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A cross continental scale comparison of Australian offshore charter boat recreational fisheries research and its applications to Marine Park and fisheries management

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EXECUTIVE SUMMARY

Recreational fisheries are complex at many levels. One specific area of complexity is reporting on various components of the sector. Alongside state-wide surveys of the general shore and boat-based recreational fishery, two other components, the charter boat (tour operator) fishery and the tournament game fishery are assessed through logbook returns in some jurisdictions. The functionality of these returns was investigated for their potential use by Australian Marine Parks (AMPs) and the Australian Fisheries Management Authority (AFMA), with Western Australia (WA) and New South Wales (NSW) used as case studies.

Charter boat fisheries became a separate, licensed fishery in WA and NSW around the year 2000. In NSW the number of licences has remained the same (~210) while in WA there was a peak in 2004/5 of 315 and a slow decline to 229 licences over the last 20 years. The charter fishery in WA went through further reforms in 2013/14 with simplification of rules to exclude reporting of shore-based fishing.

Although both states have mandatory logbook reporting for the charter fishery, WA has higher compliance (~100%) than NSW (50-60%). This may be due to non-active (latent) charter operators in NSW failing to report. Unlike the state-wide surveys, data from the charter fishery is assumed to be a census rather than a statistically generated estimate, hence results are in aggregated totals rather than estimates with errors bars.

Fishing tournament data is also collected by both states on a voluntary basis. While WA has archived data, this has not been processed to a level that is suitable for publication. NSW has a formalised process for data reporting of tournament game fishing and several recent reports have been published. Data is managed, however, by an external consultant and this was not able to be made available for analysis to this project.

Where possible, annual summaries of fishing activity from charter fishing in WA and NSW, including fishing effort and total catch, are provided in this report. Charter boat catches in WA and NSW are dominated by demersal (bottom dwelling fish) and the diversity and relative catch composition closely resembles that reported for the broader boat-based recreational fishery. The effort and numbers of fish harvested (retained) by the charter sector, however, are a small fraction of the total recreational catch. For example, the most captured fish in NSW is the bluespot flathead (*Platycephalus caeruleopunctatus*); for the charter catch this is around 30,000 fish per year, while for the recreational sector the estimated take is close to a million fish. Hence the charter fishery caught ~ 3% of the flatheads taken by the general recreational fishery.

Data from charter boats is reported at finer spatial scales than the state-wide surveys and this includes fishing within AMPs. However, data availability can be limited in some years as there was often less than 3 individual charter operators reporting, which is a requirement for maintaining confidentiality. In some parks charter operations also ceased for some years. For those AMPs where enough data was available, hot spots of fishing effort and catches for popular species could be identified down to the park zoning scale.

In the case of Ningaloo, independent small-scale spatial assessment of the entire fishery had also occurred and the reported distributions of charter effort at Ningaloo were similar in pattern to these fine scale surveys of the boat-based recreational fishery. The close correlation between the spatial distributions with specific seascapes, habitats and access points seems to be similar between the charter boat fishery and the recreational fishery more generally.

Unlike the state-wide assessments, the charter boat data is reported at much higher frequencies and finer spatial scales. It also represents a long time-series of data (20+ years). Care should be taken, however, with any calculation of trends for metrics, such as Catch per Unit Effort (CPUE), both for the charter boat and other longer terms recreational fishery time-series data. As, unlike many commercial fisheries, no adjustments have been made to standardise effort, which is known to improve in efficiency due to technological advances.

The charter boat fishery may provide a useful proxy for monitoring aspects of the general demersal recreational fisheries in AMPs. In particular, the composition and distribution of catch is at the spatial scales of interest to AMPs and the frequency of reporting is much higher than the state-wide assessments.

1. INTRODUCTION

As both fish and fishers often occupy remote, hard to reach places, fisheries, by their very nature are complex and populate a variety of domains ranging from heavy industry through to small scale commercial, indigenous, subsistence, illegal and recreational sectors. Commercial fisheries in Australia are often governed by individual transferable quotas (ITQs) and Total Allowable Catch (TAC) limits within well-defined spatial boundaries. Conversely, recreational fisheries are open access with no individual quotas and participants are free to move between jurisdictions. Generally, the demarcation between state and Commonwealth waters occurs at 3 nautical miles (nm) out to sea, with Commonwealth waters then extending to 200 nm offshore. Regulatory responsibilities for Australian fisheries are, however, shared between the Australian Commonwealth Government (herein referred to as Commonwealth) and the state governments. This is based on agreements made in 1978 when the High Court endorsed the Offshore Constitutional Settlement that enabled assignment of State, Commonwealth or joint jurisdiction on the basis of individual fisheries rather than the boundaries of State or Commonwealth controlled areas (Tilzey and Rowling, 2001).

Commercial fisheries are managed by the Commonwealth through the Australian Fisheries Management Authority (AFMA) under the Fisheries Management Act 1991, although some fisheries are managed by the relevant states under agreements with the Commonwealth, often out to 80 nm. Recently AFMA has changed its policy to more explicitly consider all forms of fish mortality when setting TAC, including those from non-commercial activities such as recreational and indigenous fishers. AFMA, however, does not collect any data on recreational fisheries as all recreational fishers, regardless of where they fish, are managed and monitored by the states (Lynch et al., 2019). Within Australia's federated systems this means that there are seven different fisheries organisations (one for each Australian State) that control and monitor recreational fishing through separate state-based legislation and monitoring programs. These programs are designed to meet each states needs but are not co-ordinated between states.

There are a variety of tools used by the states to manage recreational fishers as they utilise what is generally an open access resource. These tools may include bag (or boat) limits, minimum (or maximum) size limits, closed areas, closed seasons and gear restrictions. Each state implements these mechanisms across different spatial and temporal scales to achieve necessary management outcomes for their recreational fisheries.

There are also numerous Marine Parks located in both the state and Commonwealth waters. Of this marine park estate, Australian Marine Parks (AMPs) are a relatively recent network of multiple-use marine parks that are distributed in Commonwealth waters, sometimes adjacent to State parks but extending far offshore into Australia's exclusive economic zone (EEZ). As of July 2018 there are 58 AMPs managed by one Commonwealth agency (Parks Australia). These marine parks operate under separate Acts that restrict various activities through management plans, which often use spatial management in the form of zoning for various activities to achieve their main objectives. The main objectives of AMPs are (i) protection and conservation of biodiversity and other natural, cultural, and heritage values and ecologically sustainable use and (ii) enjoyment of the natural resources within marine parks where this is consistent with objective (i). Similar to AFMA, Parks Australia does not collect any data on recreational fishing but rather looks to form collaborations with each of the states to utilise existing data sets if they are suitable for their fisheries management of bio-diversity conservation goals (Lynch et al., 2019).

AMP managers require information on the small-scale spatial distributions of fishing effort and catch within the boundaries of their parks to help meet their objectives. At the coarsest level, there is a need for total numbers of park users and identification of their level of participation in different activities, which are important for targeting outreach, compliance, and infrastructure for parks and for both charter fishing and tournament game fishing activities. At the other end of the scale is an understanding of detailed levels of usage and catch by fishers within different park zones which are needed to ensure bio-diversity is being conserved through the management plan. AFMA focuses on the sustainable management of fish stocks harvested by commercial fishers and is therefore mainly concerned with stock surveys of individual species and the setting of sustainable quotas targets over broader spatial areas. However, understanding the take of these shared resources by the recreational sector is important for those setting these targets to properly include all fish mortality.

Both internationally and in Australia, there is considerable debate over both the status of fisheries and fisheries science as well as how this natural resource management field interacts with biodiversity conservation, especially in relation to MPAs (Worm et al., 2006; Worm et al., 2009; Edgar et al., 2018; Little et al., 2019). For both fields, accurate times-series data is required to track trends and respond to management benchmarks for either sustainable use of the resource, conservation or restoration. In the Australian context both fisheries independent data (Stuart-Smith et al., 2008; Edgar et al., 2018) and historical marine ecology (Frijlink and Lyle, 2013; Thurstan et al., 2016) have shown declines in fish stocks targeted by the recreational fishery and this is of agreed concern by both fields.

In Australia, participation in the recreational sector is large by global levels (Hyder et al., 2018) and this complicates the collection of fisheries data due to the scale of participation, as within individual fisheries there can be hundreds of thousands of recreational fishers compared to only dozens to low hundreds of commercial fishers. This large scale of participation by the recreational sector means that sampling, rather than census, is required and the cost of this has restricted the availability of data. With the exception of one baseline study (Henry and Lyle, 2003) there has been no regular national survey of recreational fishing. Many states have, however, conducted repeated state-wide surveys using similar methods (Lynch et al., 2019), though these are un-coordinated between states and often sporadic (Thurstan et al., 2016). State-wide surveys generally use broad scale off-site methods (traditionally telephone surveys through licence databases or the white pages to contact fishers that then maintain diaries of their fishing activity), which are sometimes combined with on-site methods (e.g. on-site boat ramp creel interviews) to collect biological data (Ryan et al., 2017). Sampling usually includes repeated interviews throughout the survey period to reduce recall bias, with 1,000 – 2,000 individuals of the multiple hundreds of thousands of recreational fishers in each state.

State-wide surveys do not report data from charter (tour operator) fishing. Rather, self-reporting this information by the charter boat fishery is a legislated requirement and obtained via mandatory logbook reporting. Charter fishing is a commercial business which, for a fee, provides recreational fishers with a fishing platform and the services of a professional skipper from which to access fish resources (Thurstan et al., 2016). This occurs predominately from boats and the skipper strives to maximise the success rate of their clients' fishing activity (Steffe et al., 1999). These charter boats generally have a larger capacity (up to 20 people) than recreational boats. Historically, much of the boat-based recreational and commercial nearshore fishing would have been on vessels chartered by fishing parties. It is only relatively recently that there has been a legislative separation between recreational, charter and commercial fisheries, with the final

separation of the charter fishery into its own sector in the late 1990 to early 2000s (Thurstan et al., 2016).

Technically, fishers engaged in fishing competitions or tournaments are included in the state-wide survey if a respondent participated in a tournament (Lynch et al., 2019). However, tournaments are often a localised concentration of fishing effort across both time and space (Flynn et al., 2018) by a small subset of the general fishing population and game fishing is a smaller sub-set again of tournaments (Henry and Lyle, 2003; Morton and Lyle, 2004; Zischke et al., 2012). This means that while tournament fishing may contribute considerable effort for specialised fisheries (e.g. game fishing) they will have a low probability of being captured in the state-wide surveys (Griffiths et al., 2010). More specialised off-site surveys, such as those based on data frames drawn from maritime authorities' registration lists of power-boats of sizes greater than 4m in length, have been used to more precisely target game fishing by recreational fishers (Tracey et al., 2013). In many cases data is collected in the records of the fishing clubs that hold game fishing tournaments (Ghosn et al., 2012; Ghosn et al., 2015) through such mechanisms as the Gamefish Tournament Monitoring Program (GTMP) in NSW (Lowry and Murphy, 2003).

Unlike charter fishers, that are mostly focused on demersal fish, game fishers are likely to account for a large proportion of recreational pelagic fishing effort, most of which occurs outside of state waters (>3 nm offshore) (Lowry and Murphy, 2003). Those involved in game fishing will have additional incentives to target offshore species through points, bonuses and trophies. Species targeted include pelagic sharks (Heard et al., 2016), marlins, sailfish, tunas and kingfish (Lowry and Murphy, 2003; Tracey et al., 2013; Moore et al., 2015; Hill et al., 2016). Catch and release fishing is widely practised at game fishing tournaments in Australia though rates differ across species, locations and time.

This study, which investigates charter and game fishing tournament fishing, follows on from previous work which assessed the usefulness of survey data collected from the Western Australia (WA) and New South Wales (NSW) state-wide surveys to describe recreational fishing within selected AMPs and for AFMA species of interest (Lynch et al., 2019). Unlike the sampling approach used to investigate most aspects of recreational fishing, the charter boat and tournament datasets are a census (so a complete dataset rather than a sub-sample) and with a much stronger temporal replication over multiple years.

By reviewing the available information for charter and tournament fishing we will attempt to gain a more complete picture of the recreational fishery. We do this by using research conducted in WA and NSW as case studies to ascertain if these data meet the information needs of both AMPs and AFMA. The general aims of this study included; (i) a comparison of state-based approaches for data collection of the charter and tournament fisheries in WA and NSW, (ii) a summary of state-wide catch for nine species of interest to AFMA in each state, and (iii) a summary of fishing activity, including fishing effort and catch (all species; key species) occurring within nominated AMPs of interest in both states.

2. METHODS

The methods and scope of works was based on a workshop held between NESP partner organisations (CSIRO, NSW DPI) and invited stakeholders (WA DPIRD) and experts (FRDC, AFMA, Department of Agriculture, Water and the Environment (DAWE), Charter fisher's representative) in Sydney and from follow-up meetings between DAWE and CSIRO in Hobart.

2.1 Charter sector comparison

A comparison of the legislative framework, and data collection methods for the charter (tour operator) industry occurring in WA and NSW was undertaken, including timelines for their development. We also compared data collection methods and metadata such as data variables collected, their spatial and temporal scale and confidentiality requirements. Endorsements and other legal frameworks were also considered as were the rates of returns of logbook data to the different state regulators.

2.2 Game fishing tournaments comparison

A comparison of the methods used for obtaining data from game fishing tournaments was also undertaken. These included the current rate of engagement and pathways for data reporting to the fishery departments. Where reporting was occurring, we looked at reporting frequency and the spatial and temporal scales. Gross target species and fishing methods used, and a description of the licensing/permitting requirements and conditions for game fishing tournaments were also considered. We also assessed data availability.

2.3 Data confidentiality

The confidentiality agreement between charter operators and both DPIRD and NSW DPI requires that a level of anonymity be retained in any analysis of this data. To satisfy the confidentiality agreement, whenever <3 charter operators are recorded as having actively fished within the spatial and temporal period of interest, the data may not be reported at that level of detail.

2.4 State-wide data summaries

An annual time-series is provided for the number of charter operators (active and latent) and fishing effort and catch (retained and released) occurring state-wide. Catch was summarised for all species and for key finfish species as well as by functional habitat groups (nearshore, offshore, estuarine etc.) but these functional habitat groups are not consistent between states. The species diversity of the state-wide catch was also considered, providing the proportions for the major components of the catch.

In WA Fishing effort by charter operators was measured as number of days fished and includes days with no fish caught. It is also important to note that there may be multiple fishing sessions per day on the same charter (i.e. when a charter operator changes location or fishing methods)

and, also multiple fishing charters per day (i.e. when a charter operator returns to a marina/boat ramp to pick up a new group of fishing clients).

In NSW fishing effort was measured in hours fished on individual trips, which were recorded onto logsheets. Each sheet represents an individual trip and not always individual days. There may be multiple fishing sessions per day on the logsheet (i.e. when a charter operator changes location or fishing methods) but each new charter trip will have a new sheet.

2.4.1 Temporal resolution

Although regulation of the WA charter operator industry commenced in mid-2001 (Department of Fisheries, 2012) data reports collected prior to July 2002 are incomplete. We therefore summarised charter operator's numbers between financial years 2002/03 - 2017/18, as all licences are renewed annually on 30 June. The remainder of analysis on catch and effort are reported as calendar year, which is consistent with current internal reporting that occurs within DPIRD.

In NSW regulation of the charter operator industry commenced in 2000 (McIlgorm and Pepperell, 2014). Since 2000 there have been many changes to how charter operators log their trips and how the data was managed by NSW DPI. Therefore, data collected prior to July 2009 are not reported due to inconsistencies that do not allow for reliable temporal comparisons. However, there has consistently been 210-211 operators fishing in NSW since 2000. The effort data presented in this report are from 2009/10 to 2018/19 financial years, as all licences are renewed annually on 30 June. The remainder of analysis are reported as calendar year, which is consistent with Western Australian data. Prior to 2016 there was no validation of the catch numbers and due to some questionable catch numbers (pers obs), catch is only reported from 2016–2019.

2.4.2 Habitat

In WA Species retained by charter operators were summarised by broad ecological habitats associated with Ecosystem Based Fisheries Management strategies implemented in Western Australia (Department of Fisheries, 2011). Management regulations, including bag and size limits, for finfish species are categorised according to their aquatic environment (DPIRD, 2019). These habitat types have also been used in reporting of boat-based recreational catches (Ryan et al., 2017) and are defined as:

- Estuarine: estuarine waters up to the mouth of a river
- Nearshore: from the beach up to 20 m depth
- Inshore demersal: bottom dwelling species found in 20 –250 m
- Offshore demersal: bottom dwelling species found in 250 m - to the edge of the EEZ (200nm)
- Pelagic: surface dwelling 'above' demersal species from 20 m – to the edge of the EEZ (200 nm)

For the purposes of this reporting, Nearshore and Estuarine have been combined (herein referred to as Nearshore) and Inshore and Offshore Demersal have been combined into a single 'Demersal' category, which is consistent with current internal reporting that occurs within DPIRD.

Charter operators in NSW are not generally limited by geography (e.g. depth, distance from shore) nor are they required to record habitat. Rather individual license endorsements are associated with specific groups of species. Some license holders may hold more than one endorsement but within each log sheet, they are required to note the endorsement that is being fished.

The endorsements are:

- Estuarine fishing
- Nearshore bottom and sportfishing
- Deep sea fishing
- Gamefishing

For the lists of species and definitions see these two websites:

<https://www.dpi.nsw.gov.au/fishing/recreational/resources/charter/background>

and

<https://legislation.nsw.gov.au/#/view/regulation/2019/407/part12>

The exception to the species specific endorsement are for estuarine fishing which have to occur in an estuary. Estuaries within NSW waters were defined according to Roy et al. (2001). This classification system includes several large ocean embayment's or semi-enclosed bays that are characterized by marine waters with little fresh water inflow, e.g. Botany Bay, Jervis Bay, Batemans Bay and Twofold Bay.

In both states charter catch (both retained and released) for the 9 AFMA species of interest over time was reported: gummy sharks (*Mustelus antarcticus* & *M. stevensi*), school sharks (*Galeorhinus galeus*), southern bluefin tuna (*Thunnus maccoyii*), yellowfin tuna (*Thunnus albacares*), striped marlin (*Kajikia audax*), broadbill swordfish (*Xiphias gladius*), blue-eye trevalla (*Hyperoglyphe antarctica*), pink ling (*Genypterus blacodes*), gemfish (*Rexea solandri*), bluespotted flathead (*Platycephalus caeruleopunctatus*) and deepwater flathead (*Neoplatycephalus conatus*).

2.5 Marine Park data summaries

The data were summarised to investigate charter fishing within selected AMPs in WA (Jurien Marine Park, Perth Canyon Marine Park and Ningaloo Marine Park) and NSW (Hunter Marine Park and Solitary Islands Marine Park).

Similar to the state-wide data summaries, an annual time-series for the number of operators (active and latent), fishing effort and catch (retained and released) occurring within each AMP for charter boats, where possible, was provided. Catch was summarised for all species and for key finfish species as well as by functional habitat groups. The species diversity of the state-wide catch was also considered, providing the proportions for the major components of the catch. Where sufficient data was available, then maps of the distribution of fishing effort and catch within AMPs were provided.

3. RESULTS

3.1 Charter sector comparison

Both states showed similar evolutions of reforms and regulation of their charter boat fisheries (Tables 1 and 2). This began in the early 1990s with management workshops, working groups and studies of the industry. Regulation of the industry occurred in the early 2000s in WA and NSW.

Both states have licences but following reforms in the mid-2000s WA decreased their number of licence categories to 2, removing the reporting requirement for shore-based fishing charters in 2014, while NSW has 4 categories. Both states have mandatory logbook reporting system, but the rate of reporting is much higher in WA (99%), compared to NSW (63%). Reporting is monthly and at spatial scales of 5 x 5 nm blocks in WA and 6 x 6 minutes blocks in NSW (equivalent to 6 nm).

Table 1 Timeline of key events and reports for the Western Australian charter boat fishery.

Year	Event	Reference
1990	Estimated 40 fishing charter operators.	(Millington, 1993)
1993	National charter boat management workshop held in NSW with the proceedings published by WA.	(Magee and Prokop, 1993)
1998	Estimated 135 fishing charter operators.	FMP 116 (TOFWG, 1998)
2000/01	The charter industry accounted for 2% of the total recreational catch of scale fish in Western Australia.	(Henry and Lyle, 2003)
2001 (July)	Industry regulated, with the charter boat fishery becoming a restricted access fishery.	(Telfer, 2010)
2010	First assessment of charter logbook data (2002/03 to 2007/08), high latency in effort.	(Telfer, 2010)
2012	Reform of the industry to: simplify regulation, reduce latent effort, separate charter fishing from Aquatic charters (eco-tourism).	FMP 258 (Department of Fisheries, 2012)
2019	207 Fishing Charter Operator Licences (focus on fishing, with clients able to land fish within recreational fishing regulations). 21 Restricted Fishing Charter Licences (focus on eco-tourism activities, with clients able to land a fish for a meal. No fish to be landed or retained beyond the duration of the trip). Across both licence classes there was 99% monthly return rate for logbooks.	Annual Report (DPIRD, 2019)

Table 2 Key timeline events and reports for the New South Wales charter boat fishery.

Year	Event	Reference
1993-1994	First attempt to quantify level of charter boat fishing in NSW. Estimated 11,103 boat trips.	(Steffe et al., 1996; DPIRD, 2019)
1998	211 fishing charter operators managing up to 249 boats.	(Steffe et al., 1999)
1999	It was reported that the charter boat fishing industry in NSW needs to be monitored to ensure a sustainable future.	(Steffe et al., 1999)
2000	Charter boat fishery became restricted access.	(McIlgorm and Pepperell, 2014)
2000	276 licences issued.	(McIlgorm and Pepperell, 2014)
2012	211 potentially active operators of which 63 % completed and returned logbooks.	(McIlgorm and Pepperell, 2014)
2017	Trial of on-board independent observer program on south coast.	Julian Hughes pers comms
2018	Roll out of independent observer program across NSW for nearshore charter operators.	Julian Hughes pers comms

Table 3 Survey elements and output specifications for charter boat operators in Western Australia and New South Wales.

Element	Item	Western Australia	New South Wales
Regulations	Boat	Charter operator licence (may be licensed in multiple bioregions).	Recreational charter fishing boat licence
	Licence types	2 categories (Charter operator licence & Restricted fishing charter licences)	4 categories (Estuarine, nearshore bottom fishing and sportfishing, game fishing, deep sea bottom fishing)
	Person	No licence required	Required to carry recreational fishing licence (RFL) unless charter boat operator has an exemption certificate
	Output controls	Daily bag, possession, size and gear limits	Daily bag, possession, size and gear limits
Data collection	Method	Mandatory logbook	Mandatory logbook and observer program
	Sample	Census	Census
	Return rates	99%	54-60%
Activities	Platform	Shore [^] and Boat	Boat
	Boat type	Charter operator vessels	Charter operator vessels
	Methods	All allowed recreational methods including line fishing, SCUBA diving, hand collection and spearfishing	All allowed recreational methods including line fishing, breath hold diving, hand collection and spearfishing
Persons in scope	Residency	WA residents, interstate and international visitors	Charter boat operator clients include NSW residents, interstate and international visitors
	Age	All	All
Species	Species	All aquatic (animal) species	All aquatic (animal) species
	Catch	Retained and released	Retained. Observer program collects limited data on released.
	Length	Random sample	None
Geographic scope	Fishing activity	5 x 5 nm block; fishing sites	6 x 6 minutes of long and lat.
	Fishing access	All (except sanctuary zones)	All (except sanctuary zones)
Temporal scope	Duration	Monthly	Monthly
	Coverage	All	All

Element	Item	Western Australia	New South Wales
Reporting	Confidentiality	Minimum 3 operators required	Minimum 3 operators required
	Fishing effort	Fishing days	Hours fished and number of anglers
	Total catch	By number for all species or by weight *	By number for all species, by weight for key species *

^ shore data only collected until 2014

* weights calculated using random length samples and length-weight equations for each species derived from secondary sources.

3.2 Game fishing tournament comparison

In WA, the then Department of Fisheries (DoF) launched a Recreational Angler's Daily Logbook Program in March 2004 as part of the Research Angler Program (RAP). The initial research from data collected in 2004-2020. Data from 2004-2006 was published as a departmental report (Smith et al., 2007). However, while data was still collected there has been no further reporting since this time and it is not currently available to be released.

Table 4 Timeline of key events in the Game Fishing Competition in New South Wales

Year	Event	Reference
1973	Gamefish tagging program established	(Murphy JJ, 2002)
1993	First year of data reported from NSW recreational game fishing competitions	(Murphy JJ, 2002)
2002	Gamefish tournament monitoring program report released	(Murphy JJ, 2002)
2003	39,021 angler trips from 1996 to 2000 analysed and published in Marine and Freshwater Research	(Lowry and Murphy, 2003)
2007	First decade of Gamefish tournament monitoring program data analysed and reported (1993-94 to 2004-05)	(Park, 2007)
2012	A socioeconomic evaluation of three eastern Australian game-fishing regions report released	(Ward P, 2012)
2016	Gamefish tournament monitoring program report released	(Ghosn et al., 2015)

Table 5 Survey elements and output specifications for game fishing tournament fisheries in New South Wales.

Element	Item	New South Wales
Regulations	Boat	RFL, Roads and Maritime, Club and tournament regulations
	Licence types	RFL
	Person	Must hold RFL if fishing
Data collection	Output controls	Club and tournament regulations
	Method	Self-imposed mandatory radio reporting system and random interviews for monitored competitions but not all
	Sample	Radio reporting- All Post fishing interviews- Random
Activities	Platform	Boat
	Methods	Line fishing
Persons in scope	Residency	NSW, interstate and international participants
	Age	All
Species	Species	Mainly, billfish, tunas and sharks
	Catch	Catch rates
	Length	All lengths
Geographic scope	Fishing activity	All – reported using 6x6 minutes of long and lat.
	Fishing access	All (except sanctuary zones)

Element	Item	New South Wales
Temporal scope	Duration	Summer and autumn
	Coverage	All NSW
Reporting	Confidentiality	Minimum 3 operators required
	Fishing effort	No. boats
	Total catch	All billfish, tunas and sharks numbers and weights. Estimated all other species numbers and weights.

In NSW, a program of tag and release within game fishing tournaments commenced in 1973 (Table 4) to provide basic biological data on movements and age and growth of species. Data collection on catch and effort commenced in the 1993/94 fishing season with the NSW DPI Gamefish Tournament Monitoring Program (GTMP) (Table 5). This data is held by a third-party consultant to NSW DPI and was not made available for this report.

3.3 State-wide data summary: Western Australia

3.3.1 Number of charter operator licences

The number of active charter operator licences have consistently been lower than total number of licences, which indicate a proportion are unused or 'latent' in each financial year (Figure 1). The total number of current charter operator licences was highest in 2004/05 (315) and has remained relatively steady from 2014/15–2017/18. A reduction in licences between 2013/14 and 2014/15 (260 to 229 licences) was due to the implementation of recommendations from the review of the charter operator industry, including reducing the number of categories which required licences, such as land-based charter operators (Department of Fisheries, 2016).

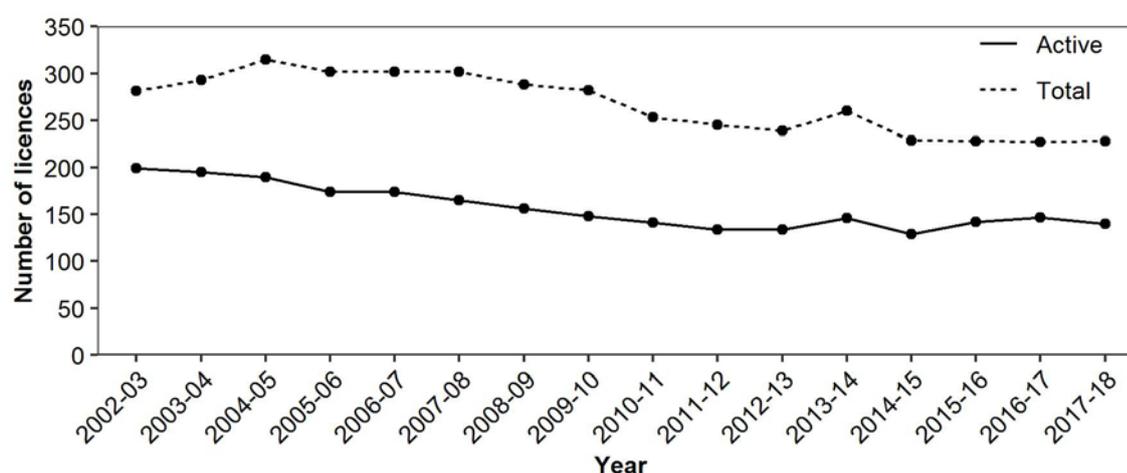


Figure 1 Total number of charter operator licences and active licences in Western Australia by financial year from 2002/03 to 2017/18.

3.3.2 Total effort by year

Fishing effort by charter operators in Western Australia was highest in 2003 (10,469 days) and has remained relatively steady from 2005–2018 (Figure 2).

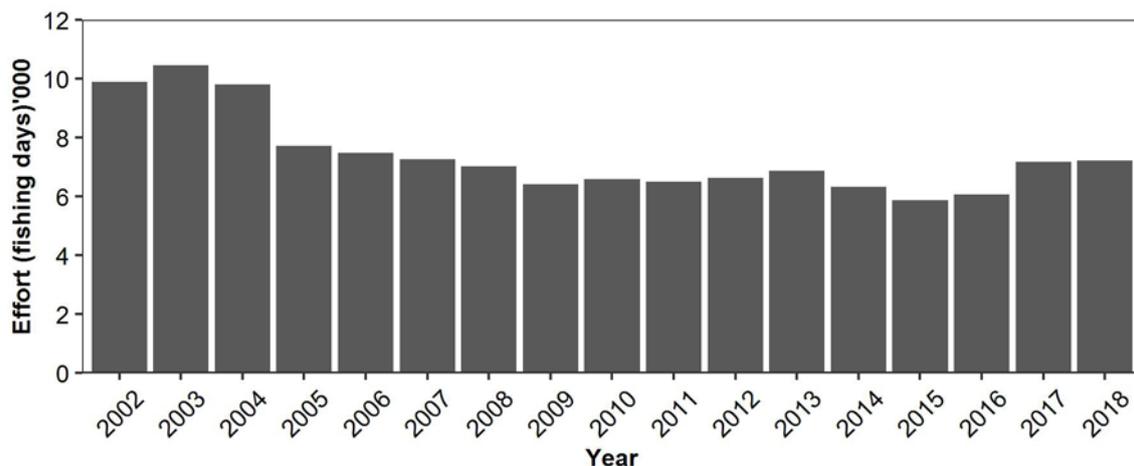


Figure 2 Fishing effort (as number of days fished) as reported from Charter Operator Returns in Western Australia from 2002–2018.

3.3.3 Catch (all finfish species) by year

Catch has been reported for finfish species only and calculated as retained and released number of fish. Retained catch remained steady from 2009–2018, from a peak in 2003 (136,622 fish, all species combined) (Figure 3)). Released catch has varied across years, with the lowest released catches occurring from 2007–2009 and 2016–2018.

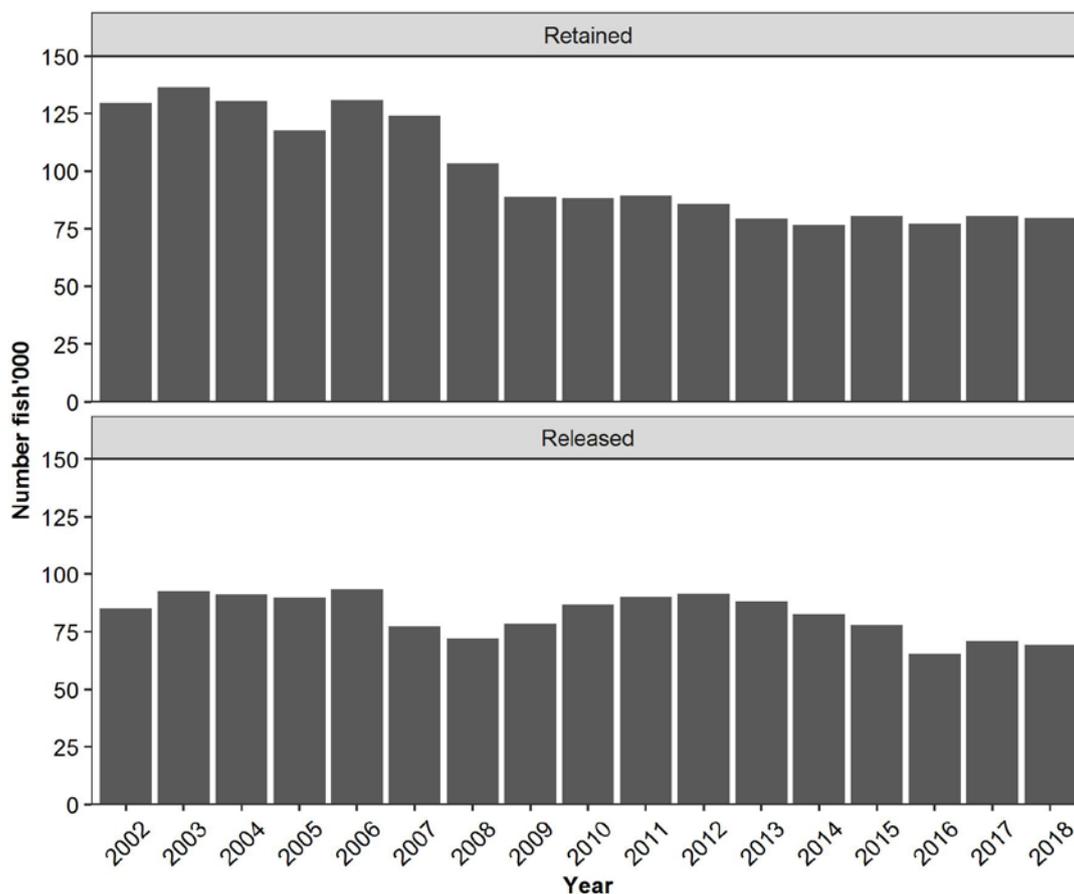


Figure 3 Retained and released catch (as number, all species combined) as reported from Charter Operator Returns in Western Australia from 2002–2018.

The decrease in retained catch from 2003–2009 corresponds to the implementation of significant changes to the management of demersal species (particularly popularly targeted species such as West Australian dhufish, pink snapper, breaksea cod and baldchin groper) which is likely to have reduced retained catches after this period (Crowe et al., 2013; Ryan et al., 2016).

3.3.4 Catch (by finfish species) by year

There were >400 species (and family groupings) of finfish recorded as retained or released by charter operators in 2002–2018. The top 30 species retained by charter operators comprise 82% of the retained catch across all years (Table 6), with Pink Snapper (*Chrysophrys auratus*) contributing the largest retained catch (16%) across all species.

Table 6 Top 30 species (and family groupings) retained, with percentage each species contributes to the retained catch of all species, as reported from Charter Operator Returns in Western Australia from 2002–2018.

Rank	Habitat	Common Name	Species Name	% Retained
1	Demersal	Pink Snapper	<i>Chrysophrys auratus</i>	16
2	Demersal	Redthroat Emperor	<i>Lethrinus miniatus</i>	6
3	Demersal	Spangled Emperor	<i>Lethrinus nebulosus</i>	5
4	Demersal	Bight Redfish	<i>Centroberyx gerrardi</i>	5
5	Demersal	Red Emperor	<i>Lutjanus sebae</i>	4
6	Demersal	Breaksea Cod	<i>Epinephelides armatus</i>	3
7	Demersal	Grass Emperor	<i>Lethrinus laticaudis</i>	3
8	Demersal	Baldchin Groper	<i>Choerodon rubescens</i>	3
9	Demersal	Rankin Cod	<i>Epinephelus multinotatus</i>	3
10	Nearshore	Silver Trevally	<i>Pseudocaranx georgianus spp complex</i>	3
11	Demersal	West Australian Dhufish	<i>Glaucosoma hebraicum</i>	3
12	Demersal	Golden Snapper	<i>Lutjanus johnii</i>	3
13	Demersal	Swallowtail	<i>Centroberyx lineatus</i>	2
14	Demersal	Emperors	<i>Lethrinidae – undifferentiated</i>	2
15	Demersal	Goldband Snapper	<i>Pristipomoides multidentis</i>	2
16	Demersal	Saddletail Snapper	<i>Lutjanus malabaricus</i>	2
17	Demersal	Mangrove Jack	<i>Lutjanus argentimaculatus</i>	2
18	Demersal	Crimson Snapper	<i>Lutjanus erythropterus</i>	2
19	Demersal	Blue Morwong	<i>Nemadactylus valenciennesi</i>	2
20	Pelagic	Spanish Mackerel	<i>Scomberomorus commerson</i>	2
21	Demersal	Barcheek Coral Trout	<i>Plectropomus maculatus</i>	1
22	Nearshore	Barramundi	<i>Lates calcarifer</i>	1
23	Demersal	Stripey Snapper	<i>Lutjanus carponotatus</i>	1
24	Demersal	Sea Sweep	<i>Scorpius aequipinnis</i>	1
25	Demersal	Rosy Snapper	<i>Pristipomoides filamentosus</i>	1
26	Nearshore	Chinaman Rockcod	<i>Epinephelus rivulatus</i>	1
27	Demersal	Robinson's Seabream	<i>Gymnocranius grandoculis</i>	1
28	Pelagic	Samsonfish	<i>Seriola hippos</i>	1
29	Demersal	Northern Pearl Perch	<i>Glaucosoma buergeri</i>	1
30	Demersal	Longnose Emperor	<i>Lethrinus olivaceus</i>	1
TOTAL				81

3.3.5 Catch (by habitat) by year

Summaries of the retained catch by habitat for the 30 most commonly captured species showed that demersal species (91%) dominated the catch, followed by nearshore (6%) and pelagic (3%). This dominance of demersal species in the retained catch was consistent across years (Figure 4.). The decrease in catch of demersal species around 2007–2009 corresponds to the implementation of significant changes to the management of demersal species, particularly indicator species such as West Australian dhufish (*Glaucosoma hebraicum*), pink snapper, breaksea cod (*Ephinephelus multinotatus*) and baldchin groper (*Choerodon rubescens*), which is likely to have reduced retained catches after this period (Crowe et al., 2013; Ryan et al., 2016).

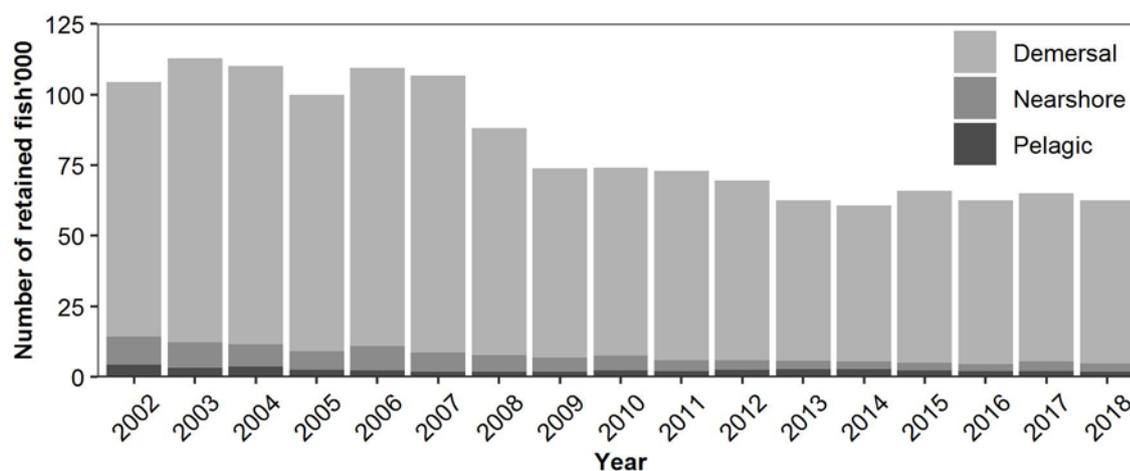


Figure 4 State-wide retained catch (as number, all 30 most caught species combined) by habitat group as reported from Charter Operator Returns in Western Australia from 2002–2018.

3.3.6 AFMA species of interest – catch (retained and released)

The distribution of the bluespotted flathead does not extend into WA waters so no catch data are therefore available. Although their distribution does extend into WA waters, there are no records for gemfish and deepwater flathead in the charter operator database. Catch records for blue-eye trevalla, pink ling and swordfish have been recorded by less than 3 charter operators in all years and cannot be reported due to confidentiality requirements.

In Western Australia, catches for five species of interest have been reported (gummy sharks, school sharks, southern bluefin tuna, yellowfin tuna and striped marlin) (Figure 5). There are some years where data were recorded by less than 3 charter operators and cannot be reported due to confidentiality requirements (indicated by <3).

The majority of gummy shark was from retained catches, with the highest retained catch in 2004 (258) and retained catches of <100 from 2007–2018. Similar numbers of school shark were retained (396) and released (328) across all years, with the highest retained catch in 2003 (89) and highest released catch in 2007 (85). The majority of yellowfin tuna was from released catches, with high released catches occurring in 2004, 2010 and 2015. Southern bluefin tuna was predominantly retained by charter operators, with the highest retained catch in 2010 (144). Insufficient logbook data were available to report catches of striped marlin for 7 years, however,

catches in other years were small (<35) and these catches were predominantly released by fishers.

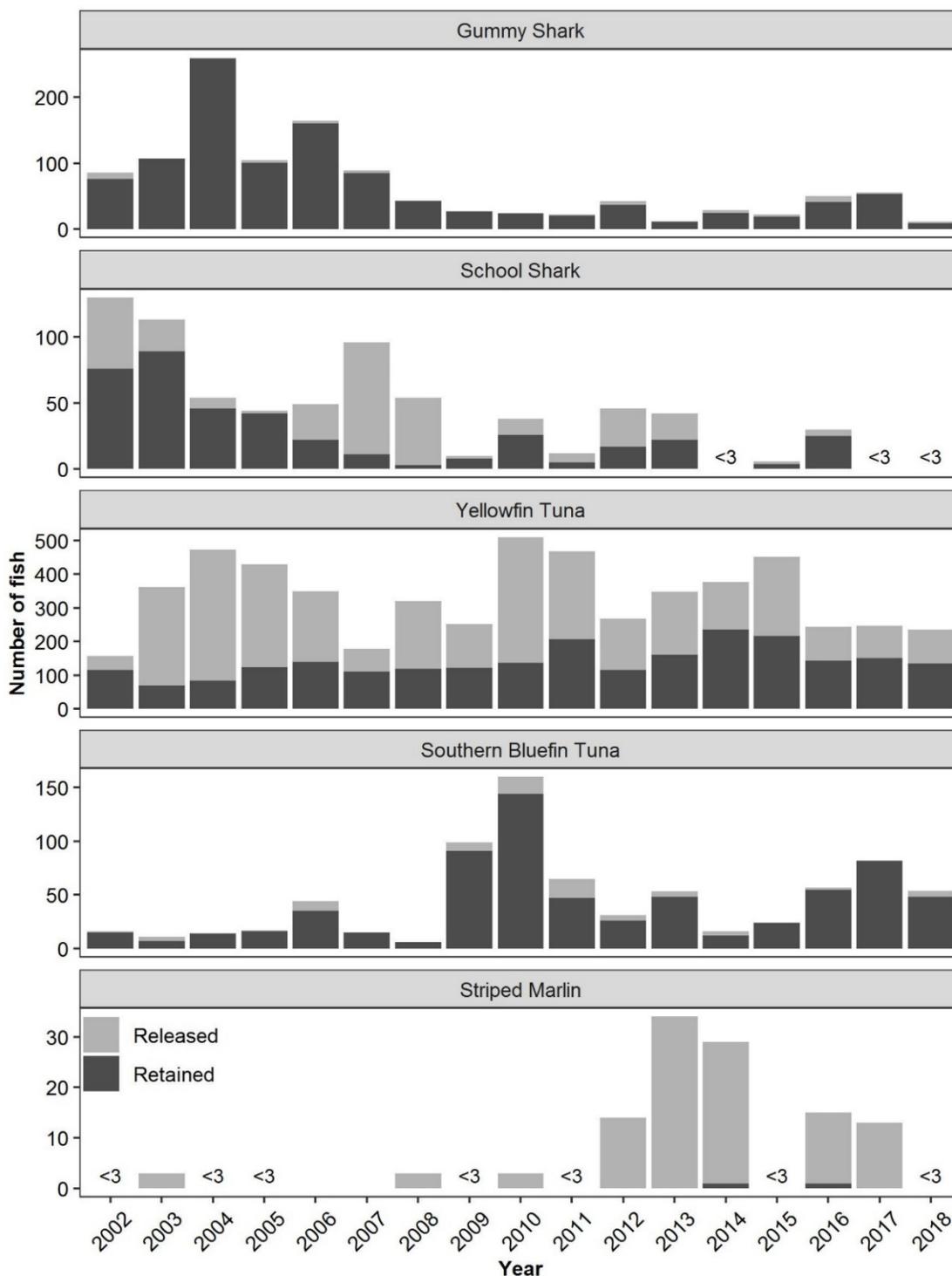


Figure 5 State-wide retained and released catch (as number) for AFMA species of interest as reported from Charter Operator Returns in Western Australia from 2002–2018. Note: different y-axis scales for each species; <3 indicates data could not be reported due to confidentiality (reported by less than 3 charter operators).

3.4 State-wide data summary: New South Wales

3.4.1 Number of charter operator licences

The number of licensed charter operators in NSW licences has consistently remained between 210 and 211 since the inception of licensing in 2000. However, the number of logbooks returned has been consistently low (50-60% return rate) despite the process being compulsorily. Still, the return rate has been consistent for the past ten years (Figure 6).

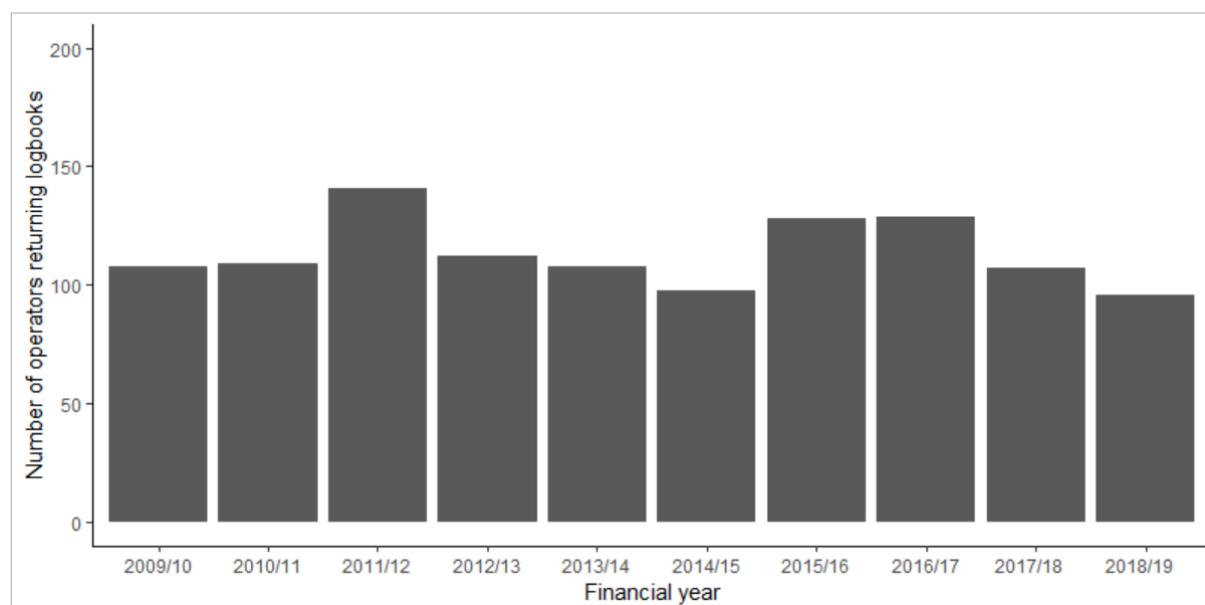


Figure 6 The number of licensed operators in NSW that have returned a logbook for each year from 2009/10 to 2018/19 financial years.

3.4.2 Total effort by year

Fishing effort from charter operators was measured from hours recorded on log sheets submitted to NSW DPI. Each sheet represents an individual trip and not always individual days. Noting that only 50-60% of operators are submitting log sheets, suggesting that this may a) only represent half the actual charter fishing effort that is occurring in NSW or b) be a proxy for latency. The number of logged hours has remained relatively consistent across the past ten years (Figure 7).

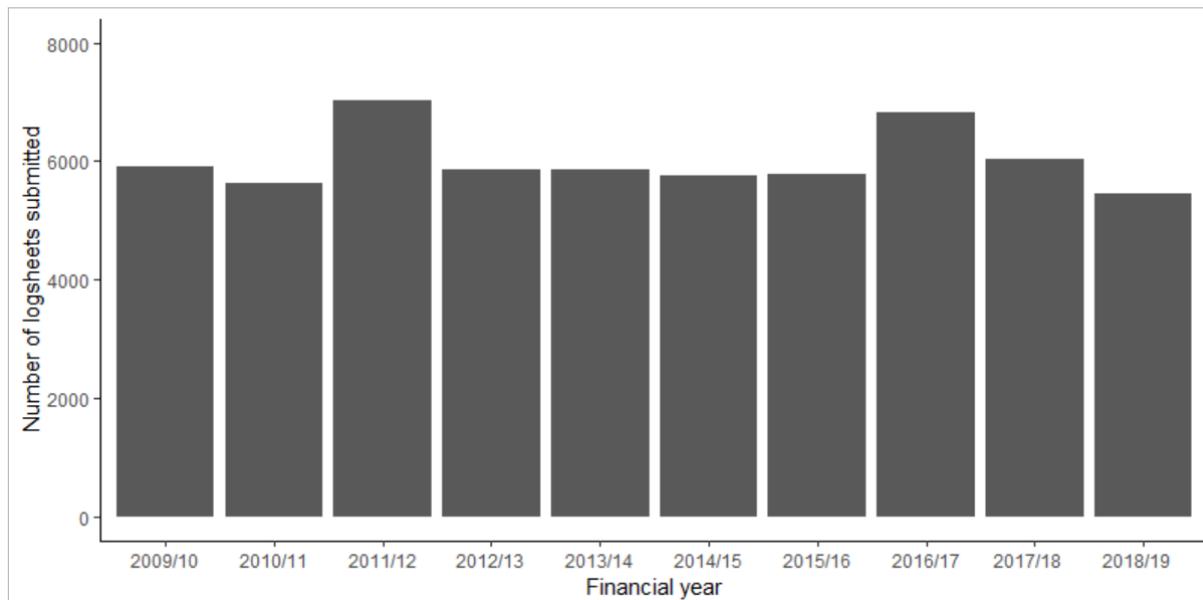


Figure 7 Number of log sheets submitted as reported from charter operators in New South Wales from 2009/10 to 2018/19 financial years.

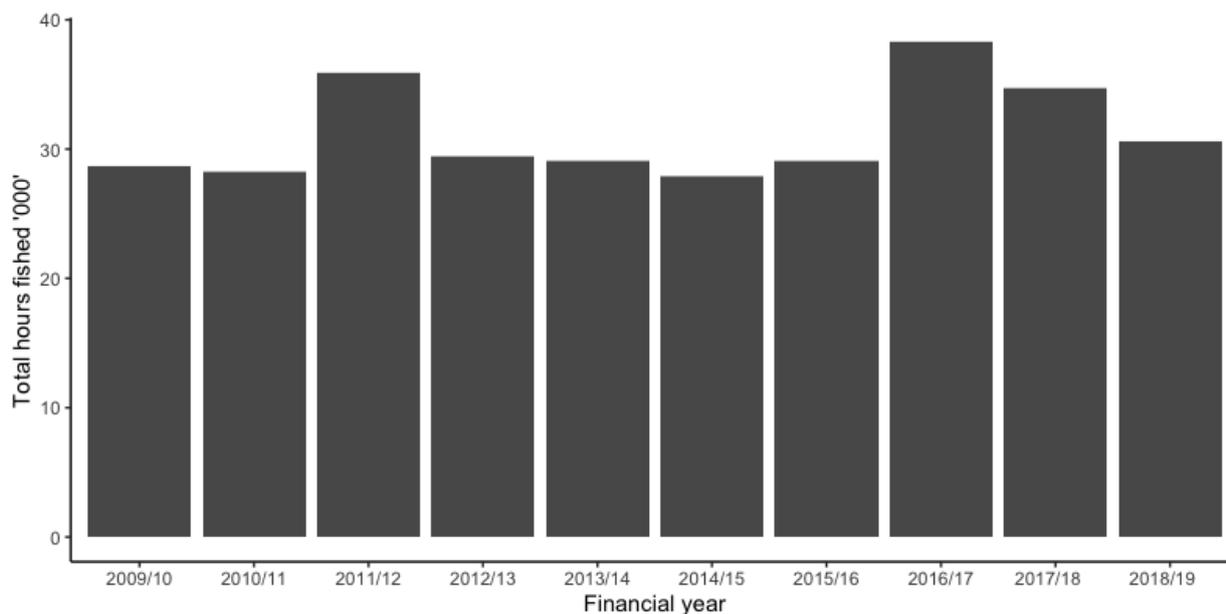


Figure 8 Total number of hours fished as reported from charter operators in New South Wales from 2009/10 to 2018/19 financial years.

3.4.3 Catch (all finfish species) by year

Catch has been reported for all finfish species that are retained. Since 2016, charter operators were only required to report retained catch and not released catch. Over the past three years there has been a small decline in catch that correlates with a small decline in effort. In the 2016/17, 186,023 fish were retained through charter fishing, compared to 159,538 fish in the 2018/19 year (Figure 9).

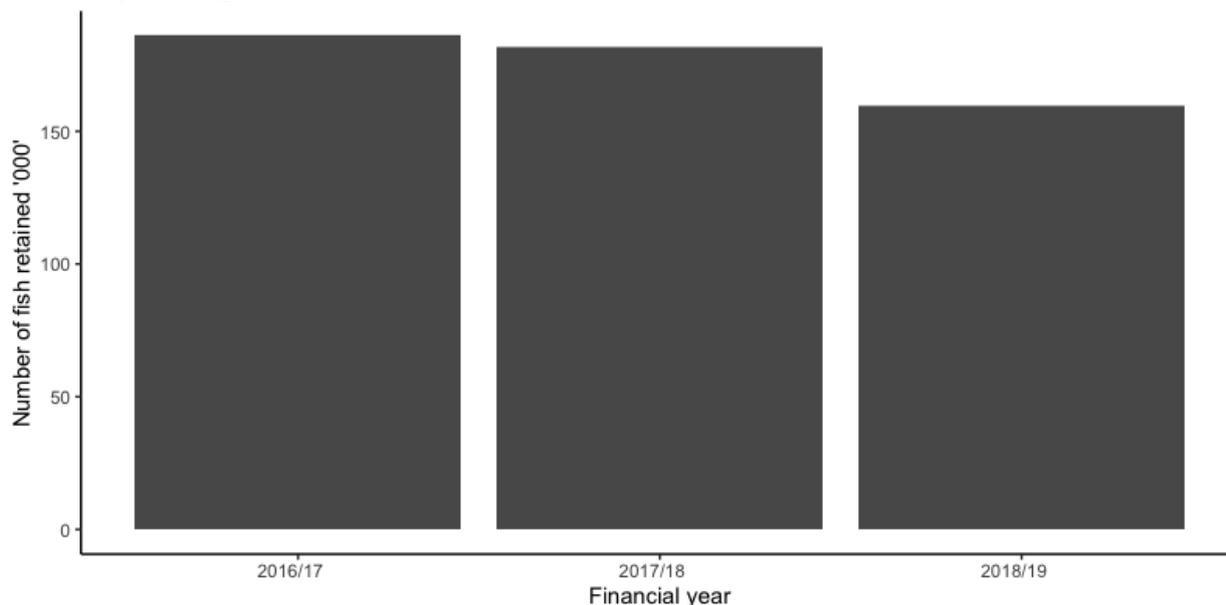


Figure 9 Retained catch (as number, all species combined) as reported from Charter Operator Returns in NSW 2016/17 – 2018/19.

3.4.4 Catch (by finfish species) by year

Reliable catch data is only available from 2016 to 2019. There were 212 species (and family groupings) of finfish recorded as retained by charter operators between 2016 and 2019. The bluespotted flathead was the highest retained fish (19% of all retained fish), closely followed by the pink snapper (14% of all retained fish). These 30 species made up 90% of the total catch retained in NSW.

Table 7 Top 30 species (and family groupings) retained, with percentage each species contributes to the retained catch of all species, as reported from charter operator logbooks in NSW from 20016/17 to 2018/19.

Rank	Common name	Species name	% Retained
1	Bluespotted Flathead	<i>Platycephalus caeruleopunctatus</i>	19
2	Pink Snapper	<i>Chrysophrys auratus</i>	14
3	Blue Morwong	<i>Nemadactylus douglasii</i>	8
4	Yellowtail Scad	<i>Trachurus novaezelandiae</i>	6
5	Blue Mackerel	<i>Scomber australasicus</i>	5
6	Flatheads - undifferentiated	Platycephalidae	4
7	Ocean Jacket	<i>Nelusetta ayraudi</i>	4
8	Teraglin	<i>Atractoscion aequidens</i>	3
9	Yellowtail Kingfish	<i>Seriola lalandi</i>	3
10	Redfish	<i>Centroberyx affinis</i>	3
11	Silver Sweep	<i>Scorpius lineolate</i>	3
12	Dusky Flathead	<i>Platycephalus fuscus</i>	3
13	Tiger Flathead	<i>Platycephalus richardsoni</i>	3
14	Pearl Perch	<i>Glaucosoma scapulare</i>	2
15	Southern Maori Wrasse	<i>Ophthalmolepis lineolatus</i>	2
16	Silver Trevally	<i>Pseudocaranx dentex</i>	1
17	Leatherjacket - undifferentiated	Meuschenia spp	1
18	Mahi Mahi	<i>Coryphaena hippurus</i>	1
19	Eastern Pigfish	<i>Bodianus unimaculatus</i>	1
20	Australian Bonito	<i>Sarda australis</i>	1
21	Sergeant Baker	<i>Aulopus purpurissatus</i>	1
22	Venus Tuskfish	<i>Choerodon venustus</i>	1
23	Eastern Red Scorpionfish	<i>Scorpaena jacksoniensis</i>	1
24	Tailor	<i>Pomatomus saltatrix</i>	1
25	Yellowfin Bream	<i>Acanthopagrus australis</i>	1
26	Grunter - undifferentiated	Haemulidae except Pomadasys spp	<1
27	Sixspine Leatherjacket	<i>Meuschenia freycineti</i>	<1
28	Marbled Flathead	<i>Platycephalus marmoratus</i>	<1
29	Reef Ocean Perch	<i>Helicolenus percoides</i>	<1
30	School Mackerel	<i>Scomberomorus queenslandicus</i>	<1
		Total	90

3.4.5 Catch (by endorsement) by year

Unlike WA, the fisheries in NSW are not divided into habitat type. However, charter operator endorsement does provide some information in habitat fished as either being near shore bottom, deep sea bottom, game fishing (could be considered pelagic) and estuarine (Figure 10).

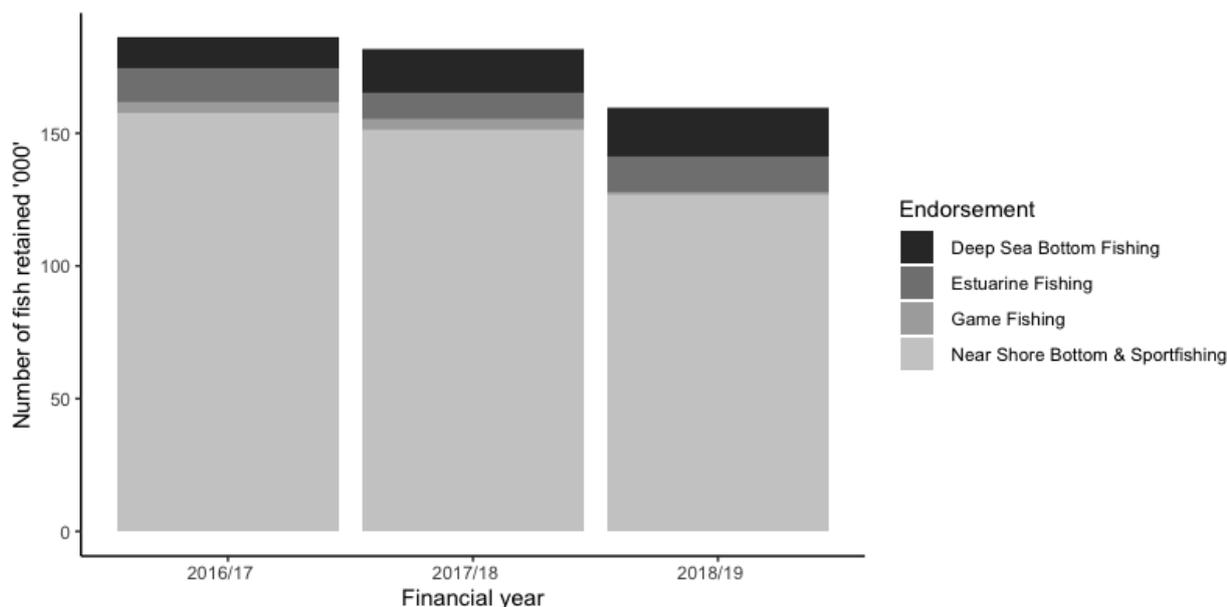


Figure 10 State-wide retained catch (as number, all species combined) by habitat group as reported from Charter Operator Returns in Western Australia summarised from 2002 to 2018. Note: based on top 30 retained species only.

The vast majority of retained catch came from charter operators with near shore bottom fishing endorsement (Figure 10). Followed by deep sea bottom fishing that overtook estuarine catch since 2017. Interesting, while near shore bottom fishing catch has reduced over the last three years there has also been an increase in the number of fish being retained from deep sea bottom fish endorsed operators (Figure 10).

3.4.6 AFMA species of interest – catch (retained and released)

In New South Wales, bluespotted flathead was the most retained species overall other species, making up 19% of retained catch (Figure 11).

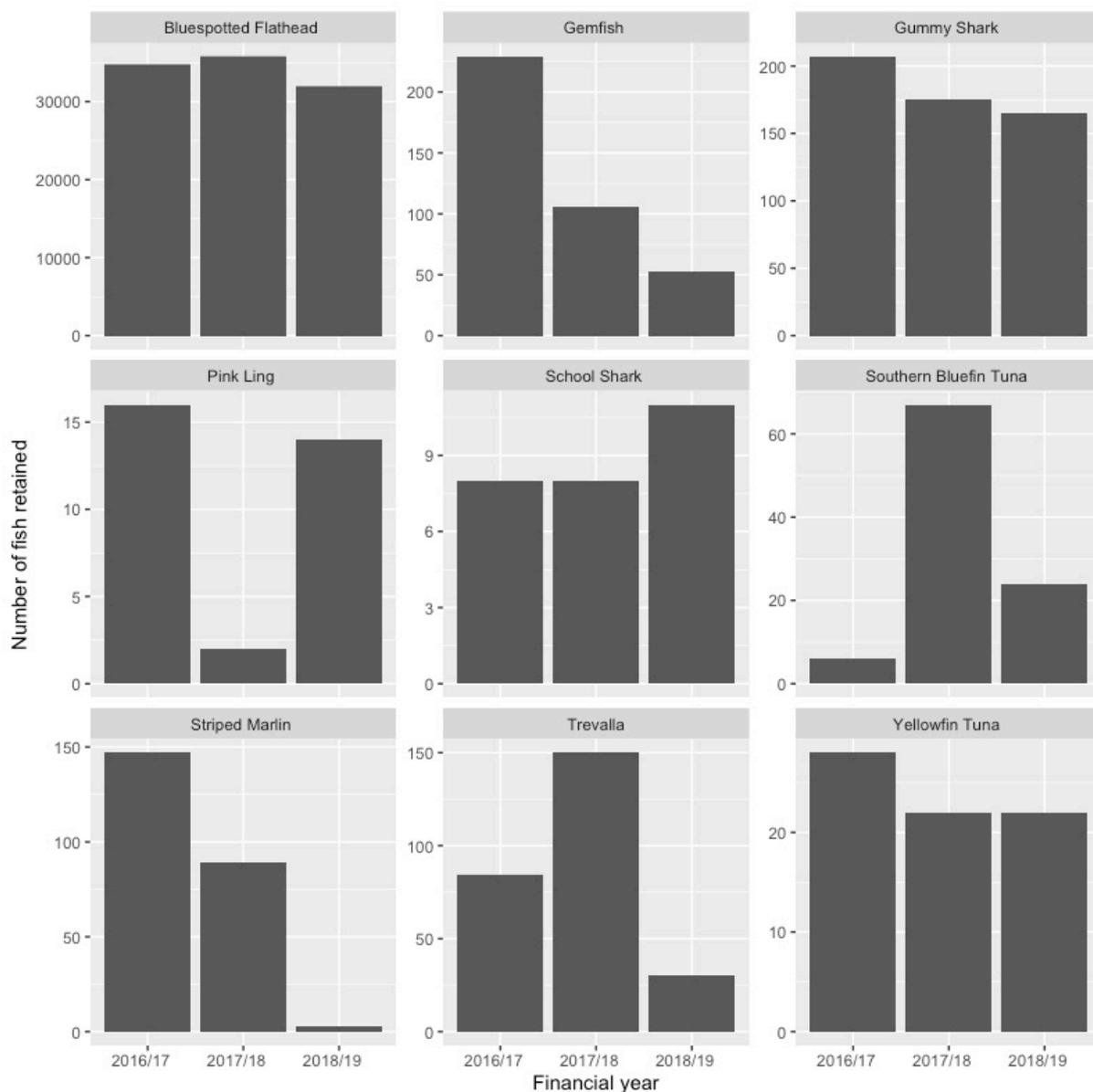


Figure 11 State-wide retained catch (as number) for AFMA species of interest as reported from Charter Operator logbooks in NSW from 2016/17 to 2018/19. Note: different y-axis scales for each species.

4. AMP DATA SUMMARY: WA

4.1 Ningaloo AMP

4.1.1 Study area

Ningaloo AMP is located 1,200 km north of Perth and, with the associated nearshore state Marine Park, includes one of the largest fringing coral reef systems in the world (Director of National Parks, 2018) (Figure 12). While the adjacent area is sparsely populated, with a residential population of 10,000 people, there are 250,000 visitors to the area annually (MPRA and CALM, 2005). Ningaloo AMP covers an area of 2,435 km², with depths ranging from 30 to 500 m, and has been assigned as an IUCN category IV which includes two zones; a National Park Zone (Schipper et al., 2008) and Recreational Use Zone (IV) (Director of National Parks, 2017) to Ningaloo AMP by charter operator vessels is predominantly via four public boat ramps (Exmouth Marine, Bundegi, Tantabiddi and Coral Bay).

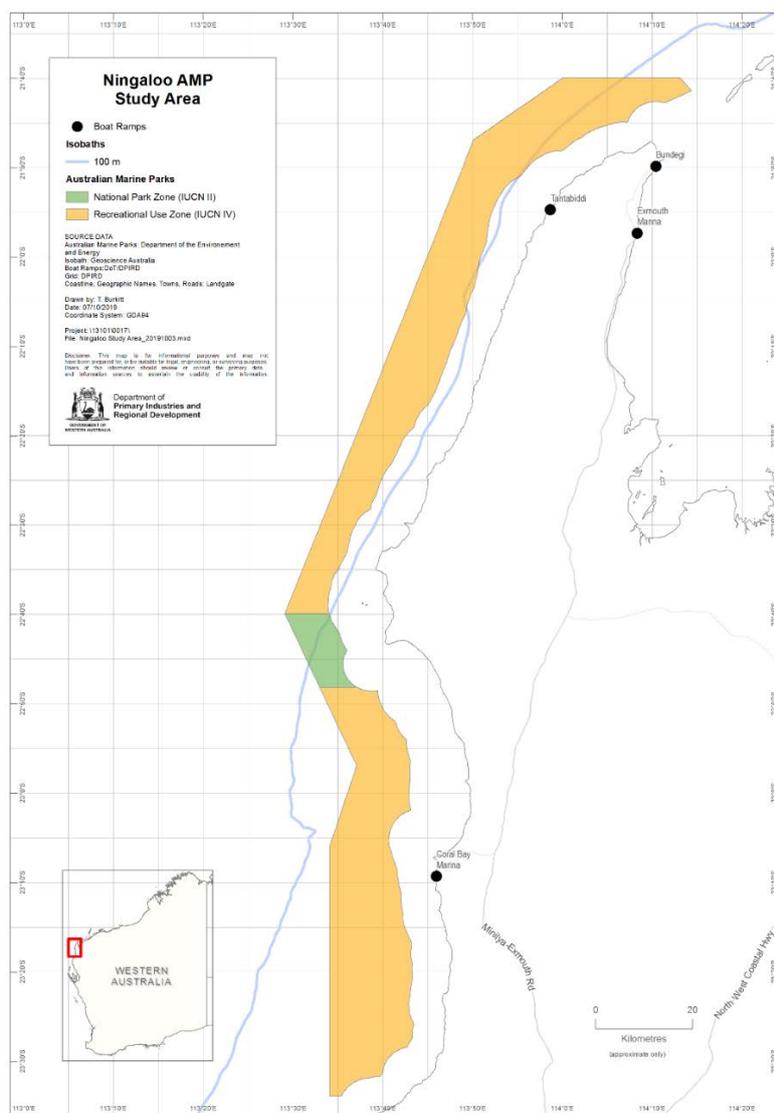


Figure 12 Map of Ningaloo AMP and 5x5 nm blocks used for reporting by charter operators.

4.1.2 Number of charter operator licences with Ningaloo AMP

Fishing Charter Operators in WA that fish at Ningaloo are not restricted to this specific AMP, rather they are licensed to operate in one (or more) marine bioregions that define state-based management areas (North Coast, Gascoyne Coast, West Coast or South Coast), within which multiple AMPs are located. Therefore, we provide information on the total number of charter operators that were active in any of the reporting blocks which intersected Ningaloo AMP (Figure 13). The highest number of active licences occurred in 2002, and the lowest in 2007. However, following a dip in activity within the park in 2005-2009, the number of charter operators per year has remained steady from 2010 to 2018, at numbers similar to those from 2002 to 2004.

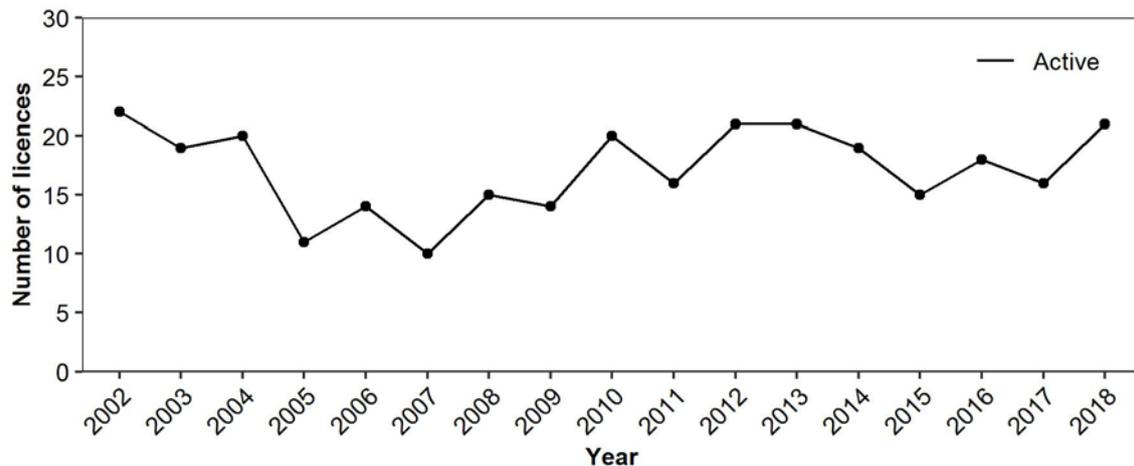


Figure 13 Total number of active charter licences in Ningaloo AMP by calendar year from 2002–2018.

4.1.3 Total effort by year

Annual fishing effort by charter operators in Ningaloo AMP was highest in 2003 (1,004 days), with the lowest annual effort in 2007 (250 days) and 2016 (314 days) (Figure 14).

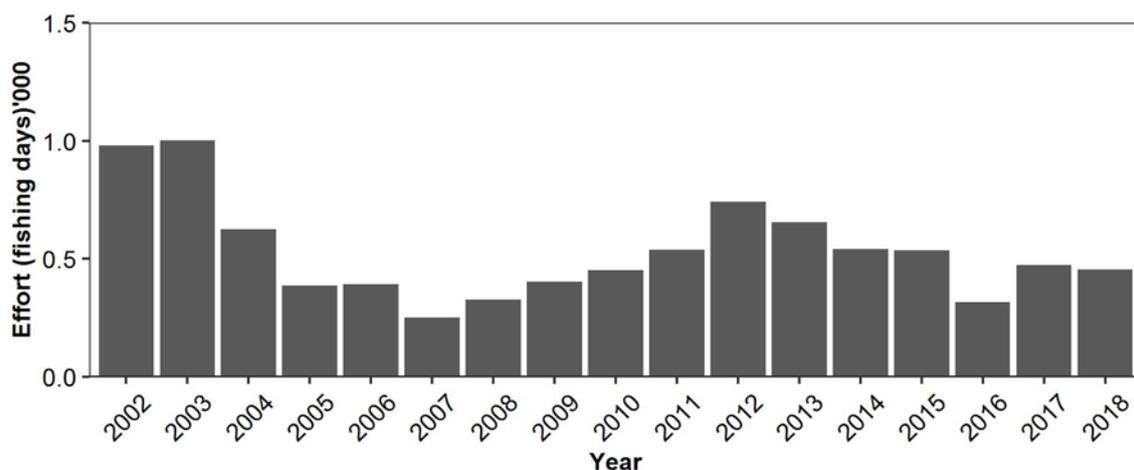


Figure 14 Fishing effort (as number of days fished) by year in Ningaloo AMP.

The distribution of fishing effort in Ningaloo AMP across all years (2002–2018) showed that highest effort occurred in the northern section offshore from Tantabiddi, Bundegi and in the southern section offshore from Coral Bay (Figure 15). Fishing effort could not be reported for one 5x5 nm block due to confidentiality.

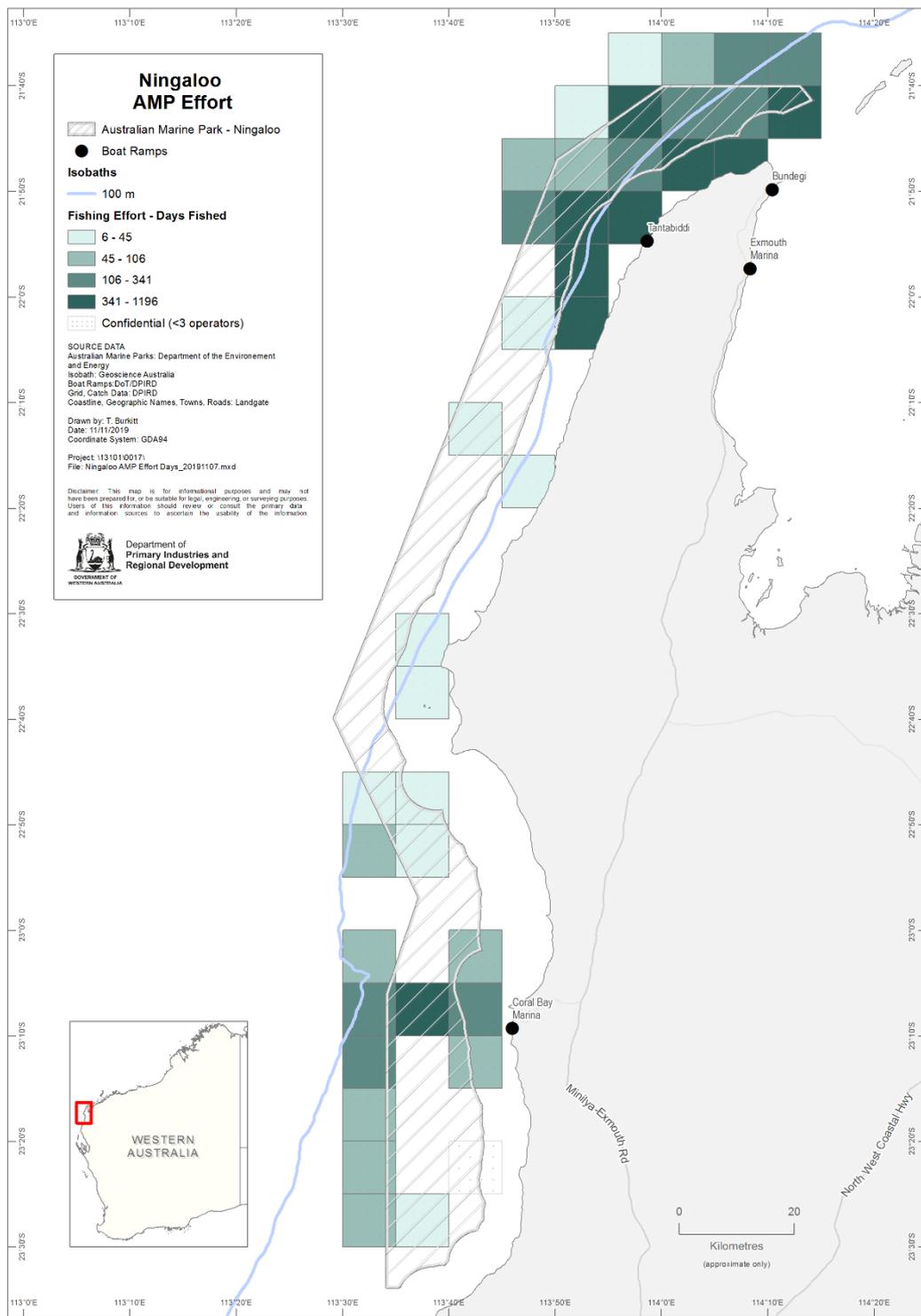


Figure 15 Distribution of fishing effort (as number of days fished) in Ningaloo AMP for all years from 2002–2018.

4.1.4 Catch (all finfish species) by year

Catch (all species) in Ningaloo AMP has been reported for finfish only and calculated as retained and released individuals. Retained catch showed variability among years, with highest retained catch in 2006 (12,105 fish, all species combined) and lowest in 2016 (2,472 fish, all species combined) (Figure 16). Released catch was lower than retained catch in all years, with the highest released catch in 2012 (3,196 fish, all species combined).

The distribution of retained catch in Ningaloo AMP across all years (2002–2018) showed the highest retained catches occurred in the northern section offshore from Tantabiddi, Bundegi and in the southern section offshore from Coral Bay (Figure 17). Retained catch could not be reported for one 5x5 nm block due to confidentiality.

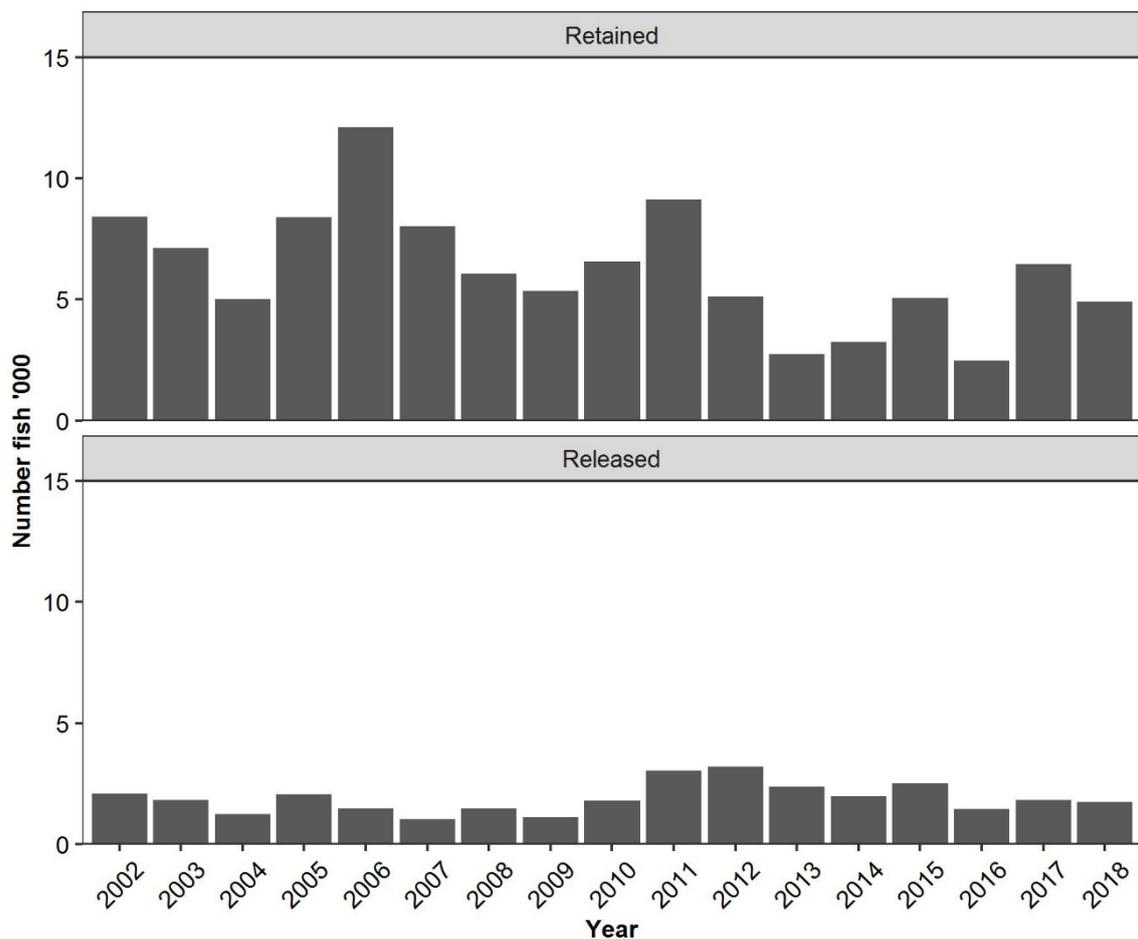


Figure 16 Number of retained and released fish by year in Ningaloo AMP.

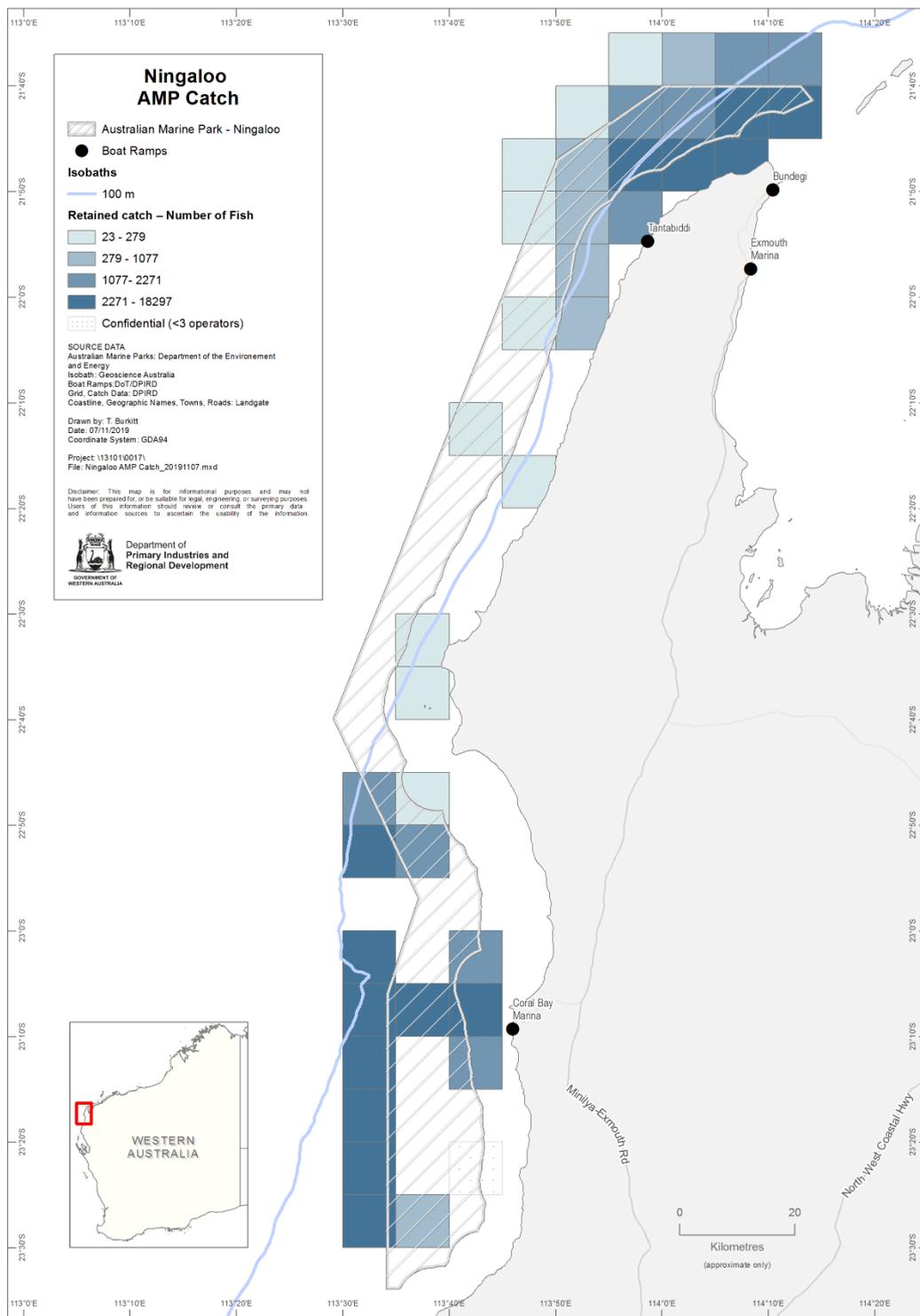


Figure 17 Distribution of retained catch (all finfish species, by number) in Ningaloo AMP for all years from 2002–2018.

4.1.5 Catch (by finfish species) all years

There were 112 species (and family groupings) of finfish recorded as retained or released by charter operators in 2002–2018. The top 12 species retained by charter operators comprise 73% of the retained catch across all years, with spangled emperor (*Lethrinus nebulosus*) contributing the largest retained catch (16%) across all species, followed by redthroat emperor (*Lethrinus miniatus*) (14%) (Table 8).

Table 8 Top 11 species (and family groupings) retained by charter operators in Ningaloo AMP, with percentage contribution to the retained catch (all species combined).

Rank	Habitat	Common Name	Species Name	% Retained
1	Demersal	Spangled Emperor	<i>Lethrinus nebulosus</i>	16
2	Demersal	Redthroat Emperor	<i>Lethrinus miniatus</i>	14
3	Demersal	Red Emperor	<i>Lutjanus sebae</i>	9
4	Nearshore	Chinaman Rockcod	<i>Epinephelus rivulatus</i>	8
5	Demersal	Rankin Cod	<i>Epinephelus multinotatus</i>	4
6	Demersal	Goldband Snapper	<i>Pristipomoides multidens</i>	4
7	Demersal	Grass Emperor	<i>Lethrinus laticaudis</i>	4
8	Demersal	Robinson's Seabream	<i>Gymnocranius grandoculis</i>	3
9	Demersal	Emperors	<i>Lethrinidae - undifferentiated</i>	3
10	Demersal	Northern Pearl Perch	<i>Glaucosoma buergeri</i>	3
11	Demersal	Pink Snapper	<i>Chrysophrys auratus</i>	3
12	Demersal	Rosy Snapper	<i>Pristipomoides filamentosus</i>	2
TOTAL				73

The distribution of retained catch of spangled emperor in Ningaloo AMP across all years (2002–2018) showed the highest catches occurred in the northern section offshore from Tantabiddi, Bundegi and in the southern section offshore from Coral Bay (Figure 18).

The distribution of retained catch of redthroat emperor in Ningaloo AMP across all years (2002–2018) showed the highest catches occurred in the northern section offshore from Tantabiddi, Bundegi and in the southern section offshore from Coral Bay (Figure 19). Retained catch could not be reported for 15 (38%) of the 5x5 nm blocks due to confidentiality.

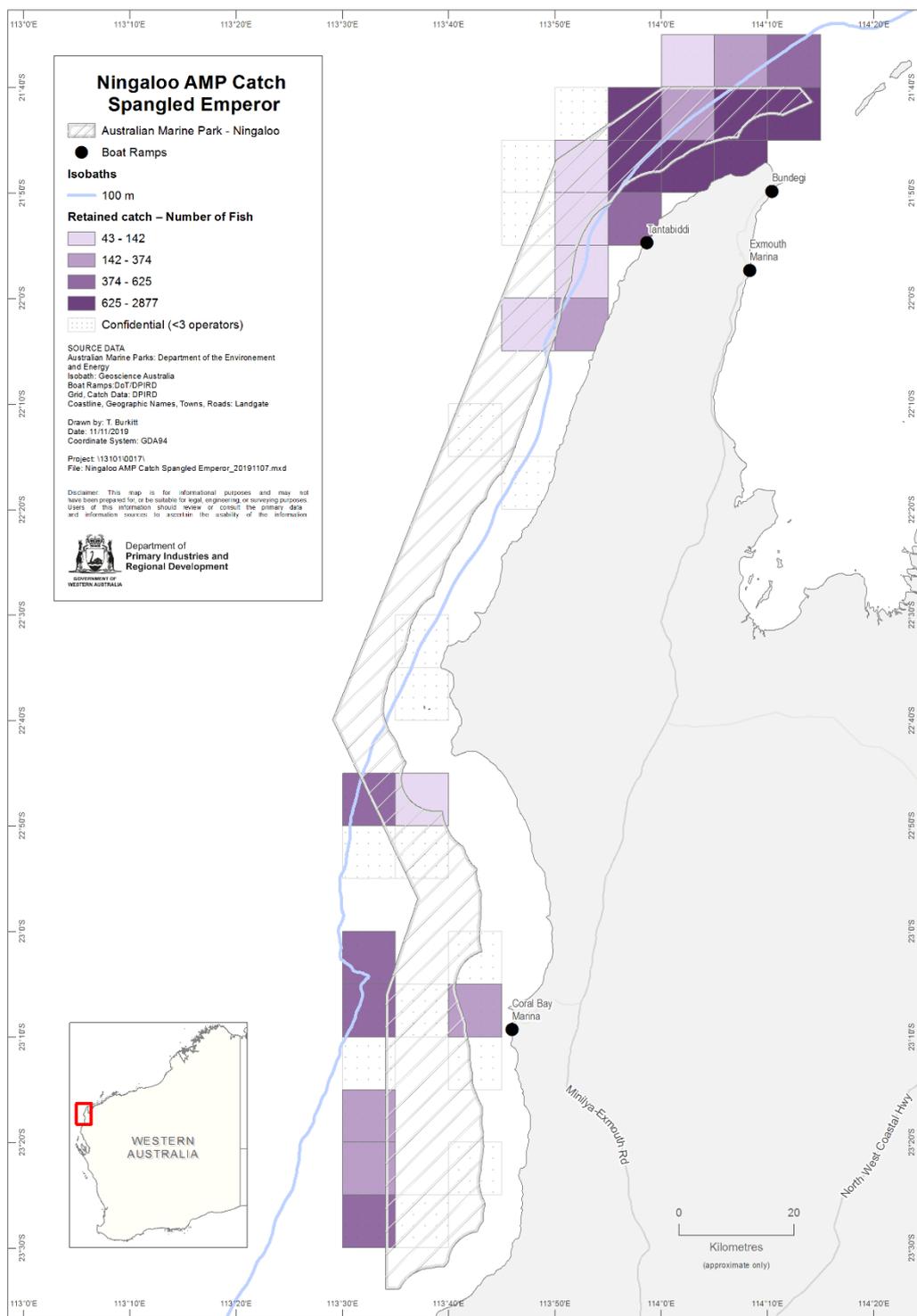


Figure 18 Distribution of retained catch (by number) of spangled emperor in Ningaloo AMP for all years from 2002–2018.

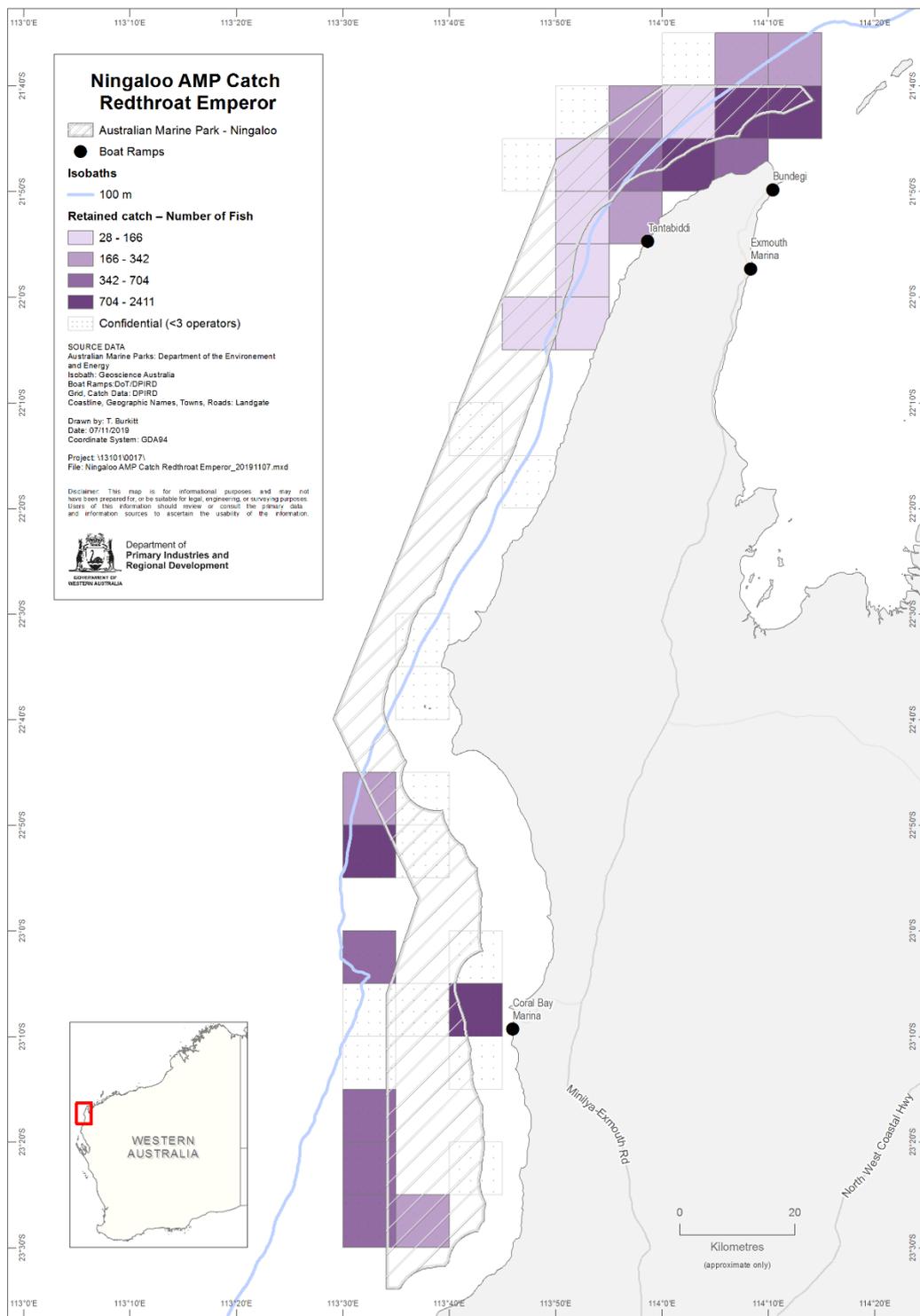


Figure 19 Distribution of retained catch (by number) of redthroat emperor in Ningaloo AMP for all years from 2002–2018.

4.1.6 Catch by habitat

Summary of the retained catch for charter operators by habitat group in Ningaloo AMP has been completed for the top 12 species identified in Table 1.. The majority of retained catches were for demersal species (Figure 20).

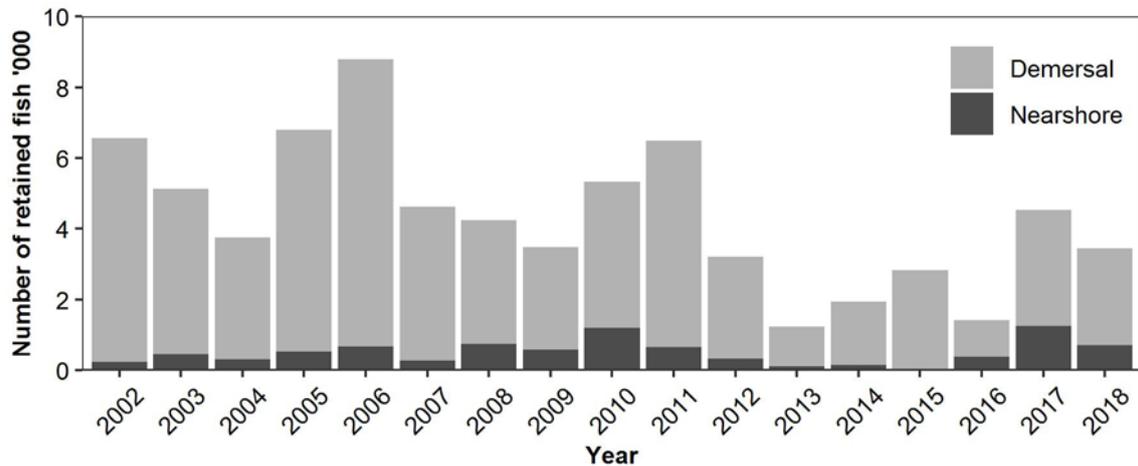


Figure 20 Retained catch for charter operators in Ningaloo AMP summarised by year and habitat. Note: top 12 retained species only.

4.1.7 Catch and effort distribution by year

The distribution of fishing effort and catch by year could not be reported for Ningaloo AMP as 53–85% of 5x5 nm blocks for each year were redacted due to confidentiality. However, the distributions highlighted in our reported aggregated data are reflective of annual patterns of fishing effort and catch with the highest effort occurring in the northern section offshore from Tantabiddi, Bundegi and in the southern section offshore from Coral Bay (Figure 17, 18 and 19).

4.2 Jurien AMP

4.2.1 Study area

Jurien AMP is located 150 km north of Perth and contains significant habitats, species and ecological communities associated with the south-west shelf transition and central western province regions including a mixture of tropical and temperate species due to the combination of southwards flowing Leeuwin Current and northward flowing Capes Current (Figure 21). The Jurien AMP covers an area of 1,851 km², with depths ranging from 15 to 220 m, and has been assigned as an IUCN category IV which includes two zones; a Special Purpose Zone (IV) for trawling and Recreational Use Zone (IV) (Director of National Parks, 2017).

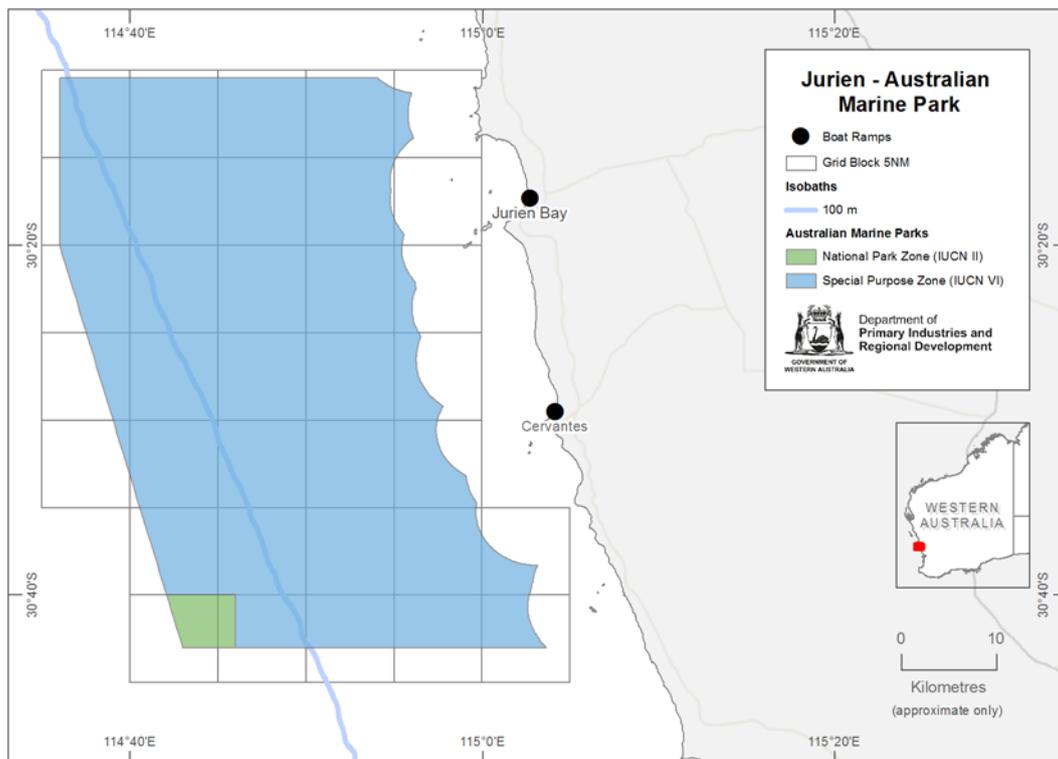


Figure 21 Map of Jurien AMP and 5x5 nm blocks used for reporting by Charter Operators.

4.2.2 Number of charter operator licences

It is only possible to provide information on the total number of charter operators that were active in any of the blocks which intersected Jurien AMP, which sits within the West Coast bioregion (Figure 22). The highest number of active licences occurred in 2018, with no charter operators active in the AMP in 2004 and between 2006 and 2008. The number of active charters operators per year was steady from 2002 to 2016 but increased in the last two years with an additional 3 operators.

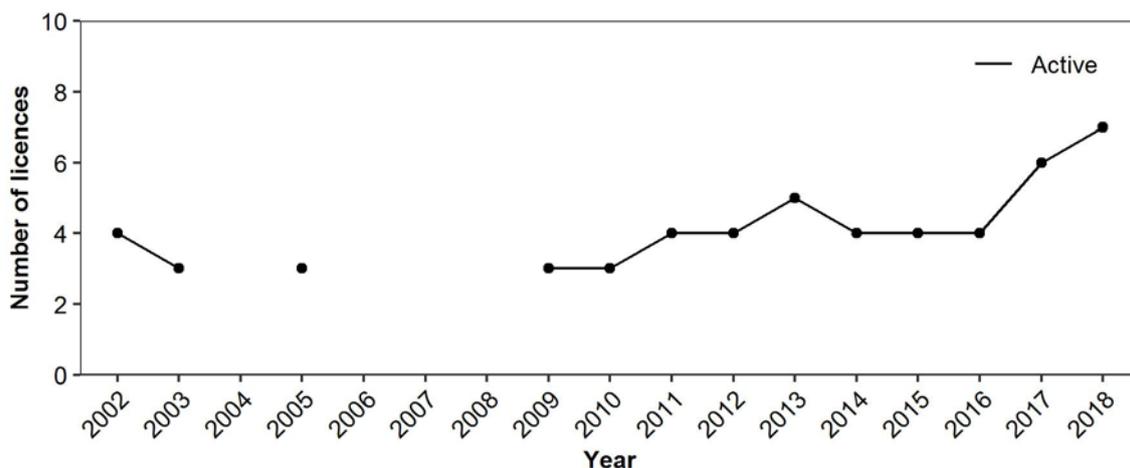


Figure 22 Total number of active charter licences in Jurien AMP by calendar year from 2002 –2018.

4.2.3 Total effort by year

Annual fishing effort by charter operators in Jurien was highest in 2017 (1,510 days), with the lowest annual effort occurring between 2004 and 2009, which included four years with no fishing activity (Figure 22). The distribution of fishing effort in Jurien AMP across all years (2002–2018) showed that highest effort occurred along the eastern boundary (Figure 24). Fishing effort could not be reported for six of 28 (21%) 5x5 nm blocks due to confidentiality.

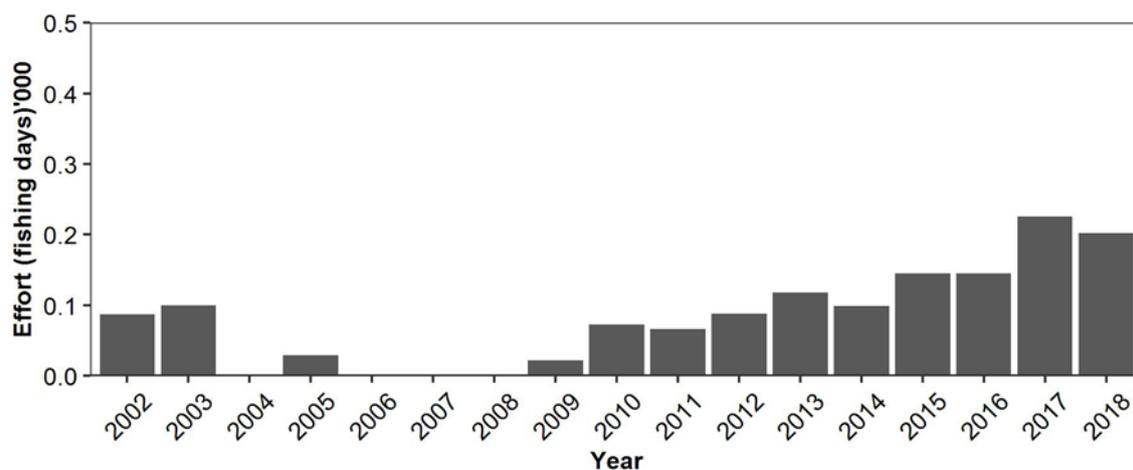


Figure 23 Fishing effort (as number of days fished) by year in Jurien AMP.

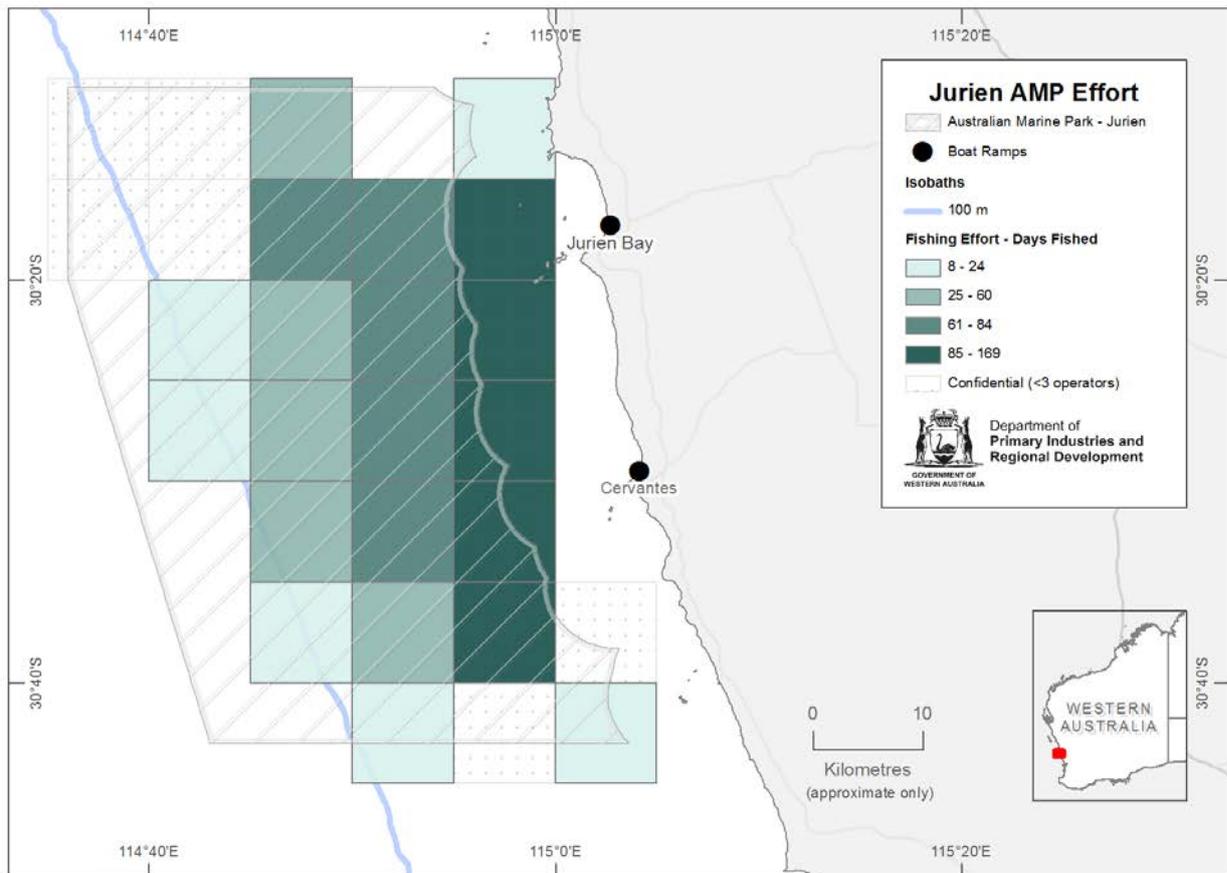


Figure 24 Distribution of fishing effort (as number of days fished) in Jurien AMP for all years from 2002-2018.

4.2.4 Catch (all finfish species) by year

Catch (all species) in Jurien AMP has been reported for finfish only and calculated as retained and released individuals. Retained catch showed variability among years, with highest retained catch in 2018 (2,022 fish, all species combined) and with the lowest annual catches occurring between 2004 and 2009, which included four years with no fishing activity occurring from charter operators (Figure 25). Released catch was lower than retained catch in all years, with the highest released catch in 2012 (1,131 fish, all species combined).

The distribution of retained catch in Jurien AMP across all years (2002–2018) showed the highest catches occurred along the eastern boundary (Figure 26). Retained catch could not be reported for six 5x5 nm blocks due to confidentiality.

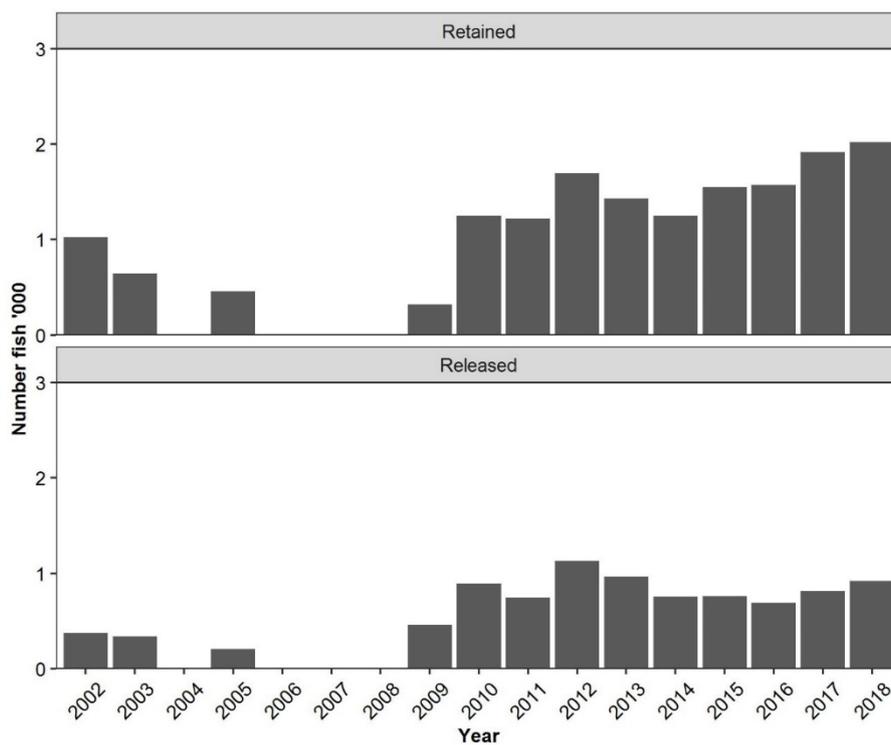


Figure 25 Number of retained and released fish by year in Jurien AMP.

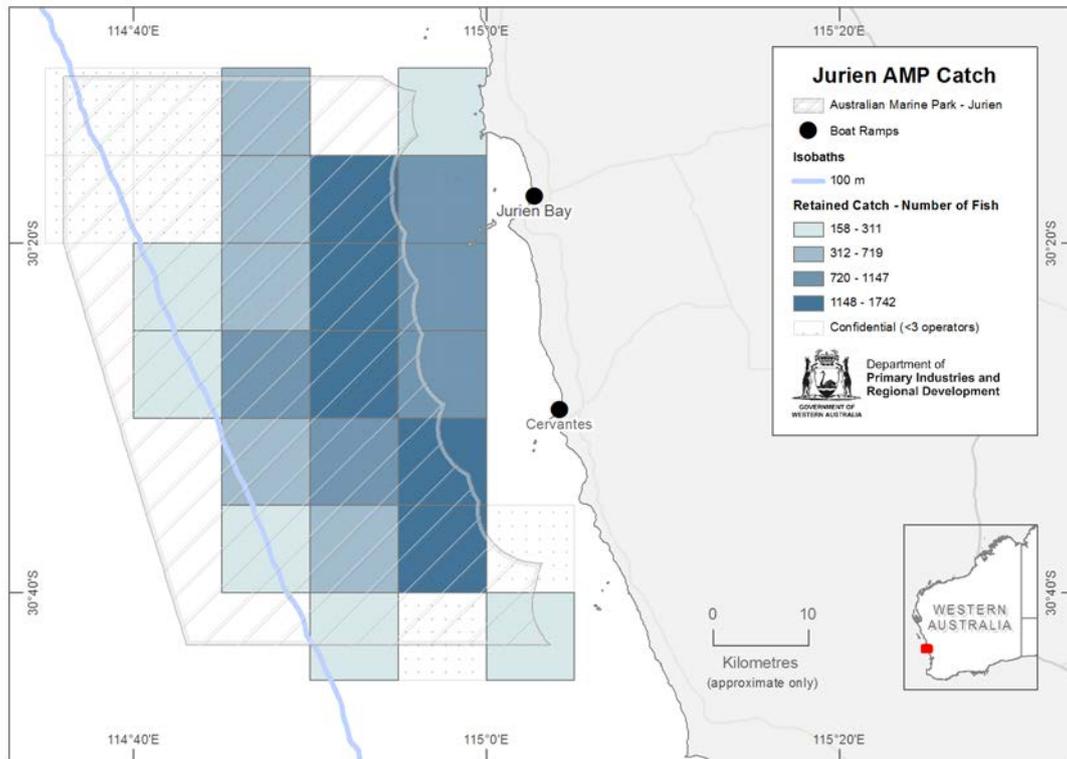


Figure 26 Distribution of retained catch (all finfish species, by number) in Jurien AMP for all years from 2002–2018.

4.2.5 Catch (by finfish species) all years

There were 41 species (and family groupings) of finfish recorded as retained or released by charter operators in 2002–2018 in the Jurien AMP. The top 6 species retained by charter operators comprise 91% of the retained catch across all years, with pink snapper contributing the largest retained catch (28%) across all species, followed by baldchin groper (23%) and West Australian dhufish (22%) (Table 9).

Table 9 Top 6 species (and family groupings) retained by charter operators in Jurien AMP, with percentage contribution to the retained catch (all species combined).

Rank	Habitat	Common Name	Species Name	% Retained
1	Demersal	Pink Snapper	<i>Chrysophrys auratus</i>	28
2	Demersal	Baldchin Groper	<i>Choerodon rubescens</i>	23
3	Demersal	West Australian Dhufish	<i>Glaucosoma hebraicum</i>	22
4	Demersal	Breaksea Cod	<i>Epinephelides armatus</i>	14
5	Pelagic	Samsonfish	<i>Seriola hippos</i>	2

Rank	Habitat	Common Name	Species Name	% Retained
6	Demersal	Redthroat Emperor	<i>Lethrinus miniatus</i>	2
TOTAL				91

The distribution of retained catch of pink snapper (Figure 27), baldchin groper (Figure 28) and West Australian dhufish (Figure 29) in Jurien AMP across all years (2002–2018) showed the highest catches occurred along the eastern boundary in less than 100 m depth. Retained catch could not be reported for 6 (22%) (pink snapper, Western Australian dhufish) or 7 (26%) (baldchin groper) 5x5 nm blocks due to confidentiality.

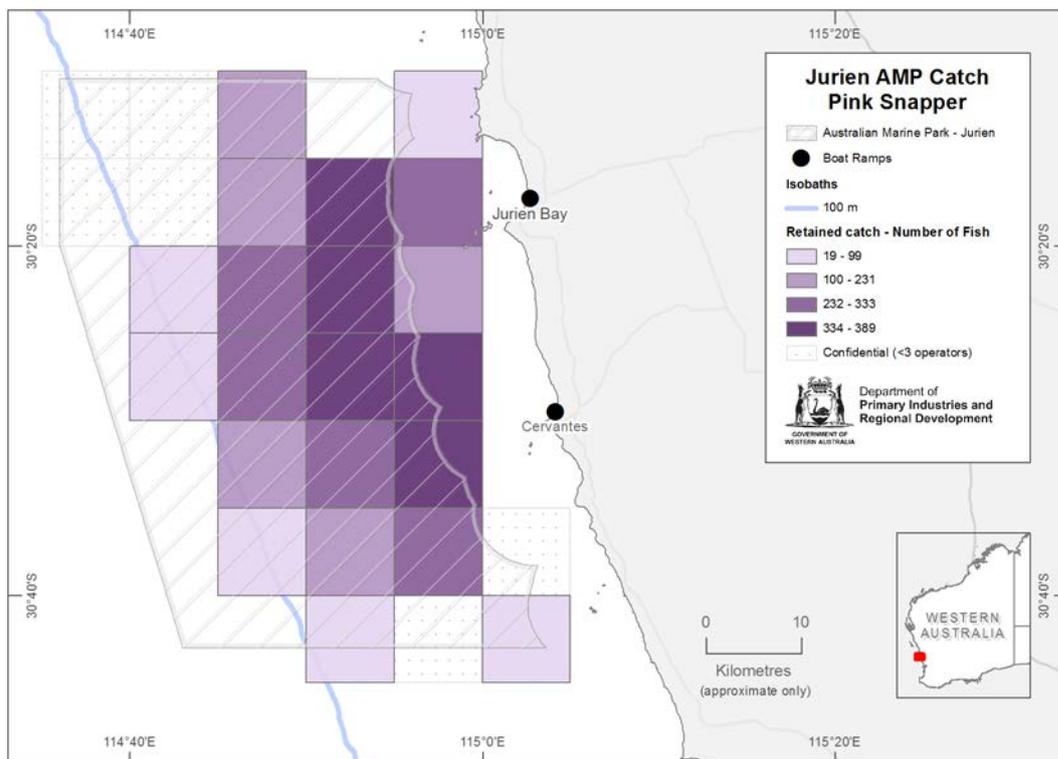


Figure 27 Distribution of retained catch (by number) of pink snapper in Jurien AMP for all years from 2002–2018.

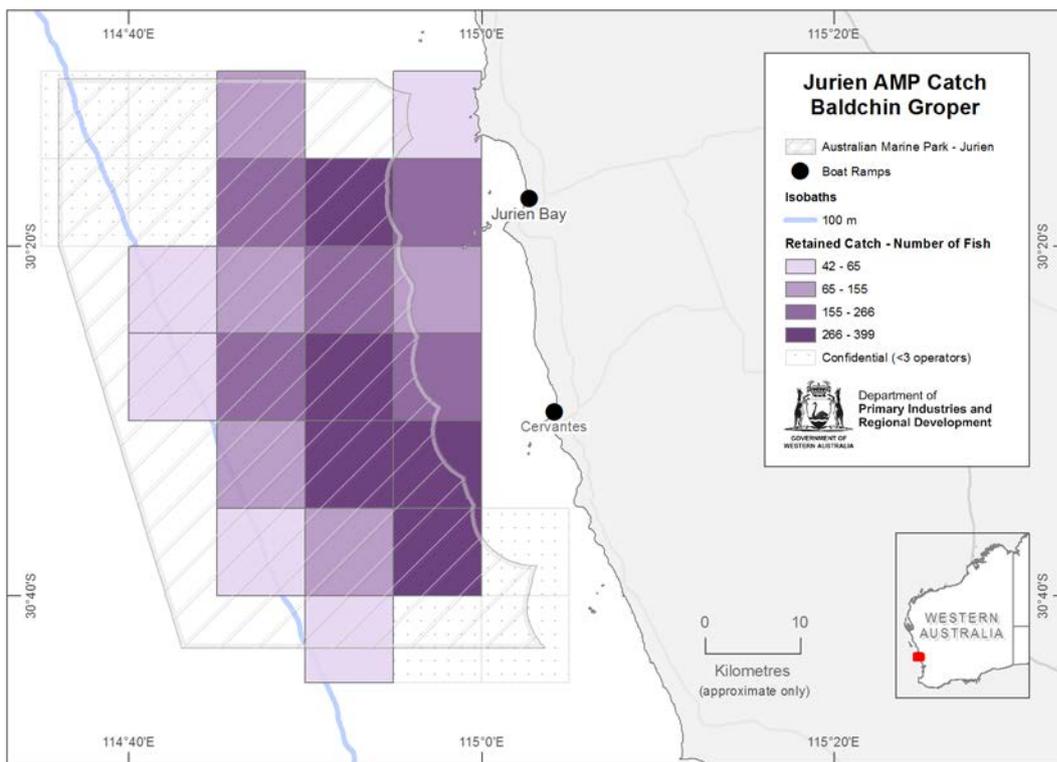


Figure 28 Distribution of retained catch (by number) of baldchin groper in Jurien AMP for all years from 2002– 2018.

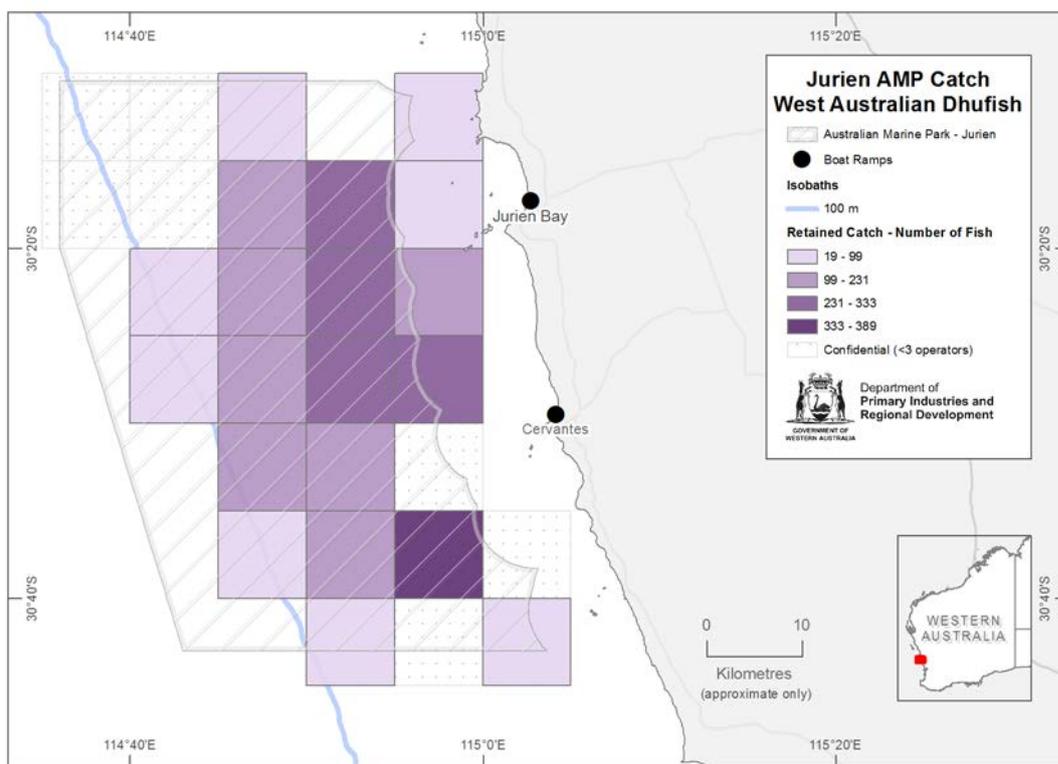


Figure 29 Distribution of retained catch (by number) of West Australian dhufish in Jurien AMP for all years from 2002– 2018.

4.2.6 Catch by habitat

Summary of the retained catch for charter operators by habitat group in Jurien AMP has been completed for the top 6 species identified in Table 9. The majority of retained catches were for demersal species.

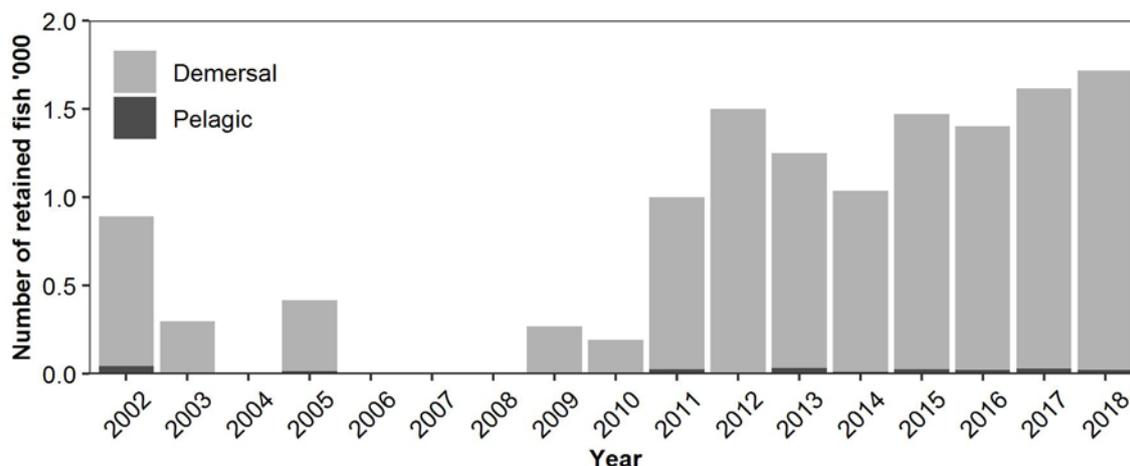


Figure 30 Retained catch for charter operators in Jurien AMP summarised by year and habitat. Note: top 6 retained species only

4.2.7 Catch and effort distribution by year

The distribution of fishing effort and catch by year has not been reported for Jurien AMP as 81 – 100% of 5x5 nm blocks were excluded from each year due to data that could not be released due to confidentiality. However, the distributions highlighted in these annual data are reflective of fishing effort and catch aggregated across all years, with the highest effort occurring along the eastern boundary of the park in less than 100 m depth (Figure 26-29).

4.3 Perth Canyon AMP

4.3.1 Study area

Perth Canyon AMP is located 50 km west of Perth in the West Coast bioregion and includes the majority of Australia's largest submarine canyon, which is home to the largest feeding aggregations of blue whales in Australia (Figure 31). The Perth Canyon AMP covers an area of 7,409 km², with depths ranging from 120 to 5 000 m, and has been assigned as an IUCN category IV which includes three zones; a Multiple Use Zone (VI), Habitat Protection Zone (IV) and National Park Zone (Schipper et al.) (Director of National Parks, 2017).

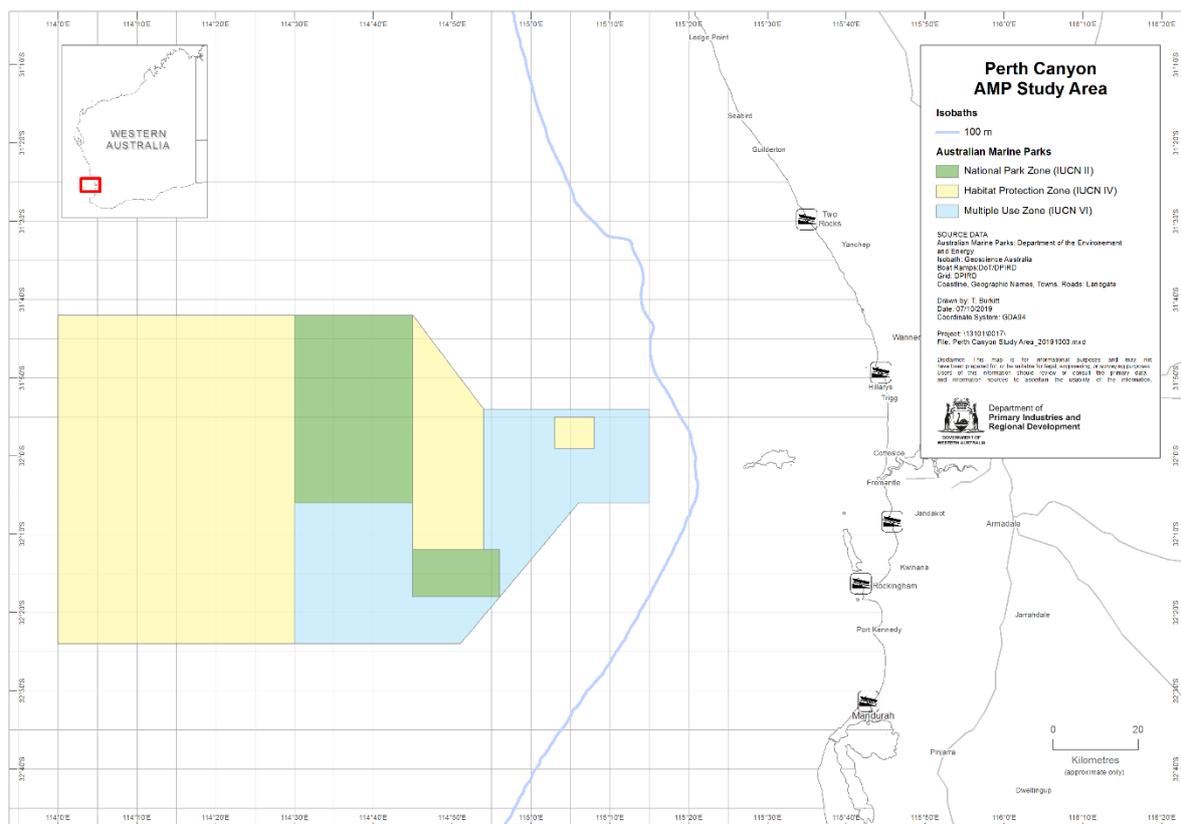


Figure 31 Map of Perth Canyon AMP and 5x5 nm blocks used for reporting by charter operators.

4.3.2 Number of charter operator licences

It is only possible to provide information on the total number of charter operators that were active in any of the blocks which intersected Perth Canyon AMP (Figure 32). The highest number of active licences occurred in 2003, with no charter operators active in the AMP for the majority of years between 2007–2018.

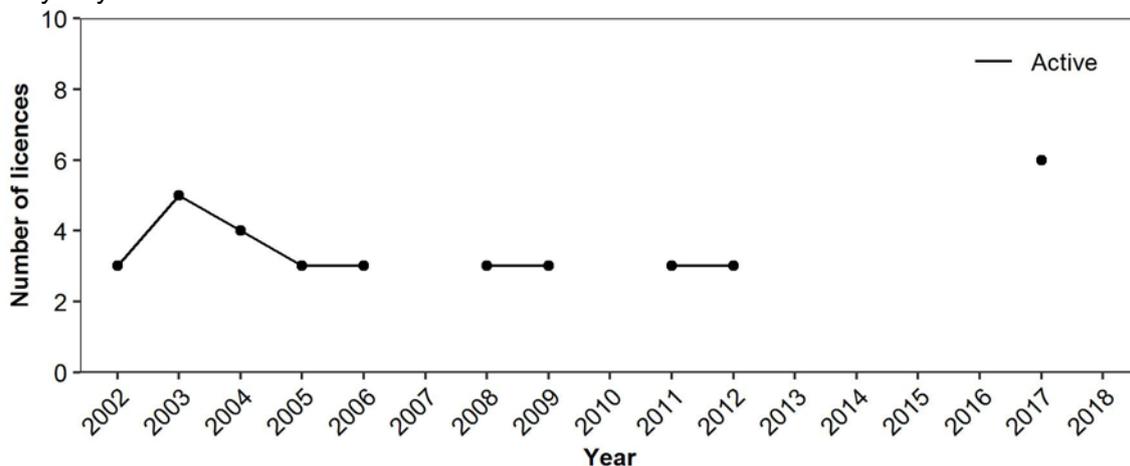


Figure 32 Total number of active charter licences in Perth Canyon AMP by calendar year from 2002–2018.

4.3.3 Total effort by year

Annual fishing effort by charter operators in Perth Canyon was highest in 2003 (91 days), with the lowest annual effort occurring between 2007 and 2018, which included seven years with no fishing activity occurring from charter operators (Figure 33). The distribution of fishing effort in Perth Canyon AMP across all years (2002–2018) showed that highest effort occurred along the eastern boundary of the AMP (Figure 34). Fishing effort could not be reported for two 5x5 nm blocks due to confidentiality.

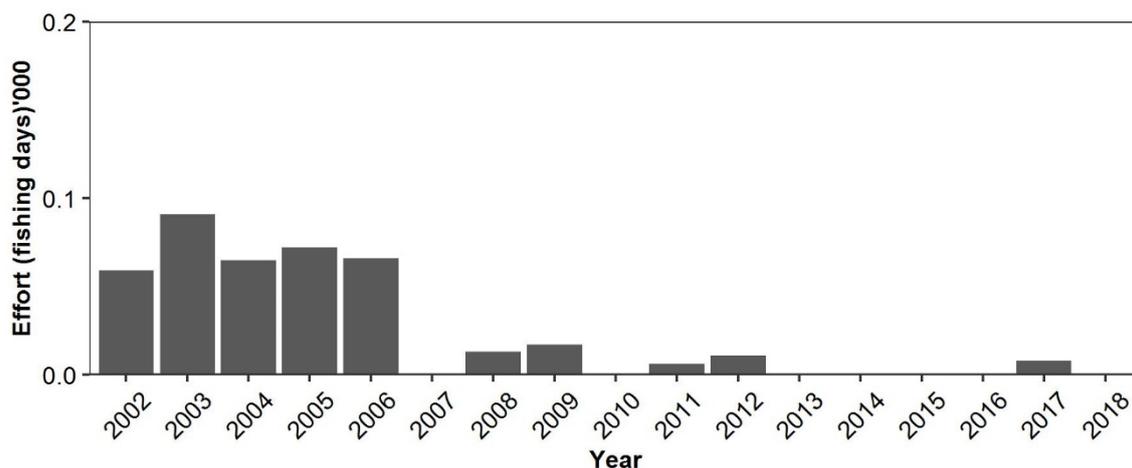


Figure 33 Fishing effort (as number of days fished) by year in Perth Canyon AMP.

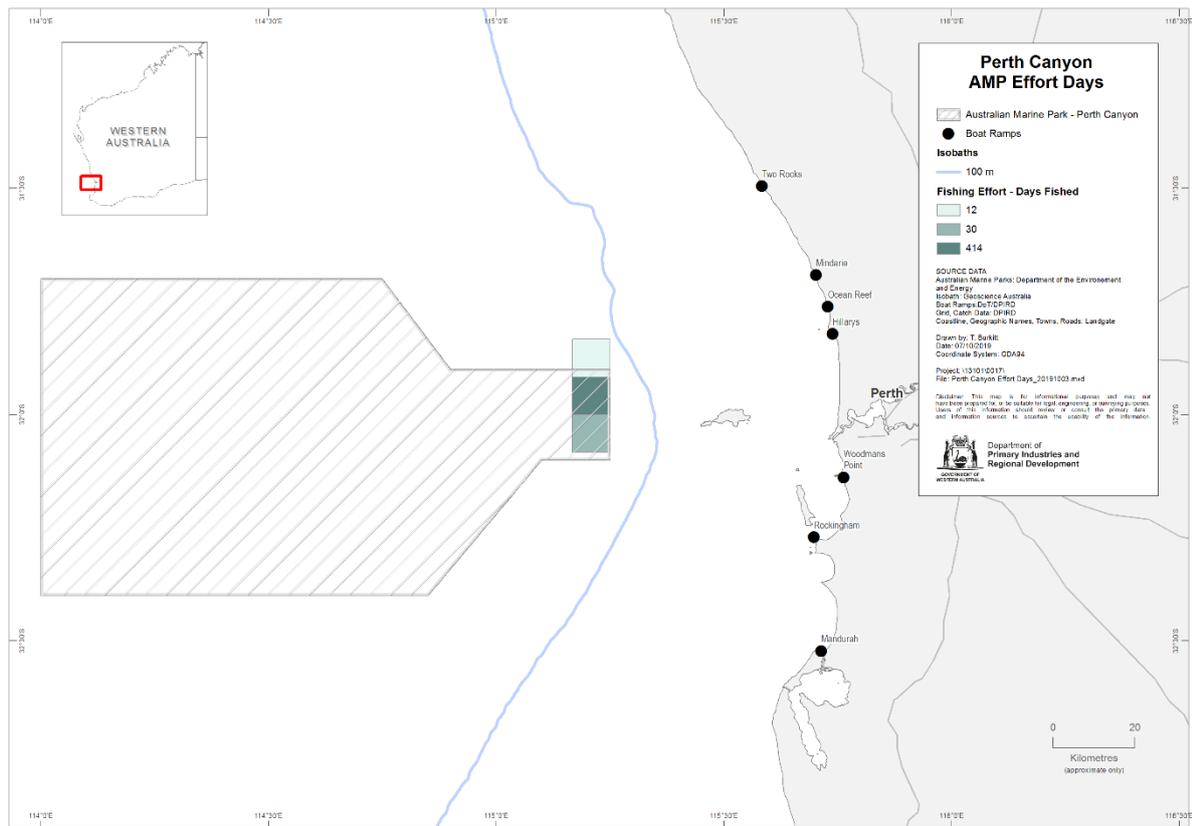


Figure 34 Distribution of fishing effort (as number of days fished) in Perth Canyon AMP for all years from 2002 - 2018.

4.3.4 Catch (all finfish species) by year

Catch (all species) in Perth Canyon AMP has been reported for finfish only and calculated as retained and released individuals. Retained catch showed variability among years, with highest retained catch in 2003 (613 fish, all species combined) and with the lowest annual catches occurring between 2007 and 2018, which included seven years with no fishing activity occurring from charter operators (Figure 35). Released catch was higher than retained catch in the majority of years, with the highest released catch in 2012 (2,245 fish, all species combined).

The distribution of retained catch in Perth Canyon AMP across all years (2002–2018) showed that effort only occurred along the eastern boundary of the AMP (Figure 36). Retained catch could not be reported for only two of the 5x5 nm blocks due to confidentiality.

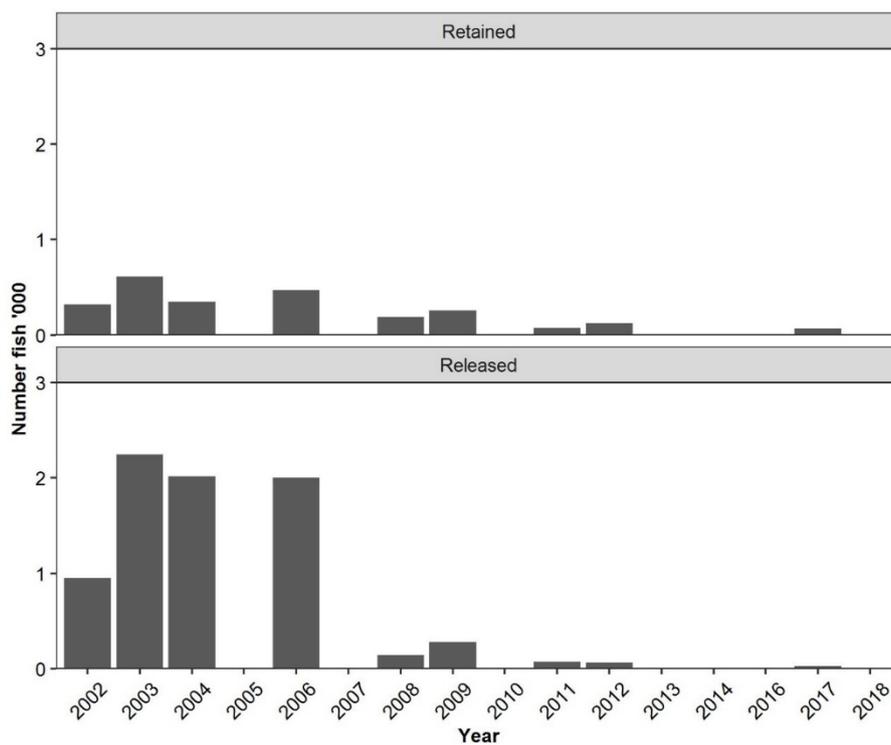


Figure 35 Number of retained and released fish by year in Perth Canyon AMP.

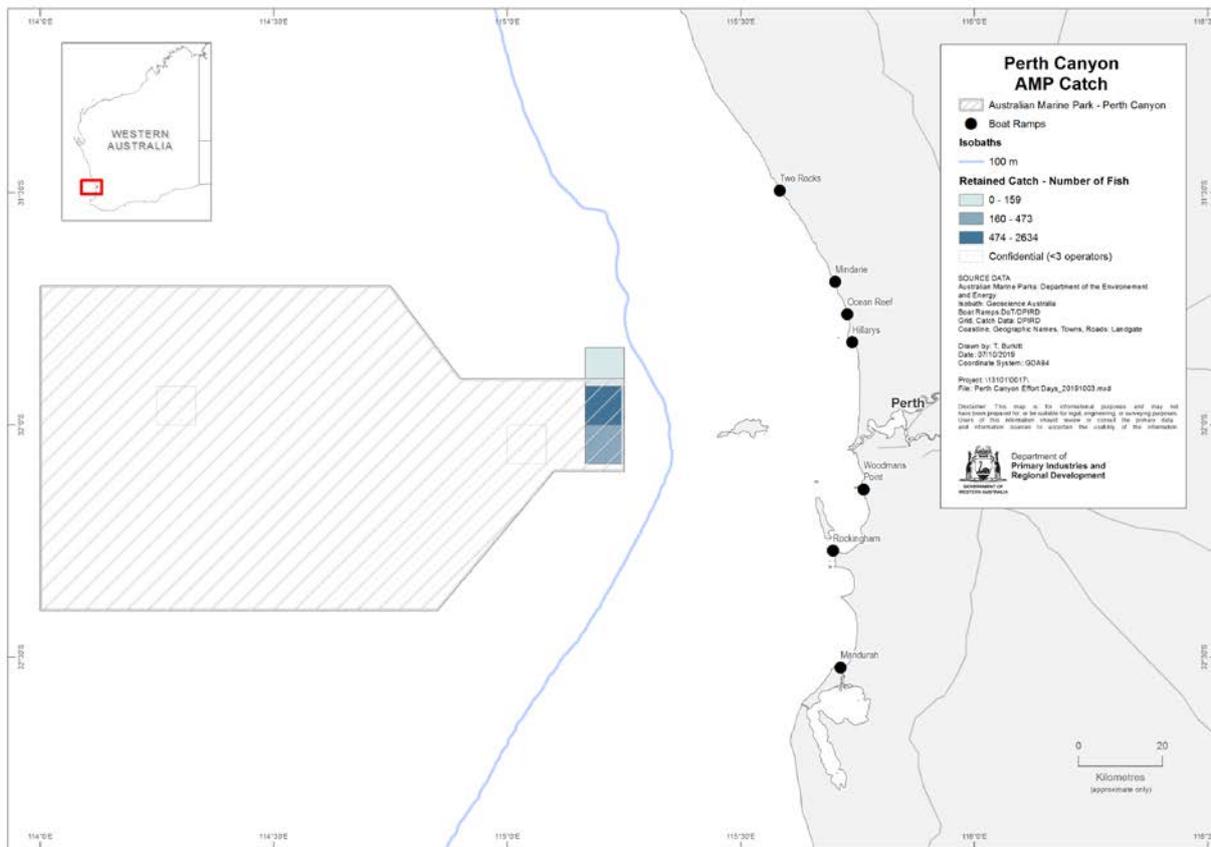


Figure 36 Distribution of retained catch (all finfish species, by number) in Perth Canyon AMP for all years from 2002–2018.

4.3.5 Catch (by finfish species) all years

There were 25 (and family groupings) of finfish recorded as retained or released by charter operators in 2002–2018 in the Perth AMP. The top 11 species retained by charter operators comprise 88% of the retained catch across all years, with pink snapper the largest retained catch (32%) across all species, followed by silver trevally (*Pseudocaranx georgianus spp complex*) (22%) (Table 10).

Table 10 Top 11 species (and family groupings) retained by charter operators in Perth Canyon AMP, with percentage contribution to the retained catch (all species combined).

Rank	Habitat	Common Name	Species Name	% Retained
1	Demersal	Pink Snapper	<i>Chrysophrys auratus</i>	32
2	Nearshore	Silver Trevally	<i>Pseudocaranx georgianus spp complex</i>	22
3	Demersal	Breaksea Cod	<i>Epinephelides armatus</i>	7
4	Pelagic	Samsonfish	<i>Seriola hippos</i>	6
5	Demersal	Blue Morwong	<i>Nemadactylus valenciennesi</i>	6
6	Demersal	Bight Redfish	<i>Centroberyx gerrardi</i>	5
7	Demersal	West Australian Dhufish	<i>Glaucosoma hebraicum</i>	2
8	Nearshore	Triggerfishes & Leatherjackets	<i>Monacanthidae - undifferentiated</i>	2
9	Demersal	Yelloweye Redfish	<i>Centroberyx australis</i>	2
10	Demersal	Swallowtail	<i>Centroberyx lineatus</i>	2
11	Demersal	Eightbar Grouper	<i>Hyporthodus octofasciatus</i>	2
TOTAL				88

The distribution of retained catch of pink snapper in Perth AMP across all years (2002–2018) showed the highest catches occurred along the eastern boundary of the AMP (Figure 37). These were only three blocks in which catch of this species was recorded.

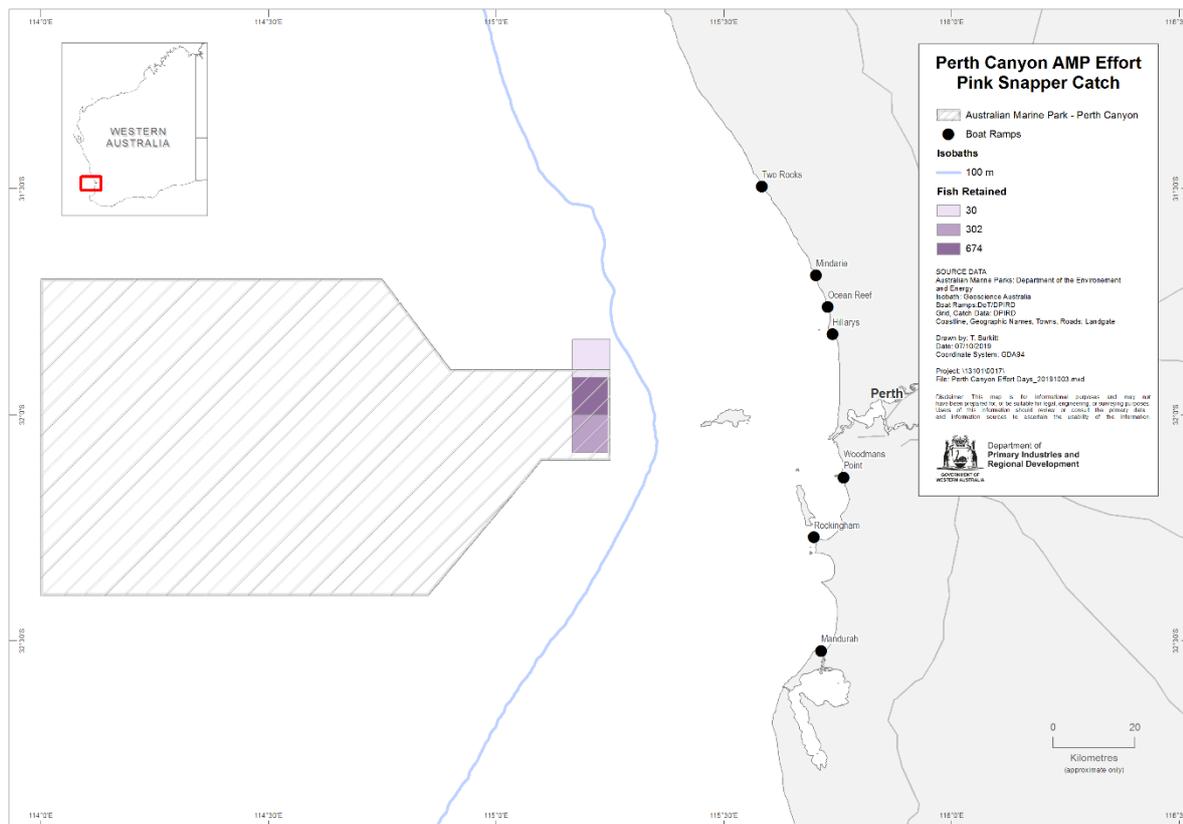


Figure 37 Distribution of retained catch (by number) of pink snapper in Perth AMP for all years from 2002– 2018.

4.3.6 Catch by habitat

A summary of the catch, by habitat groups in Perth Canyon AMP, was completed for the top 11 species retained by operators (Table 10). The majority of retained catches were for demersal species (Figure 38).

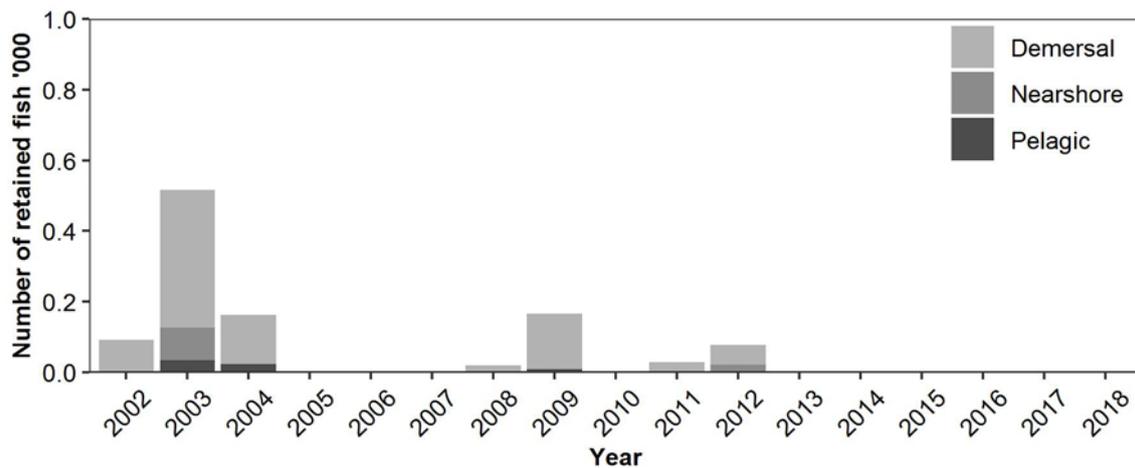


Figure 38 Retained catch for charter operators in Perth Canyon AMP summarised by year and habitat. Note: top 11 retained species only.

4.3.7 Catch and effort distribution by year

The distribution of fishing effort and catch by year has not been reported for Perth Canyon AMP as 50–100% of 5x5 nm blocks were excluded from each year due to data that could not be released due to confidentiality. However, the distributions highlighted in these annual data are reflective of fishing effort and catch aggregated across all years with the highest effort occurred along the eastern boundary (Figure 34, 36 and 37).

5. AMP DATA SUMMARY: NSW

5.1 Hunter AMP

5.1.1 Study area

The Hunter Marine Park (HMP) is located within the Temperate East region and covers an area of 6,857 km², with an area of 1,307 km² (19 %) on the continental shelf (<200 m; (Monk et al., 2017) (Figure 39). The HMP includes a habitat protection zone and a special purpose (trawling) zone. The depth range of the HMP is 30 to 6000 m. The HMP is also continuous with a section of the Port Stephens-Great Lakes Marine Park (PSGLMP) at the State coastal waters boundary (Figure 39). There were not sufficient charter boat fishers in Jervis Bay Marine Park to allow for anonymous detailing of results.

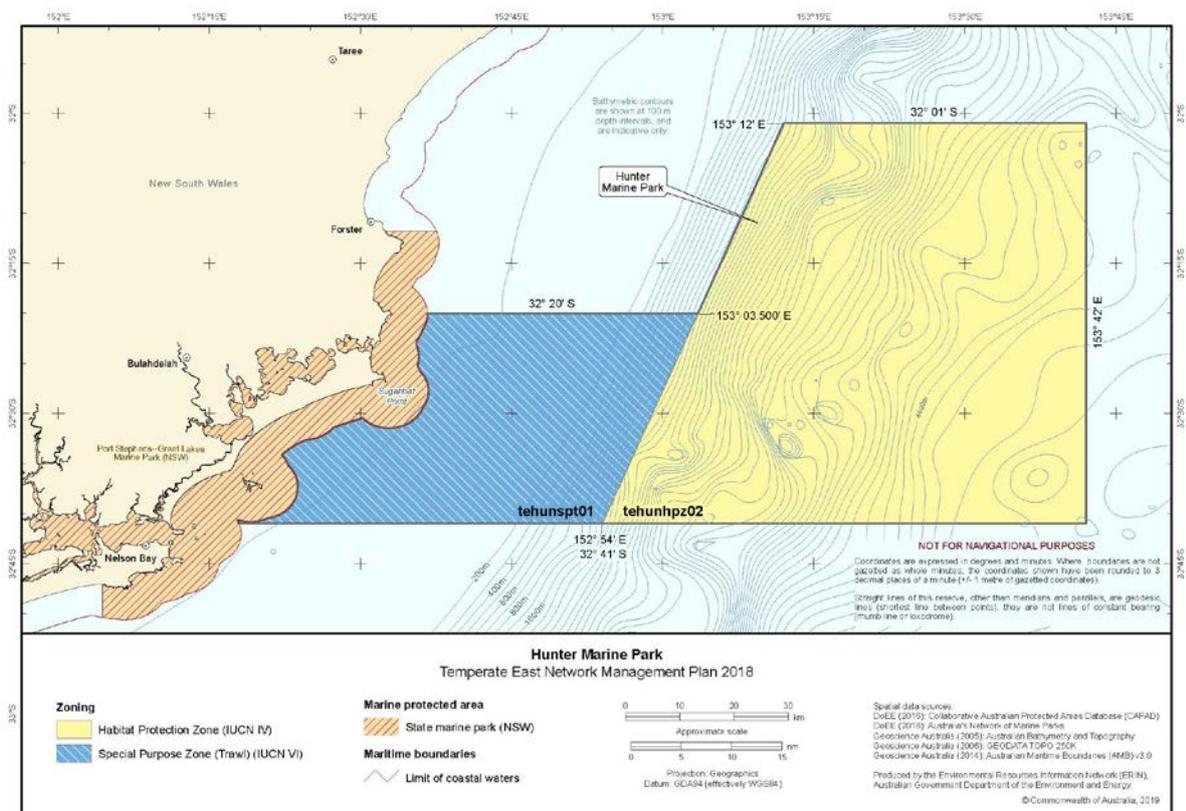


Figure 39 Map of the Hunter AMP zoning in relation to the state marine park Port Stephens – Great Lakes Marine Park.

5.1.2 Number of charter operator licences

Charter operators in New South Wales are not specifically licensed to operate within AMPs or within bioregions. Instead, operators are endorsed by fishing type or activity (estuarine fishing, nearshore bottom fishing and sport fishing, game fishing and deep-sea bottom fishing). Given the AMPs are located offshore of NSW (>3nm), it is most likely that only charter operators that are endorsed as game fishing or deep-sea bottom fishing will be fishing within the HMP.

Prior to 2016, charter operators only reported the general location or port of operation and it is not possible to establish if operators were fishing within an AMP. Since 2016 charter operators have been reporting effort and catch within a 6x6 minute grid cell, the same as used by commercial fishers. This enables us to distinguish effort within each AMP within the continental shelf. However, many of these cells span over the marine park boundaries. From here on we report effort and catch for all grid cells that are within or across the border of the HMP.

The number of charter operators who have submitted log sheets that indicate they have fished within or across the border of the HMP varied from 6 to 10 since 2016 (Figure 40). However, it should be noted that despite the logbooks being a legal requirement, the compliance rates are low (~36 % for all of NSW). It is not possible to establish the compliance rates for the Hunter region.

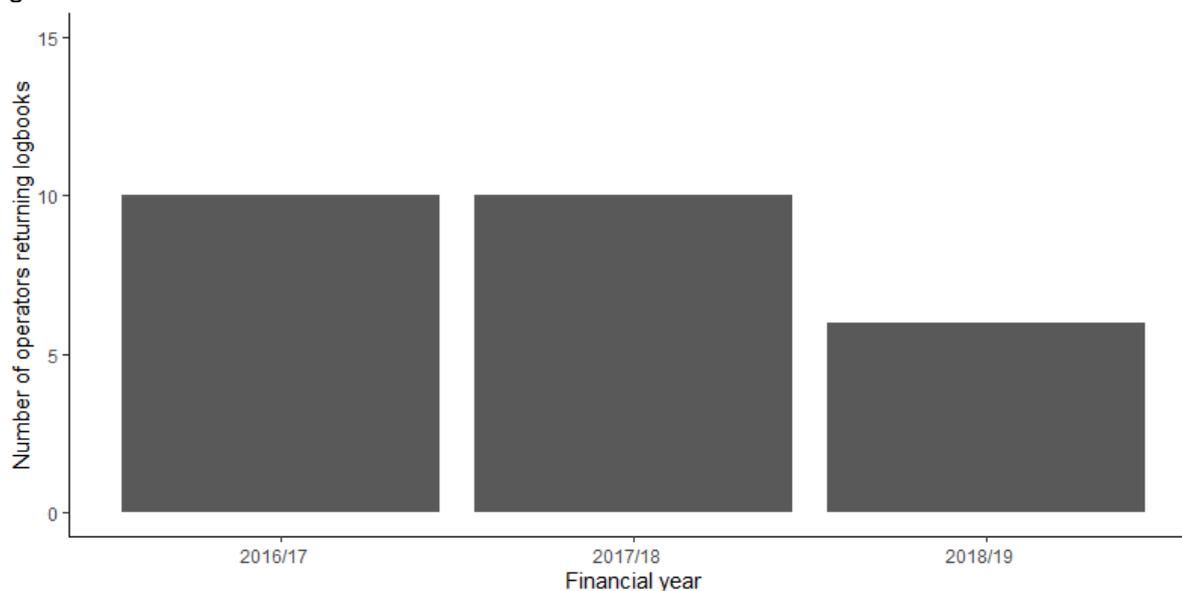


Figure 40. The total number of operators that submitted log sheets that had grid and site location codes that identified as fishing within or across the border of the HMP from 2016 to 2019.

5.1.3 Total effort by year

Based on the available data, fishing effort by charter operators was measured by the number of log sheets submitted (Figure 41) and the numbers of hours recorded as actively fishing (Figure 42). There may be multiple fishing sessions per day on the same charter, and also multiple fishing charters per day (i.e. when a charter operator returns to a marina/boat ramp to pick up a new group of fishing clients).

The number of log sheets that were returned with grid or site codes that occurred in the HMP varied between 188 and 225 log sheets per year since 2016 (Figure 41). The number of hours fished varied from 842 to 1236 hours per year since 2016 (Figure 42). It is evident that effort is concentrated around two grid cells in particular (Figure 43). Charters departing from Port Stephens are concentrating effort east of Broughton Island in a grid cell that spans both the PSGLMP and HMP. While charters departing from Forster are concentrating on a grid cell just outside the northern boundary of the HMP.

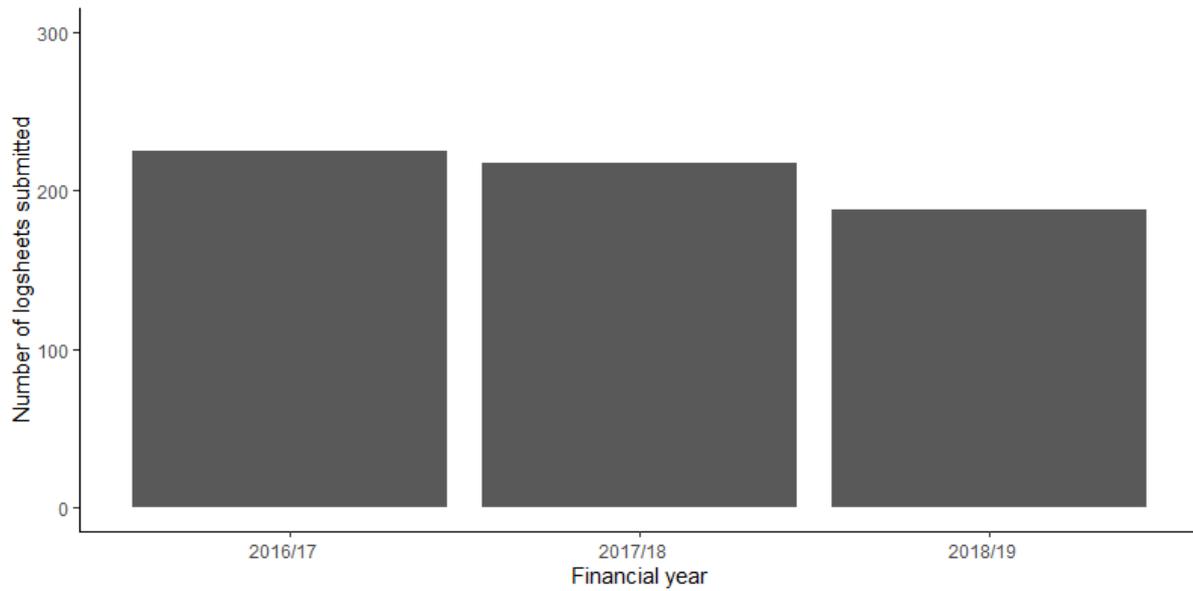


Figure 41 Number of log sheets that indicate fishing effort from within or bordering across the Hunter AMP.

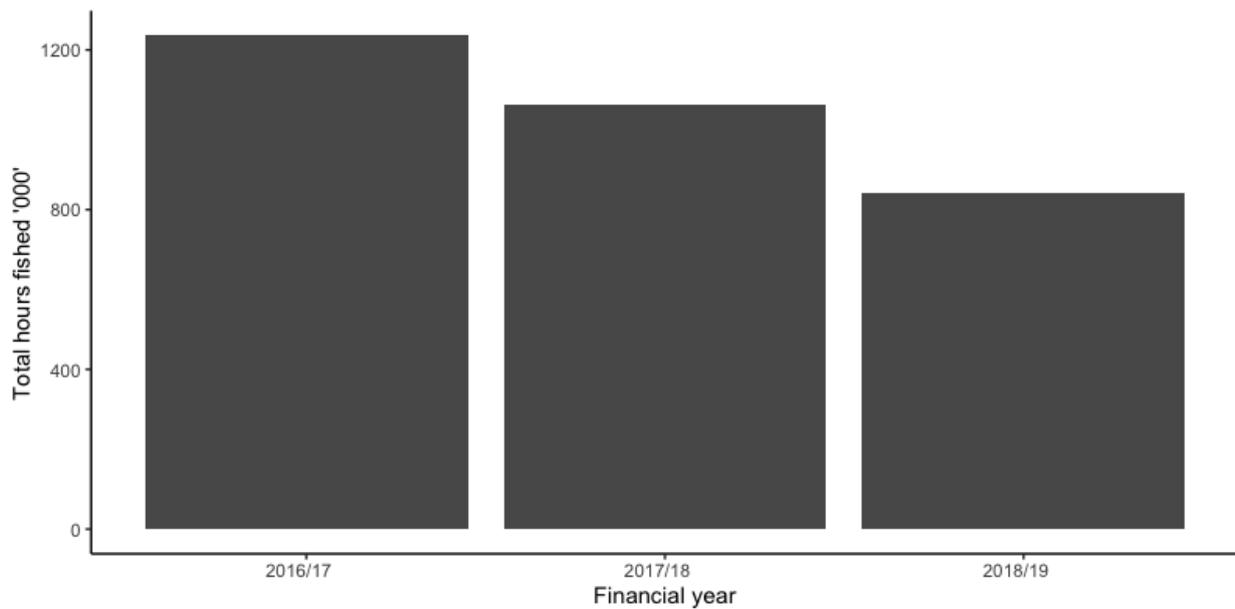


Figure 42 Number hours fished as per logged for fishing effort from within or bordering across the Hunter AMP.

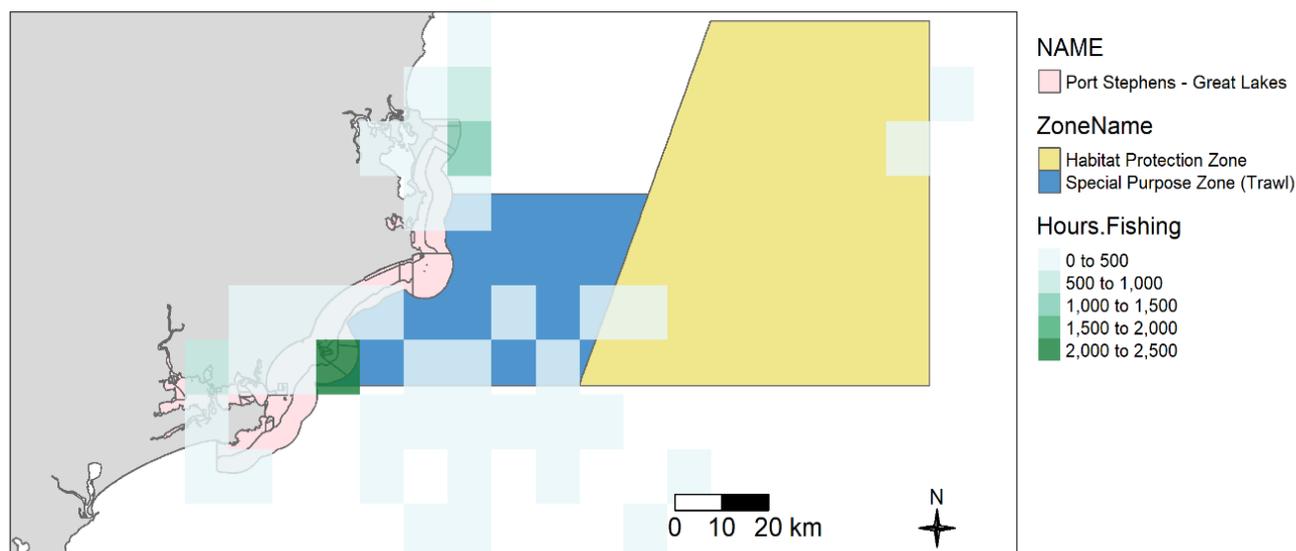


Figure 43 Distribution of fishing effort (as number of hours fished) in the Hunter AMP and surrounds for all years from 2016 - 2019.

5.1.4 Catch (all finfish species) by year

Catch (all species) in HMP has been reported for finfish only and calculated as the number of retained individuals. Since 2016, charter operators only have to report retained catch in the logbook monitoring program. Retained catch varied between 6099 and 6444 individuals, representing 55 species or species groups, which were retained between 2016 and 2019.

The distribution of retained catch in Hunter AMP across all years (2016–2019) showed the highest catches occurred in a grid cell that spanned both HMP and state marine park Port Stephens-Great Lakes Marine Park (Figure 44). It is known that charter operators' fish both areas and it is impossible to know exactly where the effort is concentrated. Overall the majority of fish retained are caught in the southern half of the HMP most likely due to this being close to Port Stephens, the closest marina and harbour.

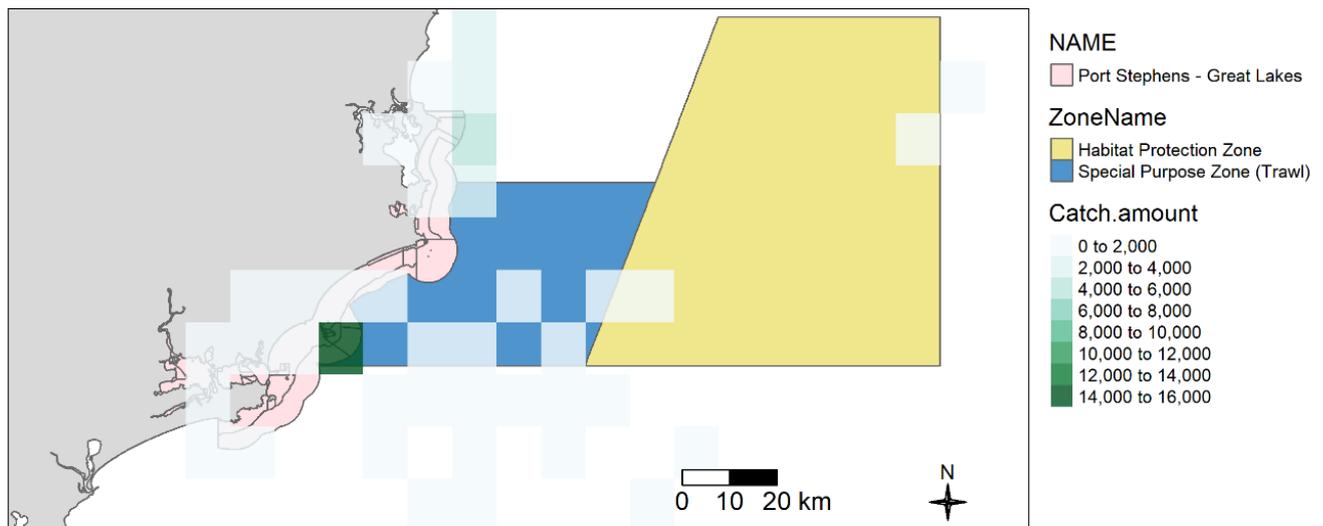


Figure 44 Distribution of retained catch (all finfish species, by number) in Hunter AMP for all years from 2016–2019.

5.1.5 Catch (all finfish species) all years

There were 55 species (and family groupings) of finfish recorded as retained or released by charter operators between 2016 and 2019. The top eight species retained by charter operators comprise 92% of the retained catch across all years, with Blue Mackerel (*Scomber australasicus*) contributing the largest retained catch (51%) across all species, followed by Pink Snapper (*Chrysophrys auratus*) (16%) (Table 11). Most of the Blue Mackerel were caught within a single grid cell to the east of Broughton Island from grid cell that borders both the PSGLMP and HMP (Figure 45). While, pink snapper were also predominately caught from within the same grid cell (where the majority of effort in concentrated; (Figure 46). Pink snapper were also caught in numbers >500 to the north of the HMP. Catches of Teraglin showed a near identical pattern of distribution to pink snapper (Figure 47).

Table 11 Top 8 species (and family groupings) retained by charter operators in Hunter AMP, with percentage contribution to the retained catch (all species combined).

Rank	Common Name	Species Name	% Retained
1	Blue Mackerel	<i>Scomber australasicus</i>	51
2	Pink Snapper	<i>Chrysophrys auratus</i>	16
3	Teraglin	<i>Atractoscion aequidens</i>	11
4	Bluespotted Flathead	<i>Platycephalus caeruleopunctatus</i>	7
5	Redfish	<i>Centroberyx affinis</i>	2
6	Pearl Perch	<i>Glaucosoma scapulare</i>	2
7	Dusky Flathead	<i>Platycephalus fuscus</i>	2

Rank	Common Name	Species Name	% Retained
8	Grey Morwong	<i>Nemadactylus douglasii</i>	1
TOTAL			92

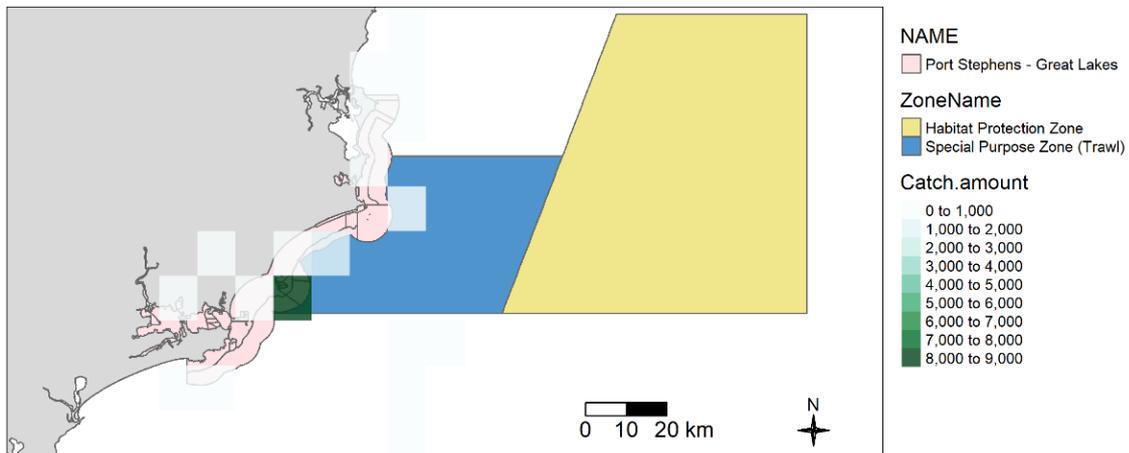


Figure 45 Distribution of retained catch (by number of Blue Mackerel in HMP for all years from 2016–2019.

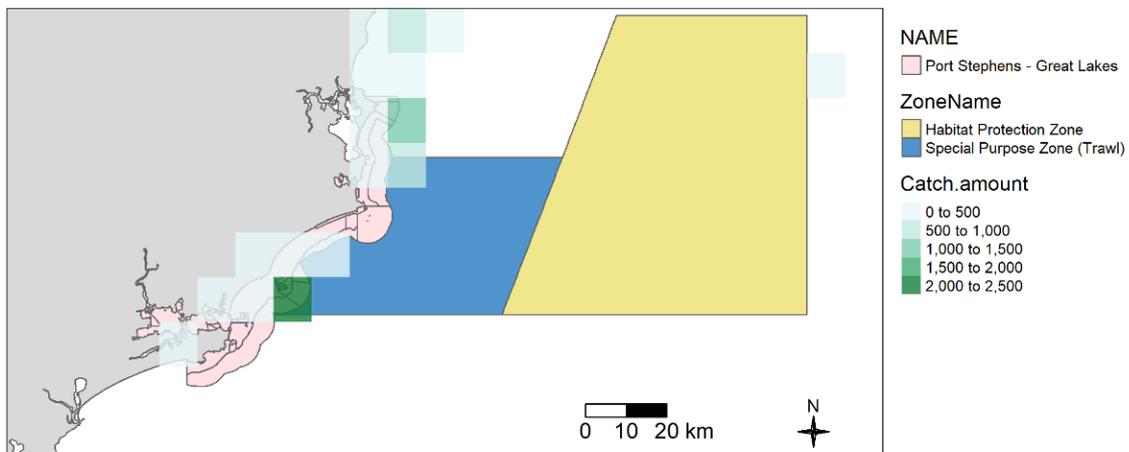


Figure 46 Distribution of retained catch (by number) of Pink Snapper in HMP for all years from 2016–2019.

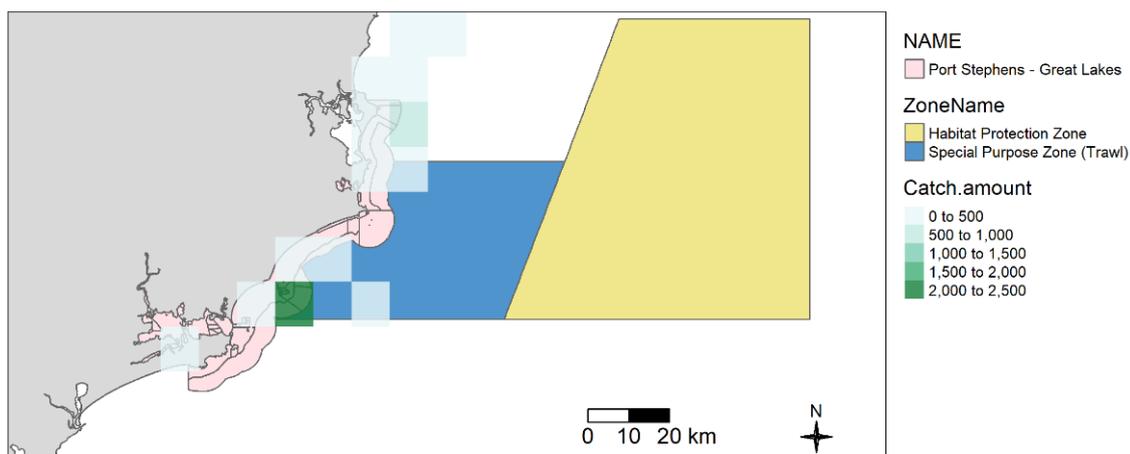


Figure 47 Distribution of retained catch (by number) of Teraglin in HMP for all years from 2016–2019.

5.1.6 Catch and effort distribution by year

With only three years of data that is available and capable of establishing catch and effort with the HMP it is difficult to make inter-annual comparison. Between 2016 and 2019 catch and effort were very similar between years.

5.2 Solitary Islands Marine Park

5.2.1 Study area

The Solitary Islands Marine Park (SIMP) is located within the Temperate East region and covers an area of 152 km², ranging in depths from 15 to 70 m (Figure 48). The Commonwealth Solitary Island Marine Park adjoins that state marine park which has the same name. For the purposes of this report we will differentiate between the two with the SIMP for the Commonwealth Park and SIMP-state for the state park. The SIMP has a National Park Zone, Multiple Use and Special Purpose Zones. The National Park Zone (no-take) is surrounding the well-known Pimpernel Rock a submerged pinnacle rising close to the surface.

SIMP is practically an extension of SIMP-state and all of the map grid cells that charter operators report to overlap both state and commonwealth marine parks or commonwealth waters. Therefore it is not possible to establish the exact effort and catch related to SIMP vs SIMP-state. The following section reports effort and catch in SIMP and SIMP-state surrounding.

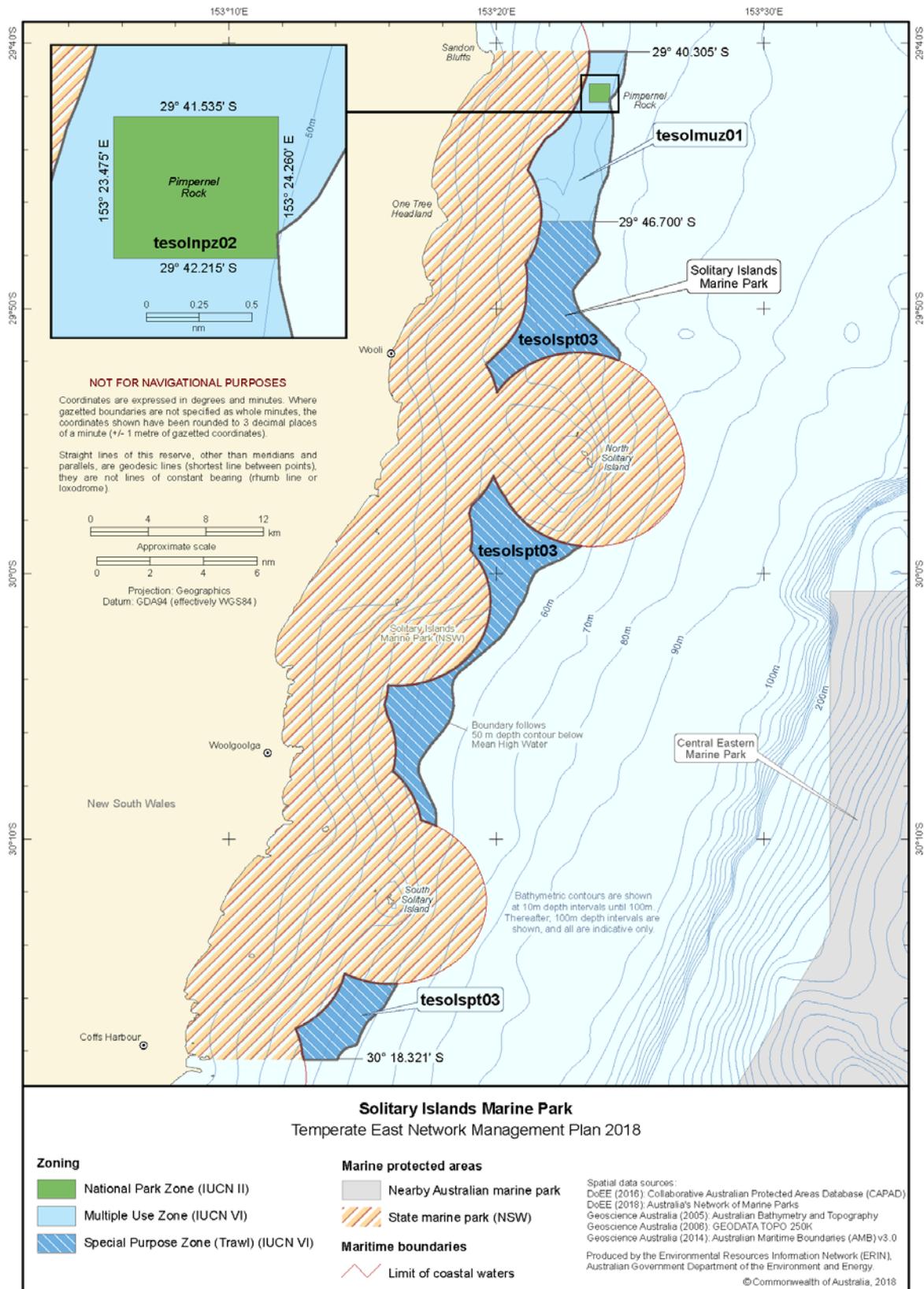


Figure 48 Map of the Solitary Island Marine Park (SIMP) zoning in relation to the state marine park.

5.2.2 Number of charter operator licences

Charter operators in New South Wales are not specifically licensed to operate within AMPs or within bioregions. Instead, operators are endorsed by fishing type or activity (estuarine fishing, nearshore bottom fishing and sport fishing, game fishing and deep-sea bottom fishing).

Prior to 2016 charter operators only reported the general location or port of operation and it is not possible to establish if operators were fishing within an AMP. Since 2016 charter operators have been reporting effort and catch within a 6x6 minute grid cell, the same as used by commercial fishers. However, all of these grid cells span over the both state and commonwealth marine park boundaries. From here on we report effort and catch for all grid cells that are within or across the border of the SIMP.

The number of charter operators who have submitted log sheets that indicate they have fished within or across the border of the SIMP varied from 7 to 8 since 2016 (Figure 49). However, it should be noted that despite the logbooks being a legal requirement the compliance rates are low (~36 % for all of NSW). It is not possible to establish the compliance rates for the SIMP region.

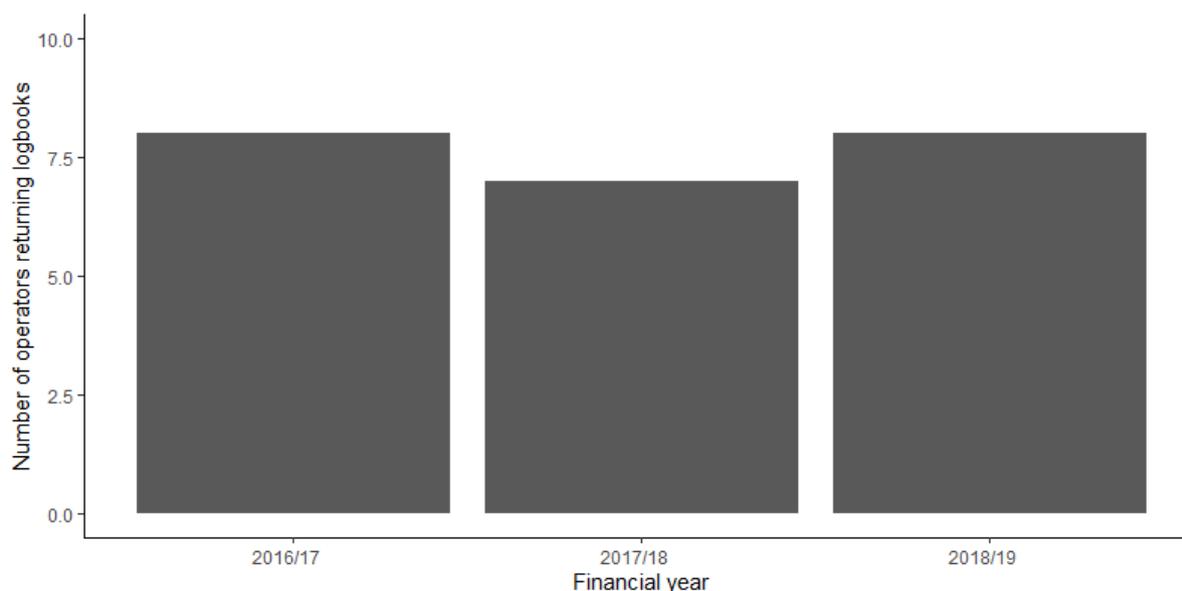


Figure 49 The total number of operators that submitted log sheets that had grid and site location codes that identified as fishing within or across the border of the SIMP from 2016–2019.

5.2.3 Total effort by year

Based on the available data, fishing effort by charter operators was measured by the number of log sheets submitted (Figure 50) and the numbers of hours recorded as actively fishing (Figure 51). There may be multiple fishing sessions per day on the same charter, and also multiple fishing charters per day (i.e. when a charter operator returns to a marina/boat ramp to pick up a new group of fishing clients).

The number of log sheets that were returned with grid or site codes that occurred in the SIMP varied between 300 and 411 log sheets per year since 2016 (Figure 51). The number of hours fished varied from 1838 to 2536 hours per year since 2016 (Figure 52). It is evident that effort is concentrated around two grid cells in particular. The bulk of hours spent fishing is occurring in the grid cell surrounding North Solitary Island and covering the southern SIMP (Figure 52).

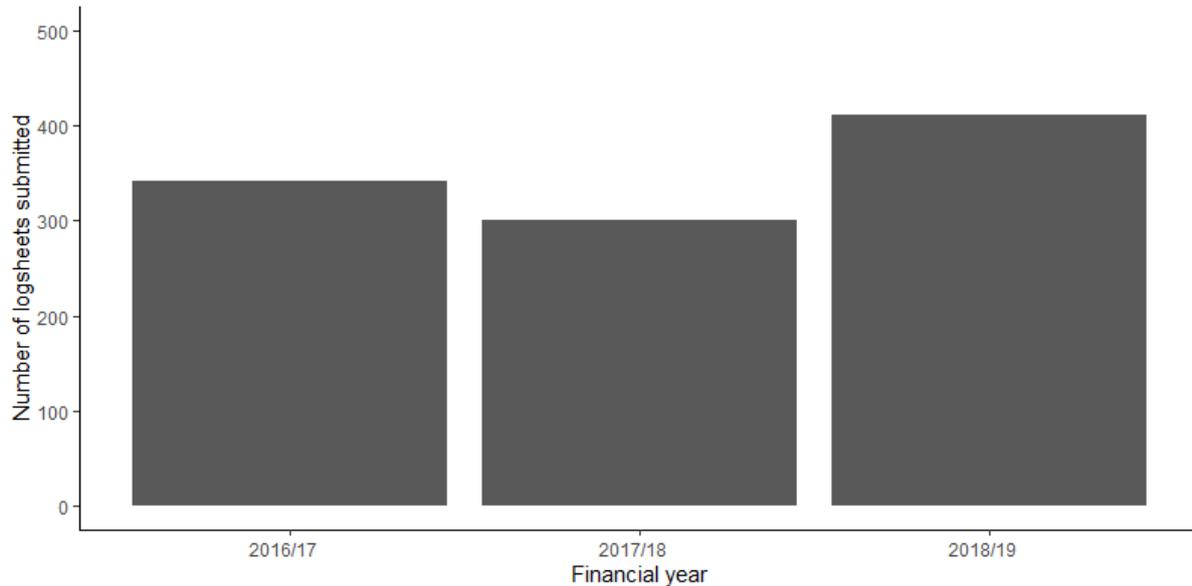


Figure 50 The number of log sheets that indicate fishing effort from within or bordering across the Hunter AMP.

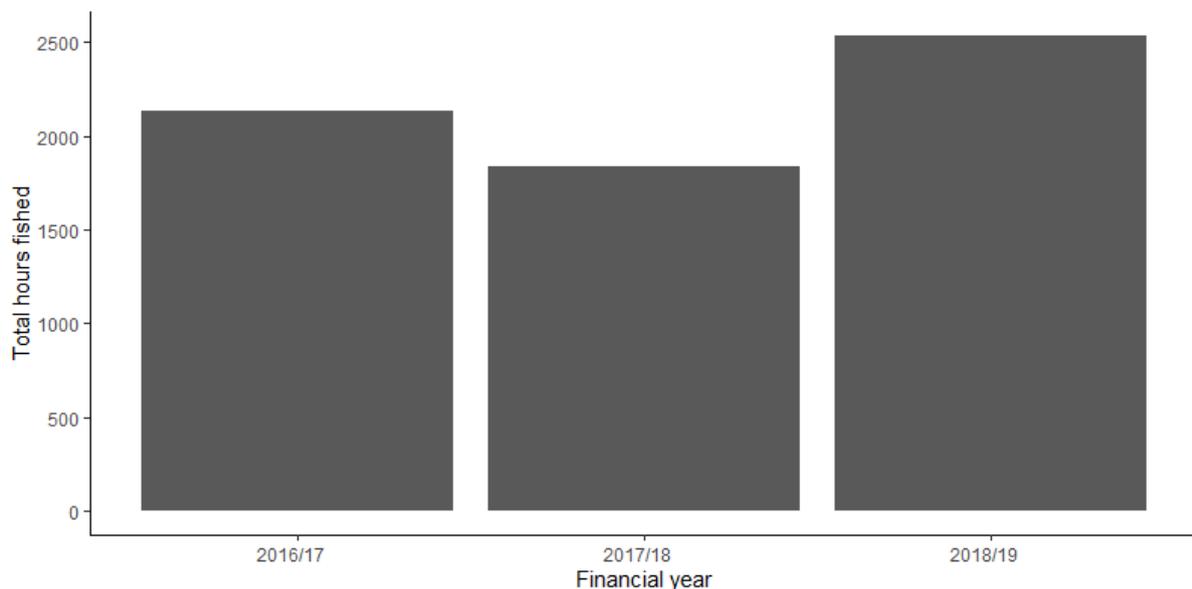


Figure 51 Number hours fished as per logged for fishing effort from within or bordering across the Hunter AMP.

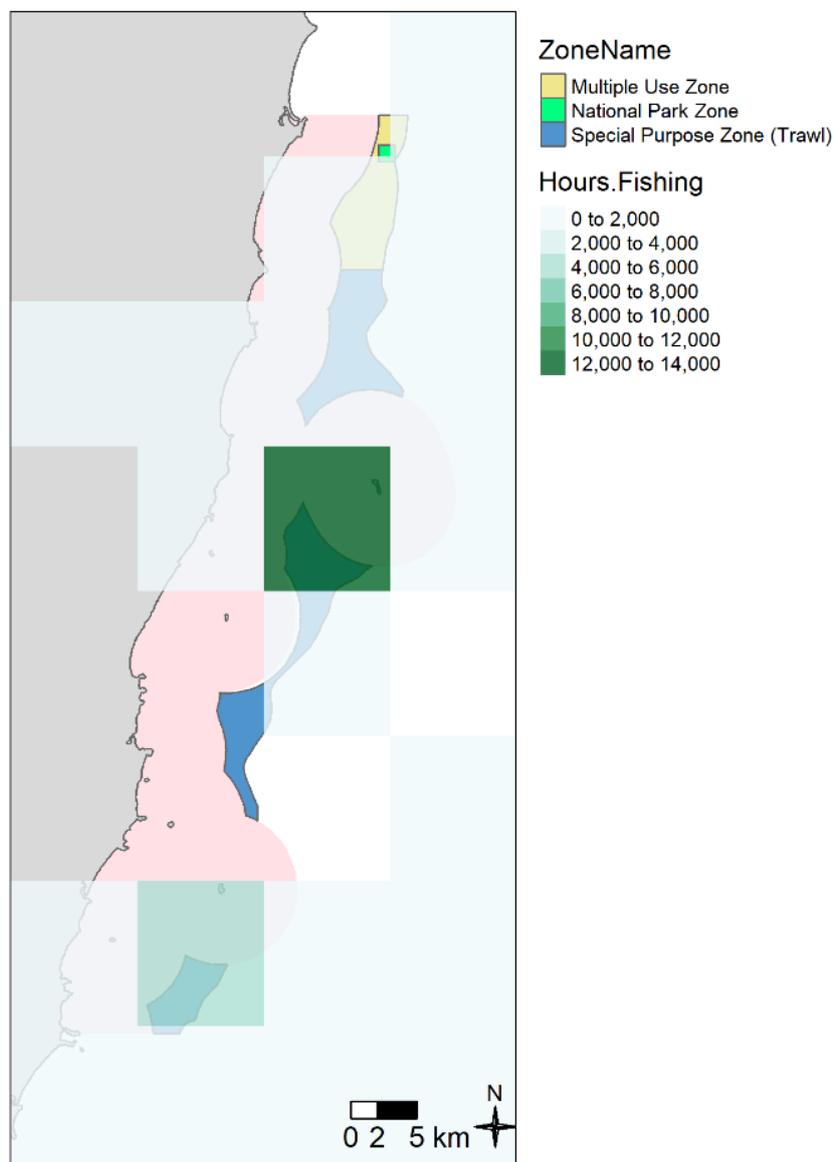


Figure 52 Distribution of fishing effort (as number of hours fished) in the Hunter AMP and surrounds for all years from 2016–2019.

5.2.4 Catch (all finfish species) by year

Catch (all species) in SIMP has been reported for finfish only and calculated as the number of retained individuals. Since 2016, charter operators only have to report retained catch. Retained catch varied between 9743 and 10646 individuals, representing 85 species or species groups, which were retained between 2016 and 2019.

The distribution of retained catch in Hunter AMP across all years (2016–2019) showed the highest catches occurred in a grid cell that spanned each of SIMP, SIMP-state and

commonwealth water (Figure 53). Overall, the majority of fish that were retained came from a grid cell surrounding North Solitary Island (Figure 53).

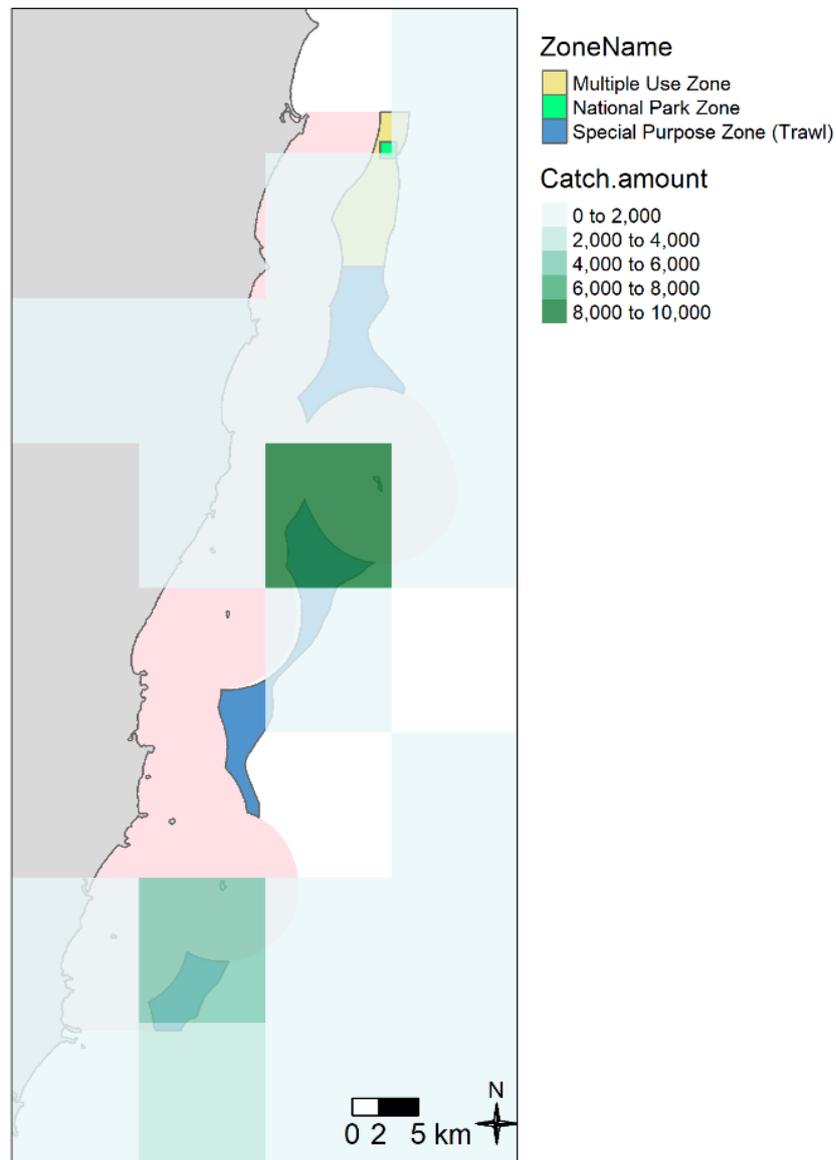


Figure 53 Distribution of retained catch (all finfish species, by number) in Hunter AMP for all years from 2016– 2019.

5.2.5 Catch (by finfish species) all years

There were 85 species (and family groupings) of finfish recorded as retained or released by charter operators between 2016 and 2019. The top eight species retained by charter operators comprise 78% of the retained catch across all years, with Pink Snapper (*Chrysophrys auratus*) contributing the largest retained catch (31%) across all species, followed by Bluespotted Flathead (*Platycephalus caeruleopunctatus*) (19%) (Table 12).

Table 12 Top 8 species (and family groupings) retained by charter operators in SIMP, with percentage contribution to the retained catch (all species combined).

Rank	Common Name	Species Name	% Retained
1	Pink Snapper	<i>Chrysophrys auratus</i>	31
4	Bluespotted Flathead	<i>Platycephalus caeruleopunctatus</i>	19
3	Teraglin	<i>Atractoscion aequidens</i>	6
4	Leatherjackets	Monacanthidae	6
5	Pearl Perch	<i>Glaucosoma scapulare</i>	4
6	Silver Trevally	<i>Pseudocaranx georgianus</i>	3
7	Fusiliers and tropical snappers		3
8	Venus Tuskfish	<i>Choerodon venustus</i>	3
TOTAL			78

The majority of Snapper and Teraglin were caught within a single grid cell surrounding North Solitary Island and covering both SIMP-state and SIMP-com (Figure 54 and Figure 55). While, Bluespotted flathead were predominately caught from the southern proportion of both SIMP and SIMP-state (Figure 56).

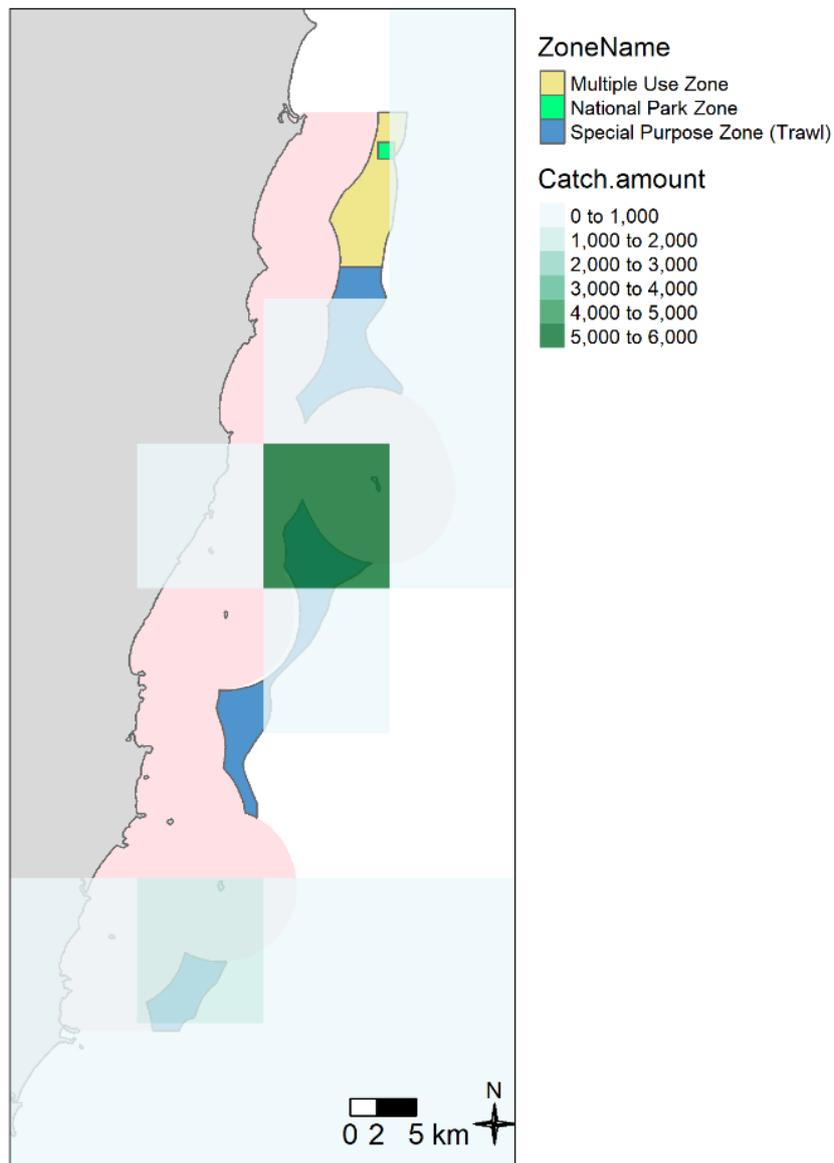


Figure 54 Distribution of retained catch (by number) of Snapper in SIMP for all years from 2016– 2019.

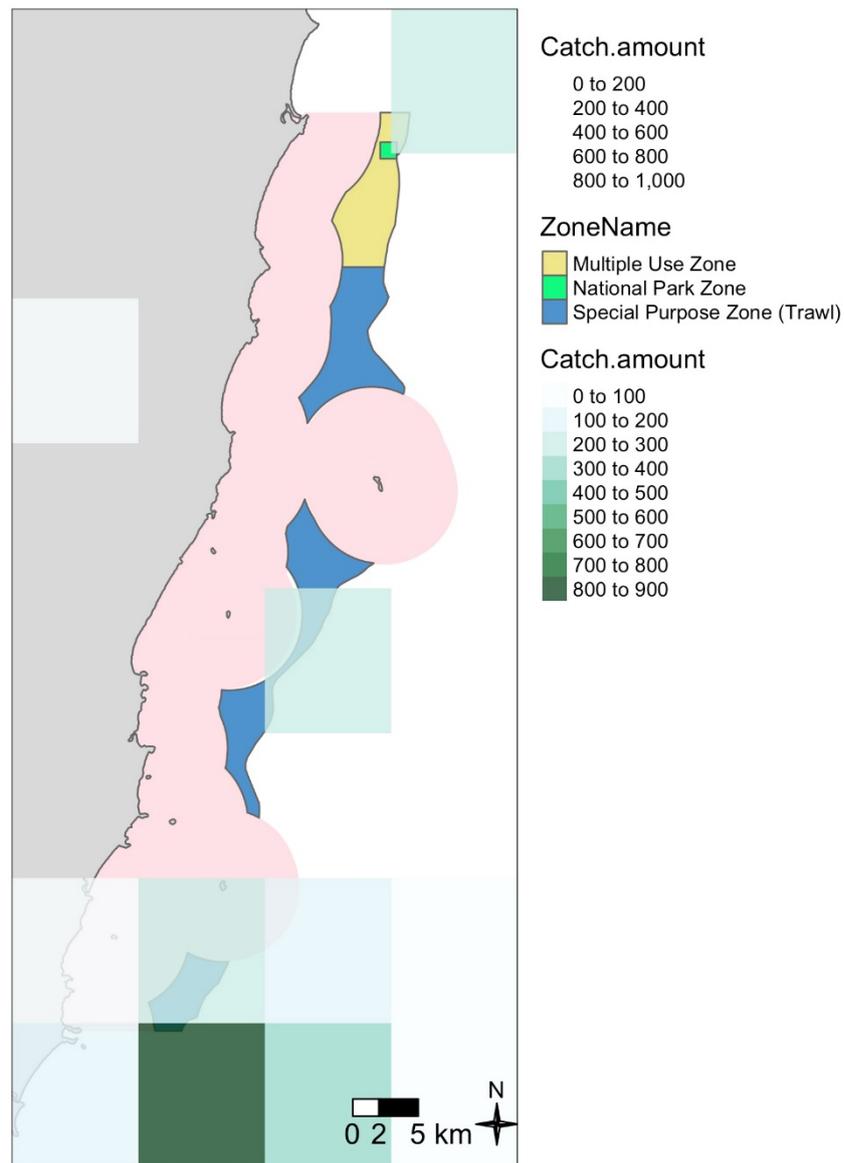


Figure 55 Distribution of retained catch (by number) of Bluespotted Flathead in SIMP for all years from 2016 – 2019.

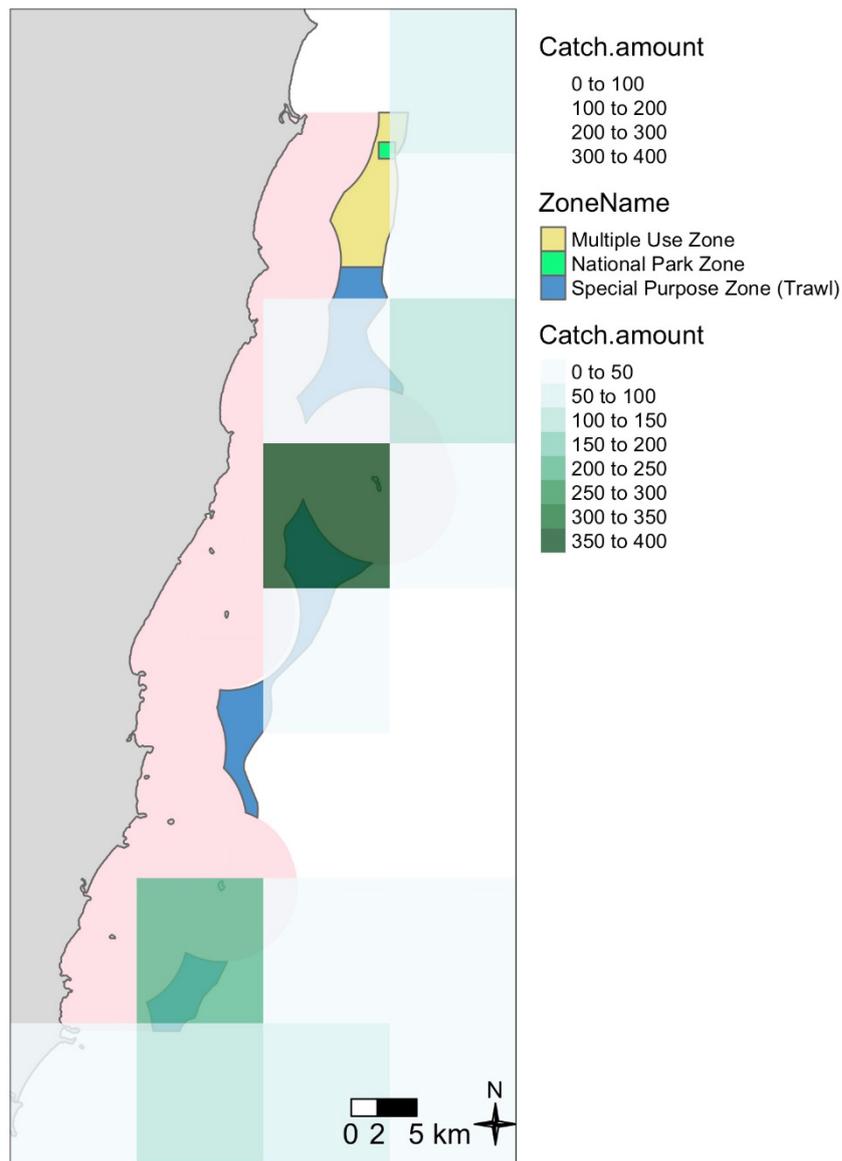


Figure 56 Distribution of retained catch (by number) of Teraglin in SIMP for all years from 2016 – 2019.

5.2.6 Catch and effort distribution by year

With only three years of data that is available and capable of establishing catch and effort with the SIMP-com it is difficult to make inter annual comparison. Between 2016 and 2019 catch and effort were very similar between years.

6. DISCUSSION

All marine recreational fisheries in Australia are managed by the states and gaining an understanding of this sector has significant challenges and complexities. One of those complexities is that State recreational fisheries data is often divided into three separate databases: state-wide surveys, charter boat fishery logbook data and various game fishing or other tournament data (Georgeson et al., 2015). In our previous study we investigated the usefulness of two state-wide surveys to provide relevant information to key fisheries managed by AFMA and also more generally to candidate AMPs. In this work we follow a similar approach but focused onto the charter and game fisheries. While we were able to source reference material on both charter and game fisheries, we only received access to the charter boat data. For both WA and NSW the charter datasets are managed within the fisheries units of the larger primary industry departments.

Generally, the state-wide surveys appear to have been the primary focus by the state agencies. However, the charter boat and game fishing data are often collected at much higher temporal rates and more precise spatial scales than the state-wide surveys. Following on from initial reports of pilot studies, data appears to have been collected and archived for analysis as batches, either by students or consultants in an opportunistic fashion in NSW or annually for the status of fish stocks report in WA (Gaughan and Santoro, 2018). Like the state surveys, the charter and game fishing studies are mostly published as departmental reports or grey literature.

For the state-wide surveys we found that each state's fishery survey designs were contextual to their own management needs, however aspects of each states surveys still provided useful information to Commonwealth jurisdictions, particularly for the AFMA species of interest. Disaggregation of data to the scale of particular AMPs extended the application of data beyond the objectives for which each survey was designed and hence stretched the power of the designs to make meaningful statistical inference – particularly for NSW. Conversely, the charter boat and game fishing data may be of less use to AFMA, as these fisheries are relatively small and limited in Commonwealth waters.

Relative to the general recreational fishery the charter catch is tiny, for example the reported catch of Bluespot flathead (the most caught fish in both the charter and general recreational fishery in NSW) was ~30,000 for the charter fishery, compared to ~1,000,000, so around 3%, of the general recreational fishery. Analysis of the impact of AMP zoning on charter operations in north west WA suggested that low levels of charter activity would be displaced from the Gascoyne, Pilbara and Kimberley areas and overall displacement of charter fishing is estimated to be low for Western Australia as a whole (ABARES, 2012). However due to the much finer scales of data collection, they may be of more interest to AMPs as potential proxies for the general recreational fishery. The more intensive time-series may also be of interest for modelling of catch per unit effort (CPUE) over time to assess trends - especially for technological effort creep and hyperstability.

6.1 Development of Data collection

6.1.1 Charter

Across Australia there was a fisheries management response to charter fishing during the early 1990s. Concerns were raised over unsustainable growth in the sector combined with a lack of

knowledge of the industry's impact on fish resources. Charter fisheries are now licensed, limited access fisheries in all states.

The first attempt to understand the scale of the charter boat fishery in NSW occurred as part of a larger assessment of recreational fishing in the mid-1990s (Steffe et al., 1996). As the charter fishery was not specifically licensed at the time, boat counts from on-site surveys and logbooks from sea rescue organisations were used to estimate effort and logbooks from volunteer charter skippers were used to estimate harvest (retained) as well as released fish. This preliminary work was followed by the development of a comprehensive register of charter boat operators in 1997/98 and categorisation of their targets and activities. A total of 211 operators/companies providing charter services, with a fleet of 237 vessels engaged in a great variety of recreational fishing and non-fishing activities which often overlapped (Steffe et al., 1999).

When this more direct approach to charter skippers was taken it also became apparent that non-fishing activities, such as ecotourism (51.7% of boats and 8.5% effort), diving (24.2% of boats and 4.4% effort) and miscellaneous work (e.g. parties and pleasure cruising, ferry services, scientific research, shark meshing etc.) (11.7% of boats and 3.4% effort) were a considerable component of the work of the charter boat fleet (Steffe et al., 1999).

Both studies provided a baseline for monitoring the charter boat fishery and also made recommendations to introduce both licensing and a mandatory reporting system. These recommendations were adopted, with the charter fishery became a restricted access fishery in 2000 (McIlgorm and Pepperell, 2014). However, concerns have been raised over the quality and the validity of NSW charter boat reporting (Gray and Kennelly, 2017). Returns from operators to the NSW database have hovered around 50-60% for the entire program.

The quality of the charter boat data from WA appears to be higher, with return rates over time approaching 100%. This may be due to a more proactive approach, with a dedicated Research Officer directly contacting licensees in WA and collecting information, including for periods where no fishing occurred, compared to passive self-reporting in NSW. This has resulted not only in a higher rate of returns but also a good understanding of latency in effort, which is the difference between total licence holders and active participants. An initial review of the WA charter boat fishery suggested that the average proportion of inactive operators ranged from 41.4% to 54.7% over the study period (2002/03 and 2007/08) and licence transfers within the charter industry were also highly variable (Telfer, 2010). Following the initial round of reforms in the early 2000s that led to licensing of the industry, WA introduced a further series of reforms to remove latent effort and streamline the number of licence categories.

Unlike WA, which actively contact all license holders, NSW relies on self-reporting. If the NSW charter fishers have similar amounts of latency to what occurs in WA, their low returns may just be an indication of latency, with only those licensees activity participating in the fishery bothering to send in returns. This hypothesis could be easy tested with several rounds of phone contacts with all licence holders.

6.1.2 Gamefish

West (1990) identified a system being used by the GFAA and its affiliated clubs to monitor their vessels whilst at sea during competitions. This was a mandatory radio schedule reporting system (known as 'scheds') that was identified as a potential source of effort and catch data.

Scheds involves a marine radio base (usually situated on land) and a radio operator who contacts each participating vessel at regular intervals for information about the location of the vessel (as a spatial alpha-numeric grid), their fishing activity (travelling, trolling, drifting or anchored) and a fishing report, which includes details of fish strikes, fish hooked and fish captured or tagged and released.

Tag and release increased over time and this coincided with changing fisher attitudes towards the conservation of billfish and the introduction of minimum size requirements for captured individuals (Ghosn et al., 2012). Annual landed catch records from game fish clubs represent the only available long time series of catch data for the southeast Australian recreational striped marlin fishery. These records are combined with records from the New South Wales (NSW) Gamefish Tagging Program (GTP) to provide an annual weight index for recreationally caught striped marlin from southeast Australian waters from 1936 to 2010.

While game fishing records exist in each state, for separate reasons these were not available for use in this study. In WA the data was not considered of suitable quality for external release and in NSW the data was held by an external contractor. For individual AMPs, access to game fishery data could be obtained through local out-reach to clubs permitted to operate competitions within the park.

6.2 Time-series

As charter boat fisheries have mandatory logbook reporting these provide a census of fishing activity. This contrasts with the estimation approach based on the randomised sampling of recreational fishers that occurs with state-wide surveys. Our data on charter fishers are thus presented as whole numbers or percentages rather than estimates with error bars. Data from WA is a comprehensive 17-year time-series for charter boats, while in NSW there is a 10-year time-series for effort/participation and a 3-year series (due to data quality concerns) for catch. This compares to 4 data points over the same period in WA from the state-wide surveys and only 2 data points for NSW. While we provided data on an annualised basis, charter return rates are much higher, with WA and NSW receiving data on a monthly basis. The charter data thus has the potential to deliver detailed time-series at much higher frequencies than the state-wide surveys.

In both states the catch diversity was high but ~30 species contributed 80-90% of the catch which declined into a long tail of individual contributions (1-3%). The remainder (10-20%) included many more species that contributed <1% of the total catch. These proportional distributions of catch are generally similar to what is found in state-wide surveys of the recreational fishery (West et al., 2015; Ryan et al., 2017; Lynch et al., 2019) and suggest that the charter boat fishery may be a good proxy for understanding the diversity of the recreational catch.

In both states the charter fishery is almost entirely focused onto demersal species and this has been the pattern over the long term. In WA pink snapper (16%) were the most caught followed by red throat emperor (6%) and spangled emperor (5%), while in NSW bluespotted flathead dominated the catch (19%) followed by pink snapper (14%) and grey morwong (*Nemadactylus douglasii*) (8%).

With their much higher frequency of reporting, the charter fishery could provide a finer scale assessment of shifts in the diversity of catch. These could provide rapid reporting of either changes in abundance, preference for targeting or climate shifts. These types of analysis have already been made with the game fishing datasets. The long time-series and high resolution citizen science data from the NSW DPI Game Fish Tagging Program allowed for detection of a rapid poleward shift in the geometric mean of black marlin habitat, occurring at 88.2 km per decade (Hill et al., 2016). Due to their fine spatial resolution, charter fishing datasets may also be able to detect these sorts of movements but for demersal species. Both Australian coasts are undergoing rapid climate change leading to changes in species compositions and regime shifts in community composition (Johnson et al., 2011; Frusher et al., 2014; Wernberg et al., 2016). In response to this rapid pace of climate change, fishers show varying abilities to adapt to the changing conditions (van Putten et al., 2017).

As a proxy for temporal variation in effort for the recreational fishery, the charter boat returns are not a suitable metric. This is because unlike the recreational fishery, entry into the charter boat is capped so effort does not have the same inherent level of variability as the general recreational fishery, where licenced fishers are free to enter or leave the fishery regardless of the total numbers of fishers. Participants in charter fisheries are also not representative of all recreational fishers as they are guided by the very experienced charter operators, who have an incentive to deliver quality catches to their clients. Variability in client fishing skill would also be dampened by the presence of the charter operator. Clients are coached and guided by the operator who has extensive local knowledge. If novices, they will also be provided with gear and have their lines set and baited and then placed onto fish. Interestingly, avidity would also not be an issue, as each trip by an individual client is an independent event in the census dataset, so if they go more than once it will be captured.

Most recreational fisheries in Australia appear to have two modes of catch per unit effort (CPUE). The bulk of the fishery (70-80%) catches few fish (20-30%), while the second, smaller group of fishers catch most of the fish (West et al., 2012; West et al., 2015). It would be expected that catch rates by charter boat fishers would be like the second mode in the distribution of recreational fishing catch. The charter boat fishery may thus be a better proxy for insights into catch and catch per unit effort (CPUE) rather than temporal variations in effort. We did not, however, present CPUE trends as without adjustment these would have been bogus due to issues with hyper-stability and effort creep.

6.3 Hyperstability and effort creep

In our analysis we have presented descriptive statistics to illustrate spatial patterns and temporal trends in participation, effort and catch. Over our time-series effort and catch rates showed similar patterns of stability with some declines, which we proposed were influenced by various reform of the industry. For instance, WA removed licensing requirement for land-based charter fishers in 2014. More generally, across the entire recreational fishery, there were also changes in management arrangements such as reduced bag limits and introduction of closed seasons for some key species caught by charter operators (Crowe et al., 2013; Ryan et al., 2016). However, there are two concepts that need to be considered when during inference from our time-series data. The first of these is hyperstability, which has been a concern regarding charter boat fisheries since some of the first work on this sector in Australia.

Hyperstability is when catch remains stable while true abundance declines (Erisman et al., 2011), and this can have a number of mechanisms. The first of these is from expansion of fishing

grounds into new un-exploited areas, also known as “cowboy economics” (Barrett and Farina, 2000). For example, reconstruction of catch from historical records in South East Queensland showed pink snapper catch rates remained stable throughout the early part of the time series between 1871 and 1939, averaging 3.75 snapper per fisher hour. This catch rate was maintained as the fishery continually expanded into new un-fished grounds. Once the edge of this fishery frontier had been fully extended, however, so no more easily accessed virgin stocks remained, catch rates decline. In comparison, a contemporary (1993–2002) south-east Queensland charter fishery produced an average catch rate of 0.4 snapper per fisher hour (Thurstan et al., 2016).

Fisheries that target fish spawning aggregations are another mechanism for hyperstability (De Mitcheson et al., 2008). If aggregations are predictable in time and space and fishers can reliably return to those points, CPUE can remain high or even increase as true population abundance declines (Walters, 2003). Pink snapper is one of those species with temporally and spatially specific spawning aggregations, which have been targeted in the past. This has led to, in some cases, to management responses of closed areas and seasons (Wakefield, 2010; Parsons et al., 2014).

The second and linked issue is effort creep, where there is ongoing increases in fishing power due to continual improvements in technologies. As fishing power increases, fishing effort, which is measured as a unit of time, changes relative to the past. Hence one hour of fishing effort now is much more efficient in catching fish than an hour of fishing in the past. Fishers are fast adopters of rapidly improving technologies such as satellite navigation (GPS), echo-sounders and computer plotting (Tidd et al., 2017; de Lestang et al., 2018). Increases in technological efficiency results in relentless increases in fishing power but adding to complexity these changes can be non-linear (Engelhard, 2016). This means that time-series of metrics for measuring fisheries, such as fishing effort or CPUE need to include a “creep factor,” so as to allow for standardisation over time, particularly if they exceed one decade in temporal coverage (de Lestang et al., 2018) as is the case with our charter boat datasets.

Standardisation of effort in fisheries time series data is a common process for surveys of commercial fisheries catch data. Palomares and Pauly (2019) identified 51 different estimates to correct changes in commercial fishing power with rates of improvements in effort efficiency of between 2-4% per year. They used these data to derive an empirical relationship and provide equations to infer creep in effort and CPUE estimates even in the absence of any knowledge about the technological creep in a given fishery. However, all of the data were for commercial fisheries and this approach has not been attempted to the best of our knowledge with recreational fisheries. For this reason we did not calculate CPUE for the charter boat time-series.

Two major issues with application of CPUE adjustments to recreational fishery more generally are the known strong heterogeneity in CPUE between individual recreational fishers due to differences in skill and the low number of data points over time for estimates. The more well developed time series for the charter boat fisheries and, due to the presence of the charter operator as guide and coach, the potential for less variability in individual fisher skill, may solve these issues. The charter fishery dataset may provide a useful model to explore long term CPUE changes in demersal recreational fisheries if appropriate adjustments for effort creep can be made.

6.4 Fishing distributions

AMP managers specifically, and Marine Protected Area managers more generally require information on the small-scale spatial distributions of fishing effort and catch within the boundaries of their parks. This is unlike fisheries managers who focus their surveys over the spatial scale of the stock, which can range from broad to small. This difference in the focus of interest is due to the different natures of park and fisheries management. Parks seek protection and conservation of biodiversity and other natural, cultural, and heritage values while also allowing for ecologically sustainable use and enjoyment of the park, while fisheries managers focus on the sustainable management of exploited fish stocks. For recreational fisheries the designed sampling scale for reporting from the state-wide recreational fisheries surveys in both WA and NSW is at the bioregion, which is larger than all AMPs. Disaggregation of data may not be appropriate at small spatial scales as it is beyond the state-wide assessments design objectives, which are generally broad bioregional scales (Lynch et al., 2019). Unlike the state-wide surveys, however, reporting of charter fishing may occur (if confidentiality requirements are met) at finer spatial scales, with 5 x 5 nm blocks in WA and 6 x 6 nm in NSW.

Once the expansion, discovery and hyperstability phase of a fishery is over, the spatial distributions of fishing effort can stabilise (Lynch, 2014). Though stability can change in response to effort creep, for instance if access is improved (new roads, new boat ramps) or if there are revolutionary technological breakthroughs allowing for easy targeting of new habitat (e.g. electric reels). This is probably because fish species distributions are related to habitat and these habitats become known and are targeted by fishers (Lynch, 2006) and fishers limit travel from access points (Stuart-Smith et al., 2008). It appears from studies that consider small scale distributions of the recreational fishery that charter boat fishing occurs in similar locations to the broader recreational fishery for particular target species (Lynch, 2008; Smallwood et al., 2011). Both our work and previous ordinary kriging results (Telfer, 2010) showed both high density and low-density fishing locations.

We compared the various datasets that we have reviewed across the entire project for their usefulness for AMPs (Table 13). In those parks with an active charter boat fishery there may be the potential for these fishers to provide a proxy for distributions of recreational fishing effort, especially for demersal species. Using the charter industry as a potential proxy for changes in CPUE may also be possible, if adjustments for effort creep can be made. The state-wide assessments are less useful for AMPs, especially in NSW but the NSW game fishery dataset has the potential to provide interesting data on pelagic species.

Table 13 Usefulness of charter, state-wide assessment (SWA) and game fisheries datasets to individual AMPs.

Datasets	Park Effort	CPUE ¹	Diversity over time	Time-series	Small scale distribution	Demersal catch	Pelagic catch
WA charter	low	high	high	high	high	high	low
NSW charter	low	high	high	med	high	high	low
WA SWA	high-med ²	med/low	med	med	low	high	med
NSW SWA	low	low	med	low-med	low	high	med
WA gamefish	low	low	low	low	low	low	low
NSW gamefish	high	high	high	high	high	low	high

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