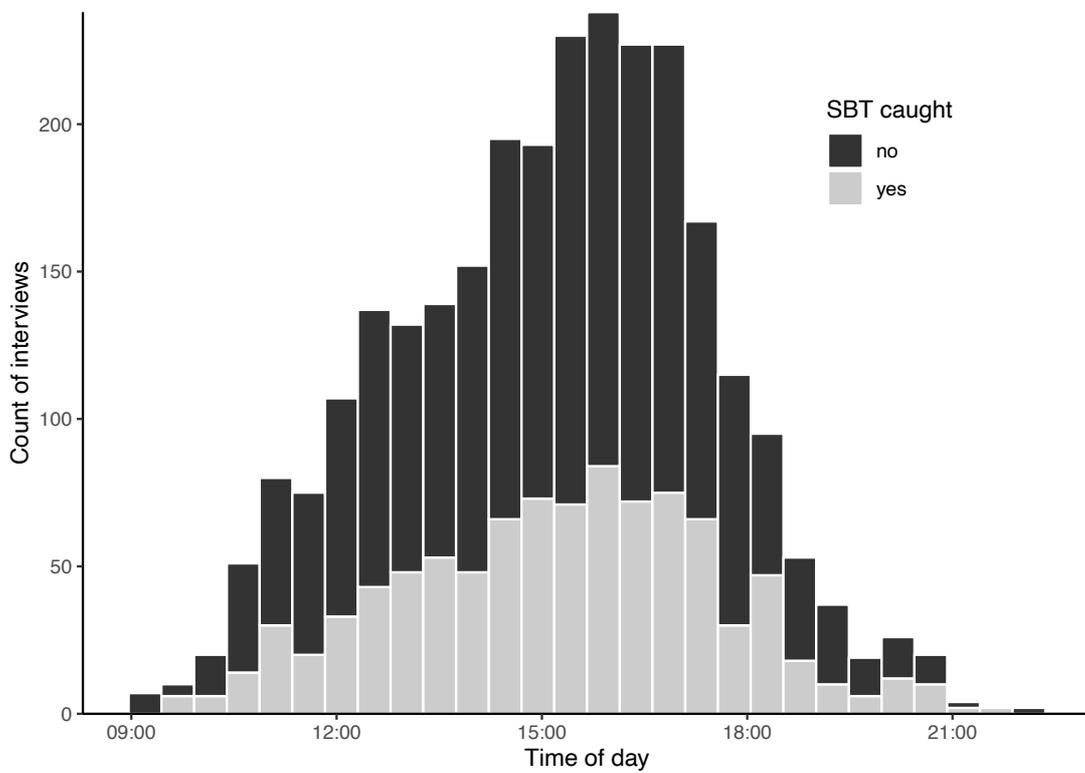


Figure 43. Frequency distribution of retrieval times reported for tuna fishing trips during the access-point survey of recreational game fishing in South Australia and Victoria during the survey period.

Table 38. Number of long-term (1 and 3 year) recreational fishing licence holders and sampling details by residential strata used in this study. Valid sample indicates at least one valid phone number associated with licence record.

Stratum_Group*	Licence holders (n)	Percent of all licence holders	Weighting factor	Gross sample	Valid sample	Sample loss	NSW survey duplicate	Final sample	Percent of population	SA4 codes
Illawarra	29,173	7%	2.1	5,323	4,841	482	48	4,793	16%	107,114
NSW South East	20,997	5%	2.1	3,831	3,513	318	39	3,474	17%	101
Victoria (coastal)	18,241	4%	1.5	2,378	2,147	231	17	2,130	12%	201,203,205–214,217
Other States/Territories	1,217	<1%	1.5	159	151	8	0	151	12%	All remaining States
Sydney	166,538	38%	1.1	15,918	14,892	1,026	60	14,832	9%	102,115–128
Hunter	42,853	10%	0.7	2,607	2,386	221	26	2,360	6%	106,111
Richmond/Tweed	16,646	4%	0.7	1,012	952	60	14	938	6%	112
Mid North Coast	30,242	7%	0.7	1,839	1,670	169	15	1,655	5%	104,108
Australian Capital Territory	14,341	3%	0.7	872	838	34	22	816	6%	Whole Territory
Queensland	14,602	3%	0.7	888	829	59	19	810	6%	Whole State
Central West/North	23,359	5%	0.5	1,015	935	80	12	923	4%	103,110
Far West/North West	6,209	1%	0.5	270	252	18	11	241	4%	105
Murray/Murrumbidgee	22,689	5%	0.5	986	893	93	15	878	4%	109,113
Victoria (Murray River)	25,900	6%	0.25	563	514	49	3	511	2%	202,204,215,216
Overseas	1	<1%	0	0						
No Geographic data	581	<1%	0	0						
Total	433,589	100%		37,661	34,813	2,848	301	34,512	8%	

Table 39. Response profile by regional strata groups for the New South Wales (NSW) Part A survey

Stratum_Group*	Net sample <i>n</i>	Contacted		Not contacted		
		Full response <i>n</i> (% of contacted)	% of Population	Refusals <i>n</i> (% of contacted)	Non-contact <i>n</i> (% not contacted)	sample loss <i>n</i> (% not contacted)
Illawarra	4,793	2,301 (85%)	8%	393 (15%)	1,695 (81%)	404 (19%)
NSW South East	3,474	1,645 (87%)	8%	247 (13%)	1,238 (78%)	344 (22%)
Victoria	2,130	1,131 (91%)	6%	117 (9%)	723 (82%)	159 (18%)
Other States/Territories	151	85 (94%)	7%	5 (6%)	47 (77%)	14 (23%)
Sydney	14,832	6,709 (84%)	4%	1,241 (16%)	5,367 (78%)	1,515 (22%)
Hunter	2,360	1,129 (84%)	3%	213 (16%)	812 (80%)	206 (20%)
Richmond/Tweed	938	508 (86%)	3%	85 (14%)	259 (75%)	86 (25%)
Mid North Coast	1,655	782 (86%)	3%	130 (14%)	559 (75%)	184 (25%)
Australian Capital Territory	816	387 (85%)	3%	66 (15%)	303 (83%)	60 (17%)
Queensland	810	523 (93%)	4%	38 (7%)	204 (82%)	45 (18%)
Central West/North	923	471 (90%)	2%	51 (10%)	304 (76%)	97 (24%)
Far West/North West	241	119 (88%)	2%	17 (13%)	77 (73%)	28 (27%)
Murray/Murrumbidgee	878	403 (85%)	2%	70 (15%)	302 (75%)	103 (25%)
Victoria/Murray	511	259 (90%)	1%	28 (10%)	171 (76%)	53 (24%)
Total	34,512	16,452 (86%)	4%	2,701 (14%)	12,061 (79%)	3,298 (21%)