11-2019

Integrated survey of boat-based recreational fishing in inner Shark Bay 2018/19

S.M Taylor

Claire B. Smallwood

Cameron J. Desfosses

K. L. Ryan

Gary Jackson

Department of
Primary Industries and
Regional Development

GOVERNMENT OF
WESTERN AUSTRALIA

Fisheries Research Report No. 298

Integrated survey of boat-based recreational fishing in inner Shark Bay 2018/19

S. M. Taylor, C. B. Smallwood, C. Desfosses, K. L. Ryan, G. Jackson

November 2019

Correct citation:
Taylor, S. M., Smallwood, C. B., Desfosses, C., Ryan, K. L., Jackson, G. 2019. Fisheries Research Report No. 298. Department of Primary Industries and Regional Development, Western Australia. 135pp.

Enquiries:

WA Fisheries and Marine Research Laboratories, PO Box 20, North Beach, WA 6920
Tel: +61 8 9203 0111
Email: library@fish.wa.gov.au
Website: www.fish.wa.gov.au

A complete list of Fisheries Research Reports is available online at **www.fish.wa.gov.au**

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

ISSN: 1035-4549 (Print) ISBN: 978-1-921258-28-2 (Print)

ISSN: 2202-5758 (Online) ISBN: 978-1-921258-29-9 (Online)

Contents

Acknowledgements

This project was made possible by the Recreational Fishing Initiatives Fund. We thank Sarah Winslade-Mullane, Ben Fraser and Selina Cranley for administering the funding. We are grateful to Recfishwest for providing feedback on our original project application and for attending project update presentations. We are very grateful to the recreational fishers who participated in this survey. We thank Mark Halse, Jess Herriot, Joe McLaughlin, Marigula Muriopulos and Tiffany Taggart for conducting the boat ramp surveys. We thank Jess Herriot and Marigula Muriopulos for being observers in the aerial survey and Dr Emily Fisher for providing training to these observers. We thank Shannon Burchert, Tarryn Coward, Blaine Hodgson, Jason Harney, Susan Martin, Matthew Navarro, David Oberstein and Daniel Yeoh for reading the camera data. We thank the staff and pilots at Shark Bay Aviation, especially Julien Wilke. We thank the owners of the Nanga Bay Resort and the RAC Monkey Mia Dolphin Resort for allowing a remote camera to be maintained on their premises. We are grateful to Teresa and Ron Reid at Tamala Station for allowing us onto the property and for providing information on visitation rates. We thank Byron Francis, Travis Feist and Leah Ricetti from the Denham DPIRD office for their observations on recreational fishing in Shark Bay and administrative assistance. We are grateful to Stuart Blight for camera technical support, Vangie Gerginis for data entry, Mark Goninon for amendments to the structure of the database and Dr Ainslie Denham for assistance with the variance calculations. We thank Dale Smith for assistance with ArcGIS Collector Software. We thank Karen Williams for administrative support and assisting in budgetary reporting. Dr David Fairclough and Joshua Brown provided useful comments on the species identification of emperors and tuskfish. We thank Dr Aldo Steffe (Fishing Survey Solution Pty. Ltd.) for earlier input into the design of the onsite recreational fishing surveys. We are grateful for comments provided by Clinton Syers, Dr David Fairclough and Eva Lai as part of the DPIRD internal review process.

Executive Summary

Inner Shark Bay is a popular recreational fishing destination. As recreational fishing occurs in a World Heritage Area and Marine Park, there is a need for ongoing reliable information on catches. Many boat-based recreational fishers in inner Shark Bay target Pink Snapper (*Chrysophrys auratus*). Three separate Pink Snapper stocks occur: Denham Sound, the Eastern Gulf and Freycinet Estuary. These stocks are particularly vulnerable to exploitation because Pink Snapper aggregate to spawn in predictable locations each winter, which leads to higher levels of fishing effort at this time.

This publication is one of two documenting the research outcomes of the project "Innovative methods for monitoring recreational fishing in Shark Bay", funded by the Recreational Fishing Initiatives Fund (RFIF). The study was initiated in response to changes to the management of recreational fishing for Pink Snapper in inner Shark Bay that were introduced in January 2016. These changes included the cessation of a harvest tag system in Freycinet Estuary (introduced in 2003 to recover stocks by limiting the number of Pink Snapper that could be retained), the introduction of a finfish possession limit within Freycinet Estuary (5kg or one day's bag limit of whole fish/trunks, all species) and the removal of a maximum size limit for Pink Snapper (700mm total length) for all three inner gulf stocks (introduced in 1997 to protect large mature adults). The main objective of the study was to provide robust annual estimates of the catch (kept, released and total) by boat-based recreational fishers operating from the three boat ramps in inner Shark Bay (Denham in Denham Sound, Monkey Mia in the Eastern Gulf and Nanga in Freycinet Estuary) between March 2018 and February 2019. In addition, this study estimated the recreational catch of Pink Snapper (kept) for Freycinet Estuary between March and August 2018, including catches from those fishers that did not use the ramp at Nanga. Collectively these objectives have allowed the initial impact of recent management changes on recreational catch levels to be reviewed.

The boat-based recreational fishery at the three boat ramps was assessed using a Traditional Access Point Survey method. Supplementary data on powerboat retrievals collected from remote cameras installed at these ramps were combined with the catch and effort information collected as part of the Traditional Access Point Survey method. This integrated survey (referred to as a Supplementary Access Point Survey) enabled ramp-based levels of fishing effort and catch to be determined for two different spatial scales: (i) inner Shark Bay and oceanic, (ii) inner Shark Bay only (including the three Pink Snapper stocks). The boat-based fishery in Freycinet Estuary was assessed using the Supplementary Access Point Survey at Nanga and a fixed-wing aerial survey of Freycinet Estuary. This integrated survey was used to generate estimates of recreational fishing effort and Pink Snapper catch for Freycinet Estuary between March and August 2018.

In total, 1,781 boat parties were interviewed, with 948 interviews at Denham (53%), 588 at Monkey Mia (33%) and 245 (14%) at Nanga. The estimated annual effort from boat-based recreational fishing in inner Shark Bay was 3,368 recreational boat trips (hereon in referred to

as boat trips, se=96) from Denham, 4,302 boat trips (se=71) from Monkey Mia and 926 boat trips (se=20) from Nanga. The majority of fishing effort in inner Shark Bay occurred in autumn and winter at Denham (81% of annual effort from ramp-based total), Monkey Mia (57%) and Nanga (87%).

In total, 127 species/taxa were caught (kept and released) in inner Shark Bay, including scalefish (n=101, including a category for unidentified fish), elasmobranchs (n=19), crustaceans (n=4) and molluscs (n=3). At Denham, recreational fishers caught an estimated 52,200 individuals in inner Shark Bay (all species/taxa), of which approximately 12,500 were kept (24%) and 39,600 were released (76%; all species/taxa). The three most commonly caught species at Denham were Pink Snapper, Grass Emperor (*Lethrinus laticaudis*) and Western Butterfish (*Pentapodus vitta*), comprising 72% of the catch for those trips that occurred in inner Shark Bay. At Monkey Mia, recreational fishers caught an estimated 95,800 individuals in inner Shark Bay, of which approximately 44,000 were kept (46%) and 51,700 were released (54%). The three most commonly caught species at Monkey Mia were Blue Swimmer Crab (*Portunus armatus*), Pink Snapper and Grass Emperor, comprising 79% of the catch for those trips that occurred in inner Shark Bay. At Nanga, recreational fishers caught an estimated 11,200 individuals in inner Shark Bay, of which approximately 1,400 were kept (13%) and 9,800 were released (87%). The three most commonly caught species at Nanga were Pink Snapper, Grass Emperor and Blackspot Tuskfish (*Choerodon schoenleinii*), comprising 91% of the catch for those trips that occurred in inner Shark Bay.

The estimated kept catch of Pink Snapper at Denham (4.6 tonnes (t), 95% CI 3.4–5.9) and Monkey Mia (2.1t, 95% CI 0.8–3.4) were both well below the Total Allowable Recreational Catch (TARC) for Pink Snapper in these two inner gulfs (11.25t for Denham Sound, 11.25t for Eastern Gulf). In contrast, the estimated kept catch of Pink Snapper at Nanga (3.2t, 95% CI 2.3–4.2) was around the TARC for Pink Snapper for Freycinet Estuary (3.75t). However, the estimated kept catch of Pink Snapper for Freycinet Estuary between March and August 2018, derived from the integrated Freycinet Estuary survey, was above the TARC (11.5t, 95% CI 4.3−18.7) as this survey accounted for catches that were not landed at Nanga. These results indicate that less than a third of contemporary catches of Pink Snapper in Freycinet Estuary are taken by recreational fishers at Nanga. Instead, the majority of catches are believed to be taken from fishers at Tamala Station, as Carrarang Station is now closed for camping and few boat parties interviewed at Denham had fished in Freycinet Estuary.

A large percentage of interviewed fishers (92%) were tourists (i.e. not Shark Bay residents) and the majority of fishers were well-informed and expressed strong levels of support for contemporary Pink Snapper management arrangements. Overall, nearly half of all interviewed fishers at Denham, Monkey Mia and Nanga (47%) were unsure whether or not they supported the recent removal of the harvest tag system. However, the majority of interviewed fishers at Nanga (64%), the only ramp within Freycinet Estuary, expressed support for the recent removal of the harvest tag system.

Alternative lines of evidence were examined to provide an overview of trends in recreational fishing activity in inner Shark Bay and to inform recommendations for future monitoring. This

included: historical boat ramp surveys (1998/1999 to 2018/19), remote camera surveys (2011/12 onwards), aerial surveys (2012 and 2018), interviews with recreational fishers at Tamala Station (2001 to 2003), visitation records at Tamala Station (2015/16 onwards) and data from the state-wide surveys of boat-based recreational fishing. These lines of evidence demonstrate that recreational fishing effort at Denham, Monkey Mia and Nanga in 2018/19 was substantially below the historical peak in 1998/1999, broadly consistent with those estimates obtained from 2000 to 2010 and higher than in 2017/18. The estimated kept catch of Pink Snapper in inner Shark Bay (all three ramps combined) in 2018/19 was also substantially below the historical peak in 1998/99. The proportion of the Pink Snapper kept catch taken by boat-based recreational fishers at Nanga prior to the implementation of harvest tags cannot be reliably quantifed; however, it is believed to be greater than that in 2018/19. This is because road access to the remote pastoral stations in Freycinet Estuary and to Steep Point has improved and in recent years, both Tamala Station and Carrarang Station have had websites that have marketed the pastoral stations as recreational fishing locations. As the estimated kept catch of Pink Snapper in 2018/19 for Freycinet Estuary was approximately half of the estimated total for Nanga (i.e. ramp only) in 1998/99, it can be concluded that the current kept catch for Freycinet Estuary is below the historical peak in 1998/99.

Future monitoring of recreational fishing in inner Shark Bay is important, to evaluate whether management arrangements are achieving their objectives of managing catches to target/sustainable levels for Pink Snapper and others species/taxa such as Grass Emperor, tuskfish and cods. Given that the estimated kept recreational catch of Pink Snapper in Freycinet Estuary has exceeded the target level, further management action is now required, supported by ongoing monitoring to evaluate the effectiveness of any potential new management changes. While the three components of this survey have been integrated in the current survey, depending on future management objectives and fiscal constraints, one or more parts of the survey could be operated across different time scales. The remote cameras provide a cost-effective means to monitor recreational fishing effort and ongoing low-level monitoring using these cameras should be continued.

1. Introduction

1.1 Recreational fishing in inner Shark Bay

Shark Bay has a long history as one of Western Australia's most popular recreational fishing destinations (Jackson and Moran, 2012). The sheltered waters of its inner gulfs attract large numbers of boat-based recreational fishers, in particular during winter when weather is milder and sea conditions more conducive to fishing from small boats (Jackson and Moran, 2012; Wise *et al.*, 2012). Recreational catches in these waters are dominated by Pink Snapper (*Chrysophrys auratus*), Blue Swimmer Crab (*Portunus armatus*) and Grass Emperor (also referred to as Black Snapper, *Lethrinus laticaudis*; Wise *et al.*, 2012). The three separate stocks of Pink Snapper within inner Shark Bay (Denham Sound, the Eastern Gulf and Freycinet Estuary; Figure 1) are particularly vulnerable to exploitation because Pink Snapper aggregate to spawn in predictable locations each winter which leads to higher levels of fishing effort at this time (Jackson and Moran, 2012; Wise *et al.*, 2012). Concern that Pink Snapper in each of these stocks were being overfished led to a range of scientific monitoring and assessments from 1996 onwards. This included boat ramp surveys involving interviews with recreational fishers at Denham, Monkey Mia and Nanga to provide fishery managers with estimates of annual effort and catch at these ramps (Wise *et al.*, 2012).

1.2 Management arrangements for Pink Snapper in inner Shark Bay

A wide range of management arrangements have been applied to recreational fishers harvesting Pink Snapper in inner Shark Bay since the 1950s (Appendix 1). Historically, recreational fishing for Pink Snapper was managed using minimum and maximum lengths and daily bag limits (Jackson and Moran, 2012). Based on assessments that showed Pink Snapper in Denham Sound, the Eastern Gulf and Freycinet Estuary had been overexploited, stricter management was progressively introduced from 1997 onwards. These management changes were developed and reviewed in consultation with a stakeholder working group comprised of recreational and commercial fishers, local tourism/accomodation providers and shire members. These arrangements were designed to deliver sustainability objectives aimed at rebuilding Pink Snapper stocks but also took into consideration social and economic objectives. Introduced management measures included a 5-year moratorium in the Eastern Gulf (June 1998–March 2003), a 6-week spawning closure in Freycinet Estuary (from 2000 onwards) and finally, in 2003, the introduction of a Total Allowable Recreational Catch (TARC) for each of the three stocks (Jackson and Moran, 2012). Since 2003 a range of different measures have been used in each of the inner gulfs, including a harvest tag system in Freycinet Estuary (Jackson *et al.*, 2016).

Following stock assessments that indicated the recovery of all three Pink Snapper stocks, a review of the management arrangements was undertaken in late 2015. Essentially, the management approach changed from a "rebuilding strategy" to a "routine harvesting strategy" of the rebuilt stock. While the Pink Snapper TARC did not change, several management

changes were introduced in January 2016 which were aimed at allowing a slight increase in the recreational catch and the opportunity to catch "trophy size fish" within the current TARC setting. The tag system in Freycinet Estuary was replaced by a new possession limit (see below) in an attempt to improve recreational amenity, allowing more fishers an opportunity to fish for Pink Snapper in Freycinet Estuary while continuing to manage the recreational catch to within the 3.75t TARC. The new management objective for Freycinet Estuary was centred on a "low take wilderness fishing experience" and specifically included:

- Removal of the 700mm maximum size limit for Pink Snapper in inner Shark Bay;
- Removal of the requirement to land Pink Snapper in whole form in inner Shark Bay;
- Replacement of the lottery quota tag system with the Freycinet Estuary Management Zone in which a new possession limit of 5kg of finfish fillets (including Pink Snapper) or one day's bag limit of whole fish or trunks applies (Freycinet only).

1.3 Need for ongoing monitoring of Pink Snapper in inner Shark Bay

Although the new 5kg possession limit was designed to regulate the Pink Snapper kept catch in Freycinet Estuary, the cessation of the harvest tag system means that the method used previously for monitoring the recreational harvest of Pink Snapper in Freycinet Estuary no longer applies. Since 2011/12 four state-wide surveys of boat-based recreational fishing have been conducted within Western Australia (Ryan *et al.*, 2013, 2015, 2017, 2019). These surveys were designed to provide state-wide and bioregion-wide estimates for commonly-caught species, recognising that obtaining accurate catch estimates for Pink Snapper at these small spatial scales is beyond the scope of the state-wide surveys of boat-based recreational fishing. Additional monitoring of recreational catches was therefore required to evaluate whether the specific management arrangements in the inner gulfs where meeting the objective of managing Pink Snapper kept catches to within the respective TARCs.

In 2016/17 a survey of boat-based recreational fishing was conducted at Denham, Monkey Mia and Nanga, the three boat ramps that provide access to inner Shark Bay (Taylor *et al.*, 2018). The study provided robust annual estimates of the recreational catch (kept, released and total) by boat-based recreational fishers at those three boat ramps shortly after the management changes that were compared with those obtained from previous surveys. The results indicated that recreational catches of Pink Snapper were below the TARC for Denham Sound and the Eastern Gulf (Figure 1); however, the estimated kept catch at Nanga was only slightly below the TARC for Freycinet Estuary (Taylor *et al.*, 2018). Observations from DPIRD staff based in Denham confirmed the capture of Pink Snapper at Tamala Station and Carrarang Station in Freycinet Estuary during the 2016/17 survey. Furthermore, high visitation rates at Tamala Station were verified in April and July 2016 based on records kept by the station manager. As this additional source of recreational catches could not be quantified in the 2016/17 survey (Taylor *et al.*, 2018) it was not possible to accurately determine whether or not the TARC has been breached for the Freycinet Estuary Pink Snapper stock.

1.4 Objectives

This publication is one of two documenting the research outcomes of the project "Innovative methods for monitoring recreational fishing in Shark Bay," funded by the Recreational Fishing Initiatives Fund. The second report is entitled "The feasibility of using remotely piloted aircraft systems (RPAS) for recreational fishing surveys in Western Australia (Desfosses *et al*., 2019)".

The primary objectives of the current study were to generate:

- An estimate of the recreational catch (kept, released and total, in numbers; kept, by weight) by boat-based recreational fishers at Denham, Monkey Mia and Nanga between March 2018 and February 2019;
- A six-month estimate of the recreational catch (kept, in numbers and by weight) of Pink Snapper by boat-based recreational fishers in Freycinet Estuary inclusive of those fishers who did not access the fishery from Nanga, during the peak fishing season.

The secondary objectives related to fishing effort and understanding recreational fishers' knowledge and awareness of management measures. Specifically, these were to:

- Generate one-year and seasonal estimates of fishing effort by boat-based recreational fishers at Denham, Monkey Mia and Nanga between March 2018 and February 2019;
- Generate a six-month estimate of fishing effort by boat-based recreational fishers in Freycinet Estuary inclusive of those fishers that did not access the fishery from Nanga;
- Profile recreational fishers' characteristics, awareness of and attitudes towards contemporary management measures for Pink Snapper in inner Shark Bay.

The ramp-based estimates correspond with the three Pink Snapper stocks in inner Shark Bay that are subject to separate resource assessments and management regulations. The additional step of estimating the six-month kept recreational catch of Pink Snapper in Freycinet Estuary for boat-based fishers was in direct response to the results of the previous survey. This involved the coordination of a fixed-wing aerial survey that was restricted to autumn and winter because previous survey data indicated that the majority of Pink Snapper catches in Freycinet Estuary occur within this period.

1.5 Report Structure

Each chapter covers specific details or outputs, including:

Chapter 2 (Survey design and analysis) outlines the survey design and scope for the three survey methods: boat ramp (hereon in referred to as a "Traditional Access Point Survey"), remotely-operated camera (hereon in referred to as a "Remote Camera Survey") and Aerial Surveys. Methods used for the expansion and analysis are discussed, along with measures of uncertainty associated with survey estimates.

Chapter 3 (Response profiles and camera outages) outlines the response rates obtained from interviewing recreational fishers during the Traditional Access Point Survey and the duration of camera outages that occurred during the Remote Camera Survey that needed to be accounted for in subsequent analysis.

Chapter 4 (Powerboat retrievals, proportion fishing and fishing effort) presents estimates of the number of powerboat retrievals, the proportion of boat parties that had been recreational fishing and boat-based recreational fishing effort during the 12-month boat ramp survey at Denham, Monkey Mia and Nanga.

Chapter 5 (Harvest rates and catch rates) presents estimates of mean harvest rates and catch rates for the three most commonly caught species by boat-based recreational fishers at Denham, Monkey Mia and Nanga.

Chapter 6 (Recreational catch) presents estimates of catch from boat-based recreational fishing, including annual catch (total, kept and released by number), proportions released (released rates), average weights and annual catch (kept, by weight) for Pink Snapper.

Chapter 7 (Freycinet Estuary Integrated Survey) presents estimates of recreational fishing effort from the Aerial Survey and estimates of the catch (kept by number and by weight) for Pink Snapper that were obtained by integrating the Traditional Access Point, Remote Camera and Aerial Surveys.

Chapter 8 (Fishers' characteristics) presents an overview of the demographic, awareness and attitudinal characteristics of interviewed recreational fishers in relation to management measures in place for Pink Snapper in inner Shark Bay.

Chapter 9 (Historical trends in recreational fishing for Pink Snapper) presents multiple lines of evidence to assist in determining historical trends in recreational fishing for Pink Snapper, particularly for Freycinet Estuary.

Chapter 10 (Summary and recommendations) summarises the key outcomes of the study and provides recommendations for the ongoing monitoring of recreational fishing in inner Shark Bay.

2. Survey design and analysis

2.1 Survey scope

The Traditional Access Point and Remote Camera Surveys focussed on boat parties using the boats ramps at Denham, Monkey Mia and Nanga (Table 1). The Aerial Survey focussed on boat- and shore-based recreational fishers in Freycinet Estuary, in addition to camps identified along the waterline. The temporal sampling frame of the Traditional Access Point and Remote Camera Surveys spanned a one-year period between March 1, 2018 and February 28, 2019, while the Aerial Survey covered a 6-month period between March 1, 2018 and 31 August, 2018. Recreational fishing was defined as the attempted capture of any aquatic (animal) species. Species taxonomy followed the Codes for Australian Aquatic Biota (Rees *et al.*, 2012). All boat-based recreational fishing activity was assessed including line fishing, diving, potting and spearfishing as undertaken from powerboats retrieving at the three ramps or identified during the Aerial Survey. Recreational fishing activities that occurred on-board Tour Operator vessels were not included because these catches are reported in Tour Operator Returns (Charter logbooks). As with previous boat ramp surveys, any potential recreational fishing activities that occurred on jetskis were also not included in addition to commercial or indigenous fishing activity.

Table 1. Survey coverage for the Traditional Access Point, Remote Camera and Aerial Surveys.

Specification	Item	Supplementary Access Point Survey		Aerial Survey
		Traditional Access Point Survey	Remote Camera Survey	
People in scope	Location of residence	All	na	na
	Age	All*	na	na
Activities	Platform	Boat	Boat	Boat
	Boat type	Powerboat	All	All
	Methods	All recreational fishing methods	na	All recreational fishing methods
Species	Species	All aquatic (animal) species	na	na
Geographical scope	Area covered	All areas accessed from boat ramps	Denham, Monkey Mia and Nanga	Freycinet Estuary
Time frame	Survey dates	1 Mar, 2018 – 28 Feb, 2019	1 Mar, 2018 – 28 Feb, 2019	1 Mar, 2018 – 31 Aug, 2018

*Only fishers ≥ 15 yrs old who had not been interviewed on a previous day for the attitudinal data.

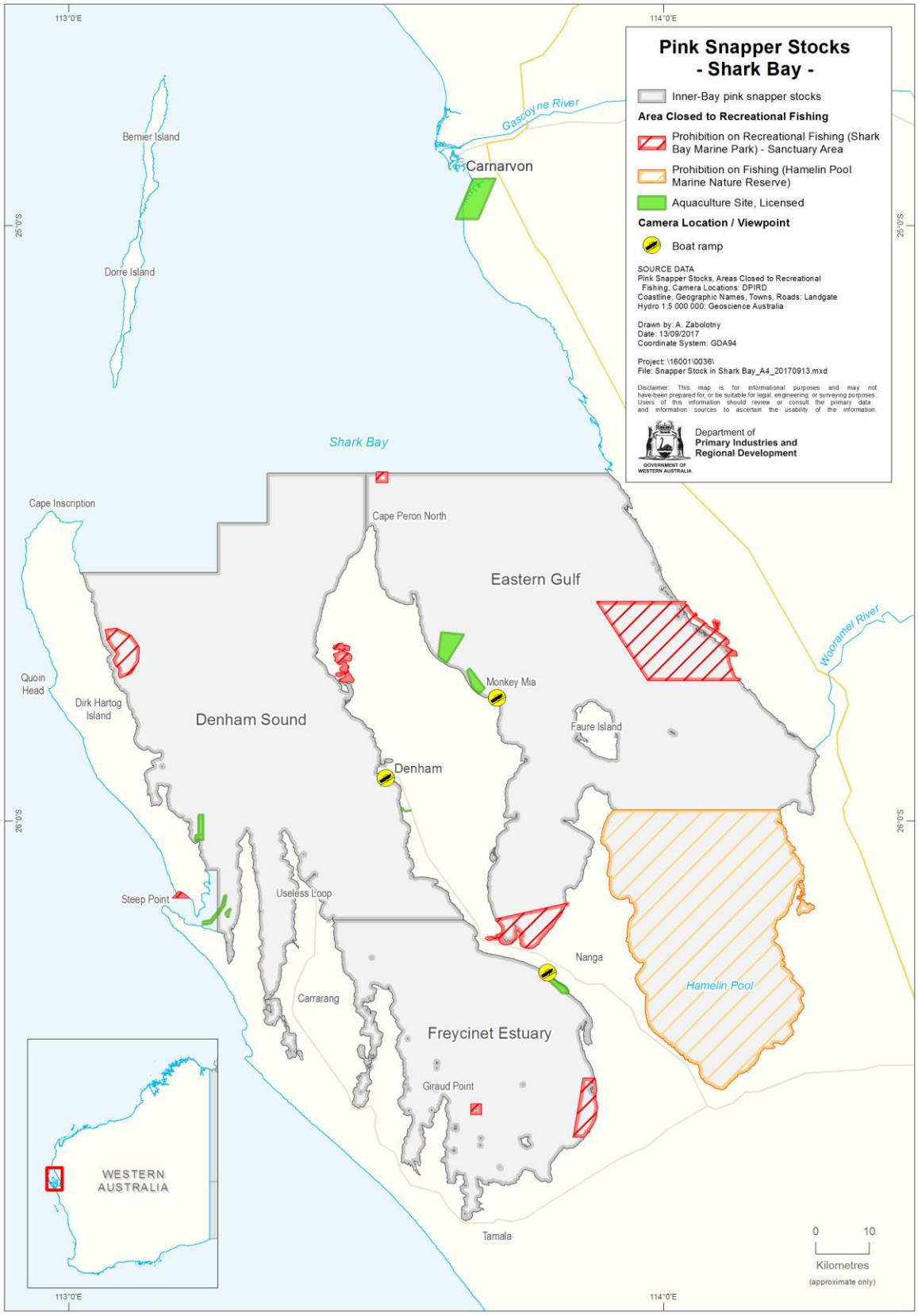


Figure 1. Map of inner Shark Bay (grey shading) indicating the boundaries of the three separate Pink Snapper stocks. Yellow circles indicate the location of the three boat ramps.

2.2 Survey methods

2.2.1 Supplementary Access Point Survey

The boat-based recreational fishery was assessed using a Supplementary Access Point Survey method. This method combined a Traditional Access Point Survey (Pollock *et al.*, 1994) with a Remote Camera Survey (Steffe *et al.*, 2008; Taylor *et al.*, 2018). Estimates of recreational fishing effort and catch were generated separately for the boat ramps at Denham, Monkey Mia and Nanga. Stratified random sampling techniques were used to select survey days separately for each of the ramps, with days being the primary sampling unit (PSU) for all strata. Each survey day was 8-hours in duration (10:00–18:00).

The survey year was stratified into seasons (autumn=March to May; winter=June to August; spring=September to November; summer=December to February) and day types (weekdays and weekend days) within seasons. Public holidays were classed as weekend days. The decision to use a daily survey period between 10:00 and 18:00 was consistent with previous boat ramp surveys in Shark Bay and cognisant of the low levels of night time fishing activity identified from remote camera data (Taylor *et al.*, 2018). Disproportional sampling was applied for each ramp, season and day type with higher levels of sampling for those ramps and time periods when fishing activity was expected to be higher (Table 2).

In total, 90 survey days were completed at Denham, 68 at Monkey Mia and 70 at Nanga. An original sample of 69 days was selected for Monkey Mia; however, a weekend shift in summer could not be conducted for logistical reasons (Table 2). On January 5th 2019 the Nanga Bay Resort was temporarily closed at short notice which meant there was no access to the Nanga boat ramp from this day forward until the end of the survey. Furthermore, because the generator providing power to the resort was turned off, the camera was not operational during the closure. While an original sample of 7 weekday and 5 weekend days were randomly selected at Nanga in summer (i.e. 79 survey days for the year), the result of this unforeseen closure was that no weekdays were sampled in summer at this location. The implications of the lack of survey days for weekdays in summer are discussed in Section 2.3.1. Nanga Bay Resort re-opened in March 2019, shortly after the completion of this survey.

Table 2. Number of days sampled for each season and day type at Denham, Monkey Mia and Nanga. WD = Weekdays, WE/PH = Weekend days and public holidays.

		Ramp					
		Denham		Monkey Mia		Nanga	
Season	Day type	Survey days	Pop days	Survey days	Pop days	Survey days	Pop days
Aut 18	WD	20	62	16	62	18	62
	WE/PH	10	30	8	30	9	30
Win 18	WD	20	65	10	65	19	65
	WE/PH	10	27	5	27	9	27
Spr 18	WD	10	64	10	64	7	64
	WE/PH	5	27	5	27	5	27
Sum 18/19	WD	10	61	10	61	0	61
	WE/PH	5	29	4	29	3	29
Total	WD	60	252	46	252	44	252
	WE/PH	30	113	22	113	26	113
	Total	90	365	68	365	70	365

2.2.1.1 Data collected from interviewed boat parties

A range of information was collected on each survey day, including the number of powerboats departing from and returning to each ramp (Appendix 2) and the number of interviews attempted and completed (and if not, the reason). For every boat party interviewed, it was determined whether the occupants had been fishing, what fishing methods were used, regions fished, time spent fishing, species targeted, and species caught (kept and released; Appendix 3). To assist fishers in recalling the broad location of their fishing trips they were referred to a map of inner Shark Bay and adjacent oceanic waters divided into 5 x 5 nautical mile grids (Appendix 4). Time permitting, fishers were referred to species identification guides to assist in the accurate identification of commonly misidentified species (e.g. emperors, mackerels). In some instances, catches were reported to broader taxonomic groups (e.g. hammerhead sharks, *Sphyrna* sp.), particularly for the released component of the catch that could not be verified by survey staff. The total length of fish kept by recreational fishers was also measured to the nearest millimetre. However, it was not feasible for all fish kept by recreational fishers to be measured, particularly during busy periods. Time permitting, attempts were also made to weigh those fish kept by recreational fishers. A higher proportion of fish were measured and weighed at Nanga in comparison to the other ramps because fewer boat parties returned to this ramp and hence more time was available to collect this information (Table 8).

The final part of the interview involved a series of demographic, awareness and attitudinal questions (Appendix 5) that were asked to one randomly-selected fisher from each boat party. The selection of a fisher for this part of the interview was based on which person's birthday occurred first after the interview date. On those occasions where the fisher had answered the same questions on a previous fishing trip, another fisher was chosen at random for interview. It was not always feasible to conduct this part of the survey because of time restrictions and

the fact that the collection of data on the number of boats launching and retrieving and interviewing fishers about their catch was deemed to be higher priority. All survey information was entered and stored within relational tables in a Microsoft Access database.

2.2.1.2 Supplementary data collected using the remote cameras

Although ramp-based estimates of fishing effort and recreational catches can be generated from the Traditional Access Point Design (Pollock *et al.*, 1994), recent research has demonstrated that more reliable estimates of fishing effort and catch can be obtained by incorporating remote camera data into the design (Steffe *et al.*, 2008; Taylor *et al.*, 2018). Therefore, information on the number of powerboat retrievals at the three ramps was obtained from remote cameras that had previously been installed at the three ramps (Table 3, Figure 2). This Supplemented Access Point Survey used a double sampling approach (Steffe *et al.*, 2008) to adjust counts of powerboat retrievals for non-fishing trips by using party-based interview information collected during the randomly scheduled survey days at those ramps. This provides better coverage of the temporal sampling frame (i.e. scheduled and non-scheduled survey days are included) and results in improvements to the accuracy and precision of catch estimates (Steffe *et al.*, 2008).

All boat retrievals which occurred during the 1-year survey period were recorded (24-hours a day). Each boat was recorded as a powerboat, jetski, yacht, kayak, commercial vessel or other. Subsequent analysis was based on the powerboat data only. All footage from the remote cameras was viewed and the boat retrieval information was entered and stored in a Filemaker Pro database. The start and finish times of outages (i.e. missing periods in the camera footage) were recorded to assist in subsequent imputation (refer to Supplementary Material 7). More detailed information on the camera network system and the process of reading the camera data are provided in Blight and Smallwood (2015) and Steffe *et al.*, (2017).

The remote camera data were used to expand the 8-hour time period covered in the Traditional Access Point Design to the period between nautical dawn and nautical dusk. The duration of this period ranged from approximately 12 hours in June 2018 to 16 hours in December 2018 (Figure 3). Daily values for the time at which nautical dawn and nautical dusk occurred (to the nearest minute) were obtained from Geoscience Australia (http://www.ga.gov.au/). The estimation of fishing effort and total catches were based on filtering the daily powerboat data obtained from the remote cameras to only include those powerboat retrievals that occurred between nautical dawn and dusk.

Table 3. Specifications for the remotely operated cameras.

Location	Latitude (DD)	Longitude (DD)	Installation date	Camera viewpoint	Camera type
Denham	-25.928	113.533	29/11/2016	Boat ramp	Mobotix M22M
Monkey Mia	-25.793	113.720	1/4/2016	Boat ramp	Mobotix M15D SEC
Nanga	-26.255	113.805	13/12/2015	Beach launch*	Mobotix M25M

*Although boat parties at Nanga access the small ramp directly from the beach (i.e. beach launch), throughout the report Nanga is referred to as a boat ramp.

A

B

C

Figure 2. Field of view for the remote camera at A) Denham, B) Monkey Mia and C) Nanga.

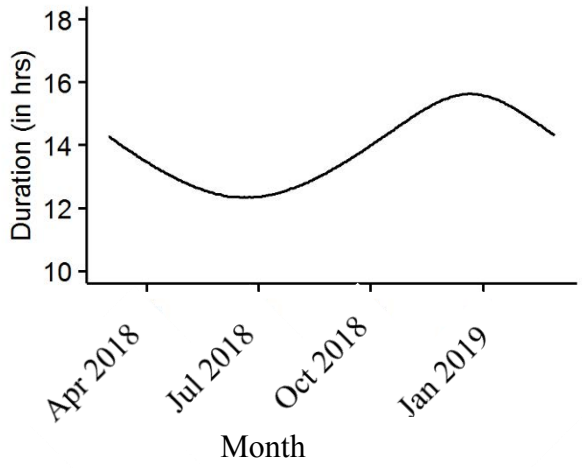


Figure 3. Daily values for the duration of time between nautical dawn and nautical dusk in Shark Bay between 1 March 2018 and 28 February 2019.

2.2.2 Aerial Survey of Freycinet Estuary

Flights were scheduled to be undertaken on 28 days between March and August 2018 at a height of 1,000ft by a single observer in a high-wing Cessna 172. The flight path used a combination of coastal tracking and over-water transects (6km in width) to provide complete coverage of the area demarcated by the Pink Snapper stock boundary in Freycinet Estuary (Figure 4).

Flights were completed on a random sample of days during which boat ramp surveys were conducted at Nanga (Table 2). These dates were selected using a stratified random sampling procedure and each season was stratified into weekdays and weekend days with days being the PSU (refer to 2.2.1). Public holidays were classed as weekend days. Seven sampling days were randomly selected for each stratum. For each flight, the starting location was randomly selected from one of eight locations in addition to the direction of travel (clockwise or anticlockwise; Figure 4). Alternative survey days were also available in case of cancellation due to weather or low cloud cover that can prevent boats and camps from being clearly visible. Although no flights were cancelled, on one occasion (winter, weekday) low cloud cover restricted visibility. Data from this flight were not included in subsequent analysis; therefore, 29 flights were required to achieve seven flights per stratum (Table 4).

Table 4. Number of days sampled for each season and day type in Freycinet Estuary during aerial surveys. WD = Weekdays, WE/PH = Weekend days and public holidays. Survey days were randomly selected from those days where boat ramp surveys occurred at Nanga (Nanga days).

Season	Day type	Survey days*	Nanga days	Population days
Aut 18	WD	9	18	62
	WE/PH	5	9	30
Win 18	WD	10	19	65
	WE/PH	5	9	27
Total	WD	19	37	127
	WE/PH	10	18	57
	Total	29	55	179

* One flight excluded from analysis due to incomplete coverage during the flight

The survey day (7am–5pm) was divided into 2-hr blocks (the expected time taken to complete an aerial survey of Freycinet Estuary) and the probability of a flight period being selected was based on the analysis of prior data on powerboats retrieving at Nanga (Taylor *et al.*, 2018). On each day, a flight period (secondary sampling unit) was chosen with unequal probability and with replacement (Table 5).

Table 5. Selection probabilities used to randomly select a flight period for each flight.

Flight period	Selection probability
07:00 – 08:59	0.2
09:00 – 10:59	0.3
11:00 – 12:59	0.2
13:00 – 14:59	0.2
15:00 – 16:59	0.1

Standard protocols were used to mitigate visibility biases during the aerial survey, including instructing the pilot not to directly overfly vessels, slowing the plane or conduct a circuit if not all information could be recorded on a single pass and asking the pilot to assist in looking for and identifying the type of vessels (Pollock *et al.*, 1994; Smallwood *et al.*, 2012). Due to the width of the aerial transects, some deviations from the flight path were permitted to obtain a better view of vessels, and the pilot was always instructed to return to the flight path as soon as possible after this had occurred.

Data were recorded electronically by the observer using an Apple iPad installed with ESRI ArcGIS Collector Software. A project was created within this software containing all the necessary fields required to collect data for each survey (i.e. pilot name, observer name, departure time, landing time, survey start time, survey finish time) and observation (i.e. vessel type, vessel activity, number of people). Descriptions of the information collected during the aerial surveys can be found in Appendix 6. Date and time fields were automatically populated when an observation was created and a track of each flight was also automatically created. A Bad Elf GPS Bluetooth receiver was used to improve the satellite signal during the flight. In addition, a Canon EOS 600D SLR camera was used to provide a digital record of observations made during the aerial surveys, and to assist with post-processing of observations, if required (Figure 5).

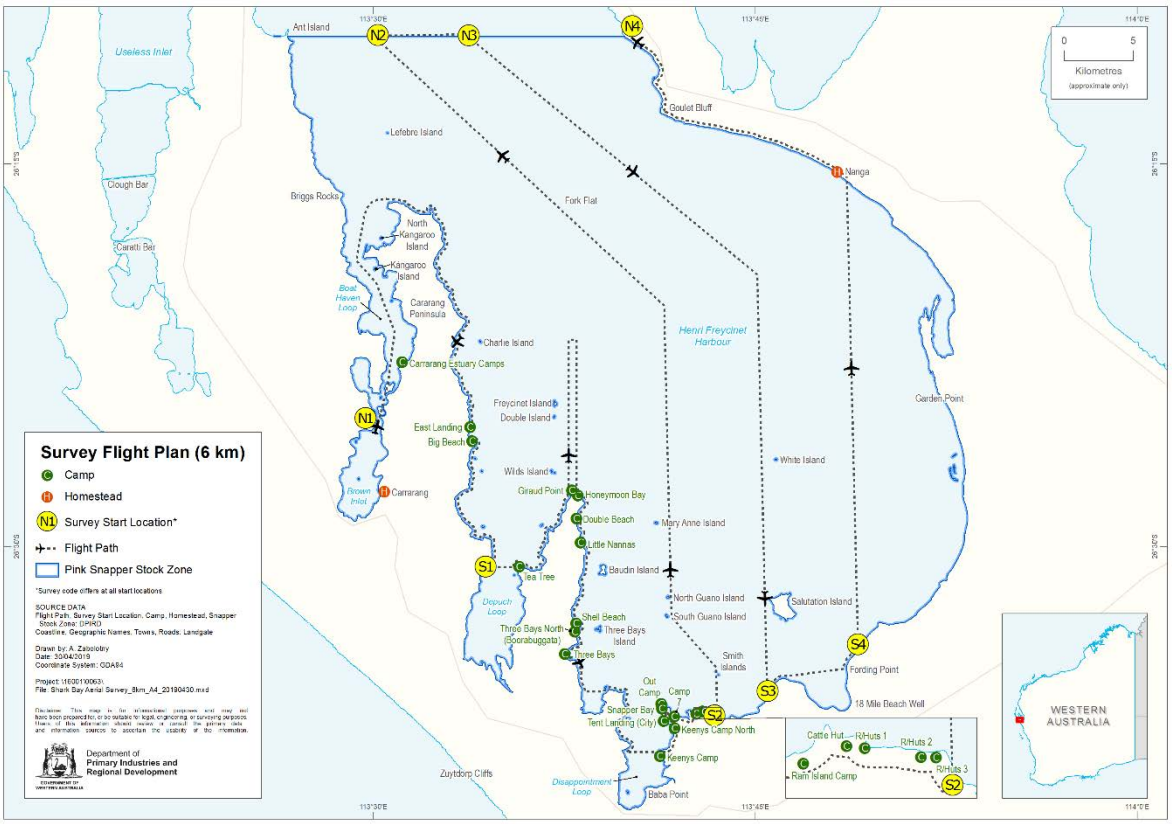


Figure 4. Flight path for aerial surveys of Freycinet Estuary in 2018. Yellow circles denote the 8 starting locations.

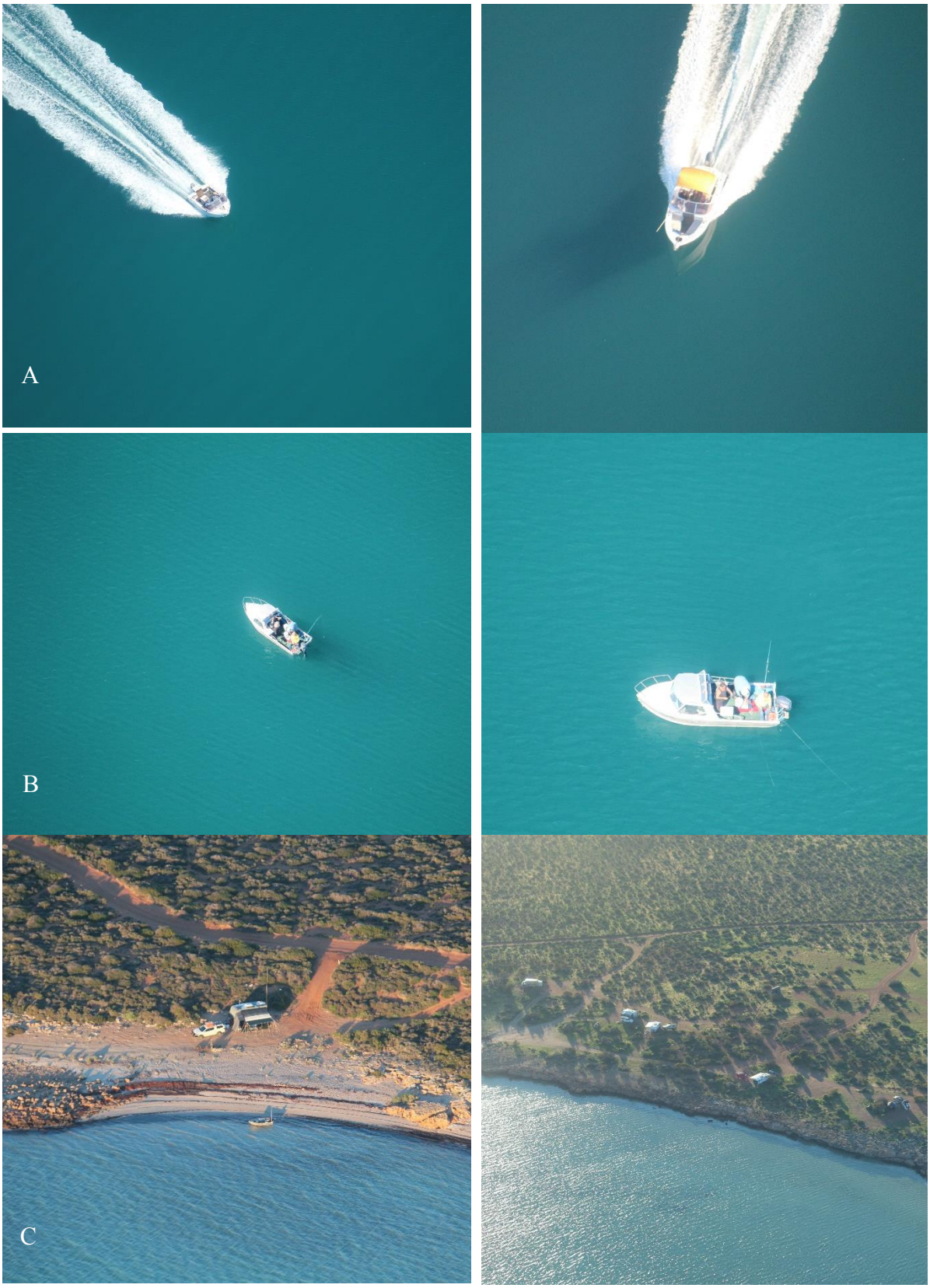


Figure 5. Viewpoint from the aerial survey showing examples of A) boats in transit, B) boat parties recreational line fishing and C) camps and moored/anchored vessels. Refer to Appendix 6 for an overview of the classification used for boats, shore-based fishers and camps.

2.3 Expansion Methods

2.3.1 Ramp-based totals of fishing effort and catch

The step-by-step process of estimating recreational fishing effort and the catch of boat-based recreational fishers at the three ramps using the Supplementary Access Point Survey is outlined in Appendix 7. This includes the estimation of daily, stratum and population totals and the conversion of the recreational catch in numbers to weight for Pink Snapper. The randomisation protocol and the analysis and expansion of all data were performed in R (R Core Team, 2018) mainly using the packages *dplyr* (Wickham and Francois, 2016) and *lubridate* (Grolemund and Wickham, 2011).

Prior to expansion of the data, the following steps were applied for the reasons outlined below:

Not able to interview all boat parties

Overall, a very high proportion of boat parties that returned to the ramps during survey days were interviewed (Table 6, Table 7, Table 8). On busy days, it was not always possible to interview all boat parties and creel staff interviewed as many boat parties as possible and the catch rate from interviewed boat parties was assumed to be representative of the catch rate of all boat parties that retrieved at the ramps. Similar assumptions have been applied to other onsite surveys when it was not possible to interview all returning boat parties (Hartill *et al.*, 2015; Lai *et al.*, 2019).

Disaggregate data for inner Shark Bay only

For management purposes it was necessary to provide estimates of fishing effort and catches for each of three Pink Snapper stocks in addition to estimates that included those fishing trips that occurred outside of inner Shark Bay. Filtering out those trips that occurred outside of inner Shark Bay had negligible impact on the estimates of effort and catch at Nanga and Monkey Mia (2 fishing trips at each ramp) but had considerable impact on estimates at Denham (201 fishing trips, 23.9% of trips). This approach is consistent with previous Shark Bay recreational fishing surveys (Wise *et al.*, 2012; Taylor *et al.*, 2018).

Multi-day fishing trips

On some occasions, boat parties had been on a multi-day fishing trip. For example, a boat party may have launched from Denham and then spent 10 days camped on Dirk Hartog Island before returning to Denham. On such occasions, only fishing activity that occurred on the day of the interview was recorded because the Supplementary Access Point Method uses daily catch rates to estimate catches. The reliability of catch and effort data pertaining to previous days would also be questionable due to known issues with recall bias (Jones and Pollock, 2012). From the 1,609 boat parties interviewed that had been recreational fishing (i.e. 1,782 total interviews minus non-fishing boat parties, Table 6, Table 7, Table 8), 40 (2.5%) had fished on the survey day as part of a multi-day trip (39 at Denham, 1 at Nanga).

Unforeseen temporary closure of the Nanga Bay Resort

The fact that survey days were randomly selected prior to the survey and that Nanga Bay Resort temporarily closed on January 5 2019 meant that no survey days were conducted for weekdays in summer. Because the closure of the resort prevented access to the Nanga boat ramp, the total number of powerboat retrievals was set to zero from January 5 to February 28 2019. This allowed annual estimates for Nanga to be compared with the other ramps and to previous data for Nanga. The conversion of powerboat retrievals to recreational fishing effort requires information on the proportion of boats fishing. Because no interviews were recorded at Nanga in summer (despite weekend sampling days), the value for the mean daily proportion of boats fishing in spring during weekend days (and the associated variance) was applied to weekdays in summer. The average catch rate for weekend days in summer was used (zero for all species) as a proxy for the catch rate for weekdays. Previous remote camera and boat ramp survey data indicate that the closure occurred during a period of comparably very low fishing activity (Taylor *et al.*, 2018), hence the assumption applied here is not likely to bias the annual estimates at Nanga.

2.3.2 Freycinet Estuary total of fishing effort

The step-by-step process of estimating recreational fishing effort for Freycinet Estuary using the Aerial Survey is outlined in Appendix 8. This includes the estimation of daily and stratum totals and the total for the 6-month period between March and August 2018. The Aerial Survey enabled all fishing activity from boats occurring in Freycinet Estuary to be counted during the survey day (7am – 5pm), including those boats that did not use the boat ramp at Nanga. Similar to previous aerial surveys, the progressive counts obtained during each survey day were treated as instantaneous due to the high speed of travel making double counting unlikely (Pollock *et al.*, 1994; Hartill *et al.*, 2011; Smallwood *et al.*, 2012). The potential for double counting to occur was also minimised as part of the standard operating procedure for the Aerial Survey.

Daily values of recreational fishing effort included those boats that were identified to be recreational line fishing (43% of boat observations) or ‘unknown’ (10% of boat observations). The decision to include unknown vessels in the calculation of recreational fishing effort was due to the fact that a high proportion of boat parties retrieving at Nanga had been recreational fishing (0.92; Table 14). Boats that were observed to be transiting (i.e. travelling at high speed and therefore not involved in trolling, refer to Appendix 6) during the survey comprised 39% of observations. While these boats may have fished prior to or post the aerial survey they were not included in subsequent analysis as per the assumptions of the progressive count method (Pollock *et al.*, 1994). Charter and commercial vessels were also excluded from the analysis.

2.3.3 Freycinet Estuary adjusted fishing effort and Pink Snapper catch

The step-by-step process of integrating the Supplementary Access Point Survey and the Aerial Survey is outlined in Appendix 9. To summarise, the integration occurred in three stages; firstly, it was necessary to adjust for recreational fishing effort that occurred outside the daily duration of the aerial survey (7am – 5pm) using the remote camera data and interview data collected at Nanga. This estimate of recreational fishing effort was then converted from boat

party hours to the number of recreational boat trips (hereon in referred to as boat trips) to make the data comparable with the other estimation methods. Finally, the estimate of total fishing effort (in boat trips) for Freycinet Estuary was multiplied by the mean daily harvest rate of Pink Snapper obtained from boat parties retrieving at Nanga to estimate the catch (done at the stratum level). This approach provided an estimate of the Pink Snapper catch (kept in numbers and weight) for the 6-month period between March and August 2018.

The following assumptions were required in the integration of the data:

Nanga activity representative of activity levels for Freycinet Estuary

It was assumed that the times in which boat parties returned to Nanga each day and the average fishing time per boat party at Nanga were representative of all boats fishing within Freycinet Estuary. A similar assumption was applied in Smallwood *et al*., (2012) whereby 24-hour activity patterns of recreational fishers at groynes in the Perth Metropolitan region were assumed to be representative of activity patterns for all shore-based fishers. Furthermore, ongoing aerial-access surveys in New Zealand also assume that the within-day patterns of fishing effort at select ramps in the study region are representative of the entire region (Hartill *et al.*, 2011, 2015).

Nanga harvest rates representative of those for Freycinet Estuary

It was assumed that the harvest rate of Pink Snapper at Nanga was representative of the harvest rate for Freycinet Estuary. This assumption is also made in ongoing New Zealand aerial-access surveys whereby catch rates from boat parties interviewed at select ramps are assumed to be representative of the entire fishery (Hartill *et al.*, 2011, 2015). Furthermore, historical data collected at Tamala Station indicates that a substantial percentage of fishers at this location were targeting Pink Snapper between 2001 and 2003 (refer to 9.4).

2.4 Uncertainty

Survey estimates are subject to uncertainty because data are derived from a sample of the total population. Throughout this report the standard error (se) for each estimate is used to express the level of uncertainty, in addition to the 95% confidence intervals (95% CI) that are reported for the estimated kept catch of Pink Snapper by weight. These measures indicate the extent to which each estimate may differ from the actual population value due to chance and sampling of the population. In general terms, and in the absence of survey bias, the se indicates how reliable the estimate is of the true value; the smaller the se, the more precise the estimate is and the more confidence there is in that estimate. The relative standard error (rse) is the se divided by the survey estimate and is a measure of precision that allows comparisons of uncertainty associated with estimates that have different magnitudes. The same criteria used in the state-wide surveys of boat-based recreational fishing has been applied (Ryan *et al.*, 2017) whereby those estimates presented in tables with an rse greater than 40% are highlighted in bold to indicate the estimate is not precise and may be inaccurate. Similarly, caution is advised in interpreting estimates with rse greater than 40%.

3. Response profiles and camera outages

3.1 Response profiles

3.1.1 Catch and effort data

3.1.1.1 Denham

In total, 1,001 powerboats were retrieved at Denham during the 90 survey days (Table 6). During peak times it was not possible to interview all boat parties and 53 boats (5%) were classified as 'Interview not attempted'. On these days, the catch and effort data from interviewed boat parties was assumed to be representative of all boat parties. Of the 948 boat parties that were interviewed, 931 (98%) participated fully (Table 6).

3.1.1.2 Monkey Mia

In total, 624 powerboats were retrieved at Monkey Mia over the 68 survey days (Table 7). For the same reasons as Denham, 36 boats (6%) were classified as 'Interview not attempted'. Of the 588 boat parties that were interviewed, 586 (99%) participated fully.

3.1.1.3 Nanga

In total, 247 powerboats were retrieved at Nanga over the 70 survey days (Table 8). Only two of those boat parties that returned during the survey days were classed as 'Interview not attempted' (1%). Of the 245 boat parties that were interviewed, 244 (100%) participated fully.

Table 6. Response profiles for the catch and effort data collected at Denham between March 2018 and February 2019. Aut=Autumn, Win=Winter, Spr=Spring, Sum=Summer. WD=Weekdays, WE/PH = Weekend days and public holidays.

Season/ Year	Day Type	No. powerboats returning	Interview not attempted	No. interviews	Non-response	Full response	Response rate (%)
Aut 18	WD	327	23	304	12	292	96
	WE/PH	131	7	124	2	122	98
Win 18	WD	234	6	228	1	227	100
	WE/PH	176	9	167	1	166	100
Spr 18	WD	85	4	81	1	80	99
	WE/PH	24	1	23	0	23	100
Sum 18/19	WD	21	3	18	0	18	100
	WE/PH	3	0	3	0	3	100
Total	WD	667	36	631	14	617	98
	WE/PH	334	17	317	3	314	99
	Total	1,001	53	948	17	931	98

Table 7. Response profiles for the catch and effort data collected at Monkey Mia between March 2018 and February 2019. Aut=Autumn, Win=Winter, Spr=Spring, Sum=Summer. WD=Weekdays, WE/PH = Weekend days and public holidays.

Season/ Year	Day Type	No. powerboats returning	Interview not attempted	No. interviews	Non-response	Full response	Response rate (%)
Aut 18	WD	155	16	139	0	139	100
	WE/PH	65	2	63	0	63	100
Win 18	WD	120	4	116	0	116	100
	WE/PH	49	1	48	1	47	98
Spr 18	WD	93	3	90	1	89	99
	WE/PH	73	7	66	1	65	98
Sum 18/19	WD	43	2	41	0	40	98
	WE/PH	26	1	25	0	25	100
Total	WD	411	25	386	1	385	100
	WE/PH	213	11	202	2	200	99
	Total	624	36	588	3	586	99

Table 8. Response profiles for the catch and effort data collected at Nanga between March 2018 and February 2019. Aut=Autumn, Win=Winter, Spr=Spring, Sum=Summer. WD=Weekdays, WE/PH = Weekend days and public holidays.

Season/ Year	Day Type	No. powerboats returning	Interview not attempted	No. interviews	Non-response	Full response	Response rate (%)
Aut 18	WD	79	2	77	0	77	100
	WE/PH	23	0	23	0	23	100
Win 18	WD	93	0	93	0	93	100
	WE/PH	44	0	44	1	43	98
Spr 18	WD	6	0	6	0	6	100
	WE/PH	2	0	2	0	2	100
Sum 18/19	WD	0	0	0	0	0	na
	WE/PH	0	0	0	0	0	na
Total	WD	178	2	176	0	176	100
	WE/PH	69	0	69	1	68	99
	Total	247	2	245	1	244	100

3.1.2 Attitudinal data

3.1.2.1 Denham

From the 1,001 powerboat retrievals, it was not possible to obtain information from 636 (64%) boat parties for a number of reasons including time restrictions, the boat was not used for recreational fishing or because the boat occupants had answered the same questions on a previous fishing trip (Table 9). All of the 365 fishers that were available for the attitudinal survey (100%) participated fully.

3.1.2.2 Monkey Mia

From the 624 powerboat retrievals, it was not possible to obtain information from 352 (56%) boat parties for the same reasons as Denham (Table 10). Of the 275 fishers that were available for the attitudinal survey, 272 (99%) participated fully.

3.1.2.3 Nanga

From the 247 powerboat retrievals, it was not possible to obtain information from 132 (53%) boat parties for the same reasons as above (Table 11). All of the 115 fishers that were available for the attitudinal survey (100%) participated fully.

Table 9. Response profiles for the demographic, awareness and attitudinal data collected at Denham between March 2018 and February 2019. Aut=Autumn, Win=Winter, Spr=Spring, Sum=Summer. WD=Weekdays, WE/PH = Weekend days and public holidays.

Season/ Year	Day Type	No. powerboats returning	Interview not attempted	No. interviews	Non-response	Full response	Response rate (%)
Aut 18	WD	327	218	109	0	109	100
	WE/PH	131	57	74	0	74	100
Win 18	WD	234	159	75	0	75	100
	WE/PH	176	112	64	0	64	100
Spr 18	WD	85	53	32	0	32	100
	WE/PH	24	19	5	0	5	100
Sum 18/19	WD	21	15	6	0	6	100
	WE/PH	3	3	0	0	0	100
Total	WD	667	445	222	0	222	100
	WE/PH	334	191	143	0	143	100
	Total	1,001	636	365	0	365	100

Table 10. Response profiles for the demographic, awareness and attitudinal data collected at Monkey Mia between March 2018 and February 2019. Aut=Autumn, Win=Winter, Spr=Spring, Sum=Summer. WD=Weekdays, WE/PH = Weekend days and public holidays.

Season/ Year	Day Type	No. powerboats returning	Interview not attempted	No. interviews	Non-response	Full response	Response rate (%)
Aut 18	WD	155	81	75	1	74	99
	WE/PH	65	31	36	2	34	94
Win 18	WD	120	50	70	0	70	100
	WE/PH	49	36	13	0	13	100
Spr 18	WD	93	65	28	0	28	100
	WE/PH	73	45	28	0	28	100
Sum 18/19	WD	43	24	19	0	19	100
	WE/PH	26	20	6	0	6	100
Total	WD	411	220	192	0	191	99
	WE/PH	213	132	83	2	81	98
	Total	624	352	275	0	272	99

Table 11. Response profiles for the demographic, awareness and attitudinal data collected at Nanga between March 2018 and February 2019. Aut=Autumn, Win=Winter, Spr=Spring, Sum=Summer. WD=Weekdays, WE/PH = Weekend days and public holidays.

Season/ Year	Day Type	No. powerboats returning	Interview not attempted	No. interviews	Non-response	Full response	Response rate (%)
Aut 18	WD	79	40	39	0	39	100
	WE/PH	23	9	14	0	14	100
Win 18	WD	93	55	38	0	38	100
	WE/PH	44	24	20	0	20	100
Spr 18	WD	6	3	3	0	3	100
	WE/PH	2	1	1	0	1	100
Sum 18/19	WD	0	0	0	0	0	100
	WE/PH	0	0	0	0	0	100
Total	WD	178	98	80	0	80	100
	WE/PH	69	34	35	0	35	100
	Total	247	132	115	0	115	100

3.2 Camera outages

3.2.1 Denham

Over the 12-month period, camera outages at Denham were minor, with only 132 minutes of footage missing (0.02% of all minutes in the year; Appendix 10). Because none of the days had a major outage (i.e. proportion of missing footage in any 2-hour period ≥ 0.5), for those days where footage was missing, the number of observed powerboat retrievals was scaled up to the total number of missing minutes in each 2-hour period (Appendix 7, 10).

3.2.2 Monkey Mia

Over the 12-month period, at Monkey Mia 23, 432 minutes of footage were missing (4.46% of annual total) and 337 days (92%) had no or minor outages. The remaining 28 days had a major outage and these days were treated as missing at random in the imputation process (Appendix 7, 11).

3.2.3 Nanga

Prior to the temporary closure of the Nanga Bay resort on Jan 5 2019, 649 minutes of footage were missing (0.12% of annual total) and 306 out of the 308 days (99%) had no or minor outages (Appendix 12). Because no access to the ramp was possible from Jan 5 through until the end of the survey, no fishing activity was assumed to have occurred (refer to 2.2.1). Therefore, even though the camera was not operational during this closure, no imputation was applied for this missing period.

4. Powerboat retrievals, proportion fishing and fishing effort

Recreational fishing effort was estimated by adjusting the number of powerboat retrievals to account for those boat parties that had been recreational fishing (see below).

4.1 Powerboat retrievals

The numbers of powerboat retrievals at Denham and Monkey Mia between March 2018 and February 2019 were approximately five times greater than at Nanga (Table 12), i.e. 5,037 (se=0), 4,710 (se=58) and 1,005 (se=13) retrievals, respectively (Table 12). Retrievals occurred largely during daylight hours, between nautical dawn and nautical dusk, with retrievals at night comprising between 1 and 4% of ramp-based activity (Table 12).

Table 12. Estimated number of powerboat retrievals derived from the camera data at Denham, Monkey Mia and Nanga between March 2018 and February 2019 for the entire day (i.e. 24-hrs) and between nautical dawn and nautical dusk; se is the standard error of the mean estimate.

Location	Estimated total number of powerboat retrievals (se)		
	Full days (24-hours)	Nautical dawn to dusk	Percent during daylight hours[#]
Denham	5,037 (0)	4,856 (0)	96
Monkey Mia	4,710 (58)	4,615 (49)	98
Nanga	1,005 (13)	991 (13)	99

Daylight hours defined as the period between nautical dawn and dusk

4.2 Proportion fishing

The proportion of boat parties that had been recreational fishing (inclusive of those who fished outside of inner Shark Bay) was 0.76 (se=0.03) at Denham, 0.93 (se=0.02) at Monkey Mia and 0.92 (se=0.03) at Nanga (Table 13). The ramp-based proportions for each of the seasons and day types at these ramps were consistently high, except in summer at Denham when the proportion of boat parties that had been recreational fishing was 0.40 (se=0.12). The proportion of boat parties that had only been recreational fishing in inner Shark Bay was 0.64 (se=0.04) at Denham, 0.93 (se=0.02) at Monkey Mia and 0.92 (se=0.03) at Nanga (Table 14).

Table 13. Estimated proportion of boat parties that had been recreational fishing at Denham, Monkey Mia and Nanga between March 2018 and February 2019. Aut=Autumn, Win=Winter, Spr=Spring, Sum=Summer. WD=Weekdays, WE/PH = Weekend days and public holidays. na indicates that no interviews occurred within the stratum.

		Denham		Monkey Mia		Nanga	
Season	**Day Type**	**Prop**	**se**	**Prop**	**se**	**Prop**	**se**
Aut 18	WD	0.88	0.04	0.97	0.01	0.92	0.05
	WE/PH	0.89	0.04	0.87	0.05	0.97	0.02
	Total	0.88	0.03	0.94	0.03	0.93	0.03
Win 18	WD	0.86	0.04	0.95	0.02	0.95	0.03
	WE/PH	0.86	0.07	0.90	0.03	0.95	0.04
	Total	0.86	0.03	0.94	0.02	0.95	0.02
Spr 18	WD	0.90	0.05	0.98	0.02	0.83	0.11
	WE/PH	0.90	0.08	0.99	0.01	1	0
	Total	0.90	0.04	0.98	0.01	0.88	0.08
Sum 18/19	WD	0.43	0.13	0.81	0.10	na	na
	WE/PH	0.33	0.26	1	0	na	na
	Total	0.40	0.12	0.87	0.07	na	na
Total	WD	0.77	0.04	0.93	0.03	0.90	0.04
	WE	0.74	0.07	0.94	0.02	0.97	0.01
	Total	0.76	0.03	0.93	0.02	0.92	0.03

Table 14. Estimated proportion of boat parties that had been recreational fishing within inner Shark Bay at Denham, Monkey Mia and Nanga between March 2018 and February 2019. Aut=Autumn, Win=Winter, Spr=Spring, Sum=Summer. WD=Weekdays, WE/PH = Weekend days and public holidays. na indicates that no interviews occurred within the stratum.

		Denham		Monkey Mia		Nanga	
Season	**Day Type**	**Prop**	**se**	**Prop**	**se**	**Prop**	**se**
Aut 18	WD	0.66	0.06	0.96	0.02	0.90	0.05
	WE/PH	0.70	0.10	0.87	0.05	0.97	0.02
	Total	0.67	0.05	0.93	0.02	0.93	0.03
Win 18	WD	0.74	0.11	0.95	0.02	0.95	0.03
	WE/PH	0.70	0.30	0.90	0.03	0.95	0.04
	Total	0.73	0.04	0.94	0.02	0.95	0.02
Spr 18	WD	0.82	0.05	0.98	0.02	0.83	0.11
	WE/PH	0.73	0.18	0.99	0.01	1	0
	Total	0.80	0.06	0.98	0.01	0.88	0.08
Sum 18/19	WD	0.36	0.11	0.81	0.10	na	na
	WE/PH	0.33	0.26	1	0	na	na
	Total	0.35	0.11	0.87	0.07	na	na
Total	WD	0.65	0.03	0.92	0.03	0.90	0.04
	WE	0.61	0.08	0.94	0.02	0.97	0.01
	Total	0.64	0.04	0.93	0.02	0.92	0.03

4.3 Fishing effort (boat trips)

4.3.1 Total fishing effort

Annual estimates of recreational fishing effort at Denham and Monkey Mia were approximately five times higher than at Nanga (Table 15). At Denham, an estimated 4,113 boat trips (se=83) occurred, in comparison to 4,313 (se=71) at Monkey Mia and 929 (se=17) at Nanga. Recreational fishing effort levels during autumn and winter were higher at Denham than Monkey Mia, while less effort occurred in spring and summer at Denham than Monkey Mia (Figure 6). At Nanga, fewer than 500 boat trips occurred in each season, with a peak in winter at 496 boat trips (se=11). These estimates of recreational fishing effort for all boat ramps excluded multi-day fishing trips whereby the interviewed boat party had not been fishing on the day of interview.

4.3.2 Inner Shark Bay fishing effort

The vast majority of fishing effort from Monkey Mia and Nanga was within inner Shark Bay, i.e. 4,302 boat trips (se=71) and 926 boat trips (se=20), respectively (Table 15). In contrast, at Denham, an estimated 82% of annual recreational fishing effort occurred in inner Shark Bay. The percentage of recreational fishing effort at Denham that occurred within inner Shark Bay was highest in summer (90%) and lowest in autumn (77%, Table 15).

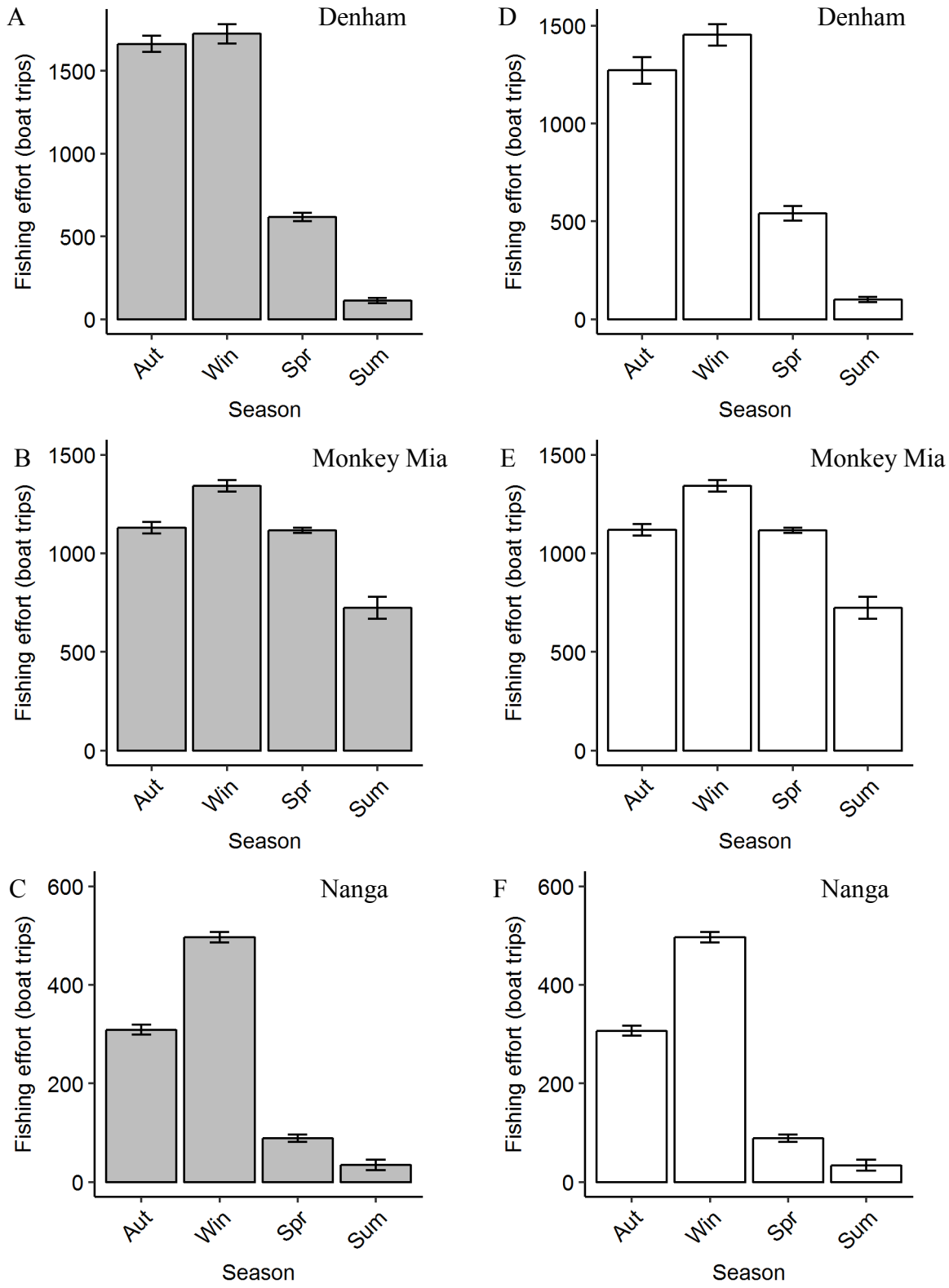


Figure 6. Estimated recreational fishing effort at Denham (A, D), Monkey Mia (B, E) and Nanga (C, F) by season between March 2018 and February 2019. Grey bars display fishing effort in boat trips for the total (inside and outside of the inner Shark Bay), bars with no fill display fishing effort for inner Shark Bay only. Fishing effort is inclusive of the period between nautical dawn and dusk; error bars represent the standard error of the mean estimates.

Table 15. Estimated annual recreational fishing effort at Denham, Monkey Mia and Nanga by season between March 2018 and February 2019. Fishing effort is reported in boat trips for the total (including fishing outside of inner Shark Bay) and for inner Shark Bay only; se is the standard error of the mean estimate. Recreational fishing effort is inclusive of the period between nautical dawn and nautical dusk; error bars represent the standard error of the mean estimates.

	Denham					Monkey Mia					Nanga				
Season/Year	**Total Effort**	**se**	**Inner Bay**	**se**	**% Inner Bay**	**Total Effort**	**se**	**Inner Bay**	**se**	**% Inner Bay**	**Total Effort**	**se**	**Inner Bay**	**se**	**% Inner Bay**
Aut 18	1,662	50	1,272	68	77	1,131	29	1,120	29	99	309	10	307	10	99
Win 18	1,723	59	1,454	55	84	1,342	30	1,341	30	100	496	11	496	11	100
Spr 18	616	26	541	37	88	1,117	13	1,117	13	100	89	7	89	7	100
Sum 18/19	112	15	101	14	90	724	56	724	56	100	35	11	34	11	97
Annual total	4,113	83	3,368	96	82	4,313	71	4,302	71	100	929	17	926	20	100

5. Harvest rates and catch rates

Mean daily harvest rates (HPUE, number kept per boat) and catch rates (CPUE, number kept and released per boat) at each ramp are displayed below for the three most commonly caught species in inner Shark Bay. Mean HPUE and CPUE values for each day type within each season are presented for Blue Swimmer Crab (Appendix 13), Pink Snapper (Appendix 14) and Grass Emperor (Appendix 15). Estimates of HPUE and CPUE will be used to estimate the harvest and catch for each species in the next chapter (refer to Appendix 7 for the method of analysis).

5.1 Blue Swimmer Crab

Mean HPUE at Monkey Mia was 7.32 crabs per boat (se=0.88). Mean HPUE at Denham was 0.01 crabs per boat (se=0.00) while no crabs were caught at Nanga (Figure 7). Mean CPUE was 11.70 crabs per boat (se=1.33) at Monkey Mia and 0.01 crabs per boat (se=0.00) at Denham. No crabs were caught at Nanga (Figure 7, Appendix 13).

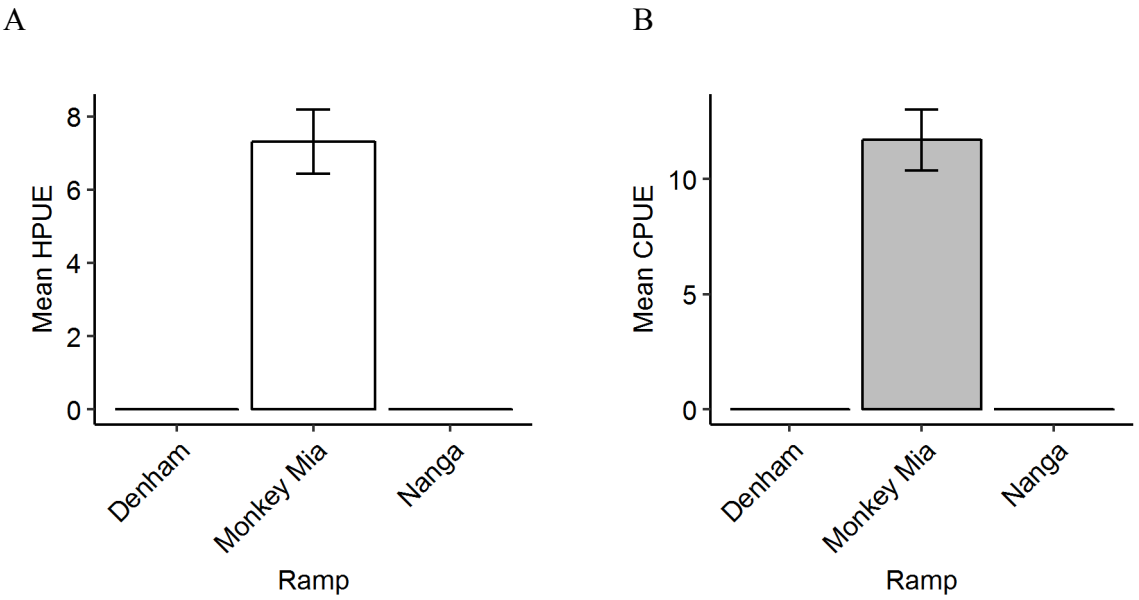


Figure 7. Blue Swimmer Crab A) mean harvest rates (HPUE, number kept per boat) and B) mean catch rates (CPUE, number kept and released) at Denham, Monkey Mia and Nanga. Estimates are for inner Shark Bay only, error bars represent the standard error of the mean estimates.

5.2 Pink Snapper

Mean HPUE was highest at Nanga at 0.63 fish per boat (se=0.12). Mean HPUE was 0.32 fish per boat (se=0.04) at Denham and 0.14 fish per boat at Monkey Mia (se=0.04, Figure 8, Appendix 14). Mean CPUE was highest at Nanga at 6.58 fish per boat (1.09). Mean CPUE was 5.10 fish per boat (se=0.64) at Denham and 3.79 fish per boat (se=0.54) at Monkey Mia (Figure 8; Appendix 14).

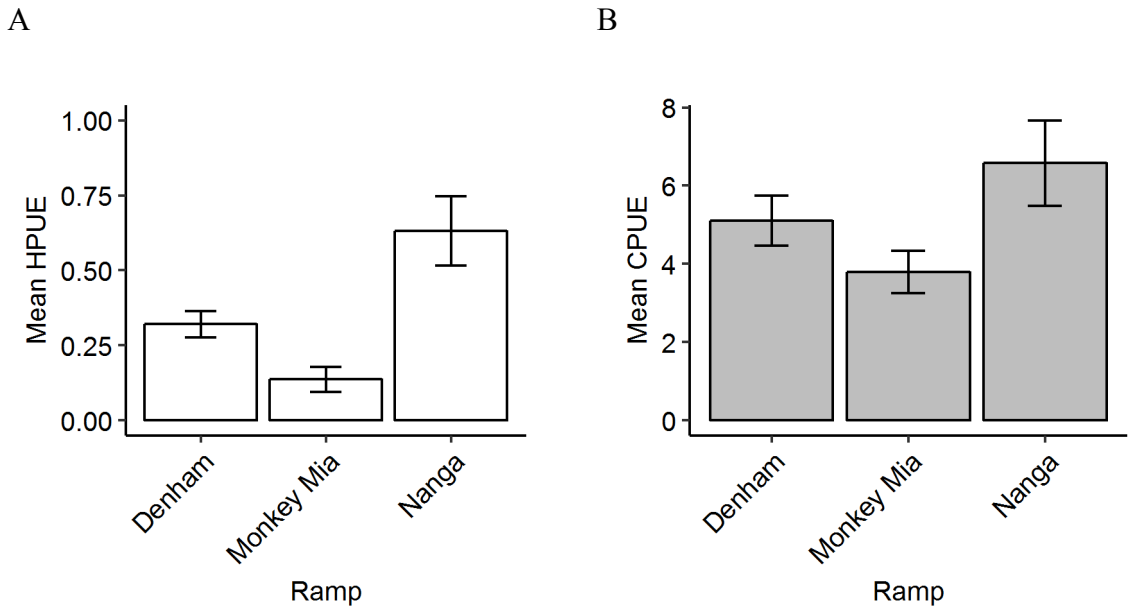


Figure 8. Pink Snapper A) mean harvest rates (HPUE, number kept per boat) and B) mean catch rates (CPUE, number kept and released) at Denham, Monkey Mia and Nanga. Estimates are for inner Shark Bay only, error bars represent the standard error of the mean estimates.

5.3 Grass Emperor

Mean HPUE was highest at Denham at 0.87 fish per boat (se=0.19). Mean HPUE was 0.39 fish per boat (se=0.09) at Monkey Mia and 0.17 fish per boat (se=0.05, Figure 9, Appendix 15) at Nanga. Mean CPUE was highest at Denham at 3.08 fish per boat (0.47). Mean CPUE was 1.30 fish per boat (se=0.30) at Monkey Mia and 0.49 fish per boat (se=0.16) at Nanga.

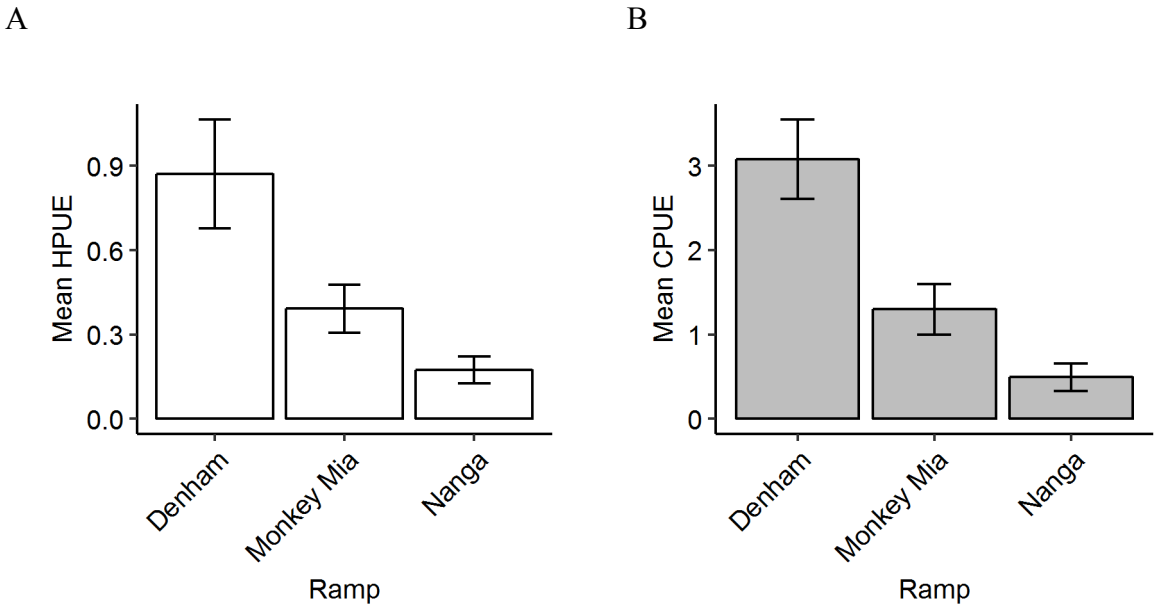


Figure 9. Grass Emperor A) mean harvest rates (HPUE, number kept per boat) and B) catch rates (CPUE, number kept and released) at Denham, Monkey Mia and Nanga. Estimates are for inner Shark Bay only, error bars represent the standard error of the mean estimates.

6. Recreational catch (ramp-based and all ramps combined)

Estimated mean daily harvest rates (HPUE, number kept per boat) and catch rates (CPUE, number kept and released per boat) at each ramp from the previous chapter were multiplied by recreational fishing effort to determine ramp-based estimates of harvest (kept only) and catch (kept, released and total) by species. Ramp-based estimates of harvest and catch are summarised below and are presented for Denham (Appendix 16), Monkey Mia (Appendix 17) and Nanga (Appendix 18). Ramp-based estimates of harvest and catch for inner Shark Bay only are summarised below and are presented for Denham (Table 16, Figure 10), Monkey Mia (Table 17; Figure 11) and Nanga (Table 18; Figure 12).

6.1 Catch in numbers

The total boat-based recreational catch (all ramps combined, including fishing outside of inner Shark Bay) was an estimated 191,300 individuals, of which approximately 64,000 were kept (33%) and 110,000 were released (67%; Appendix 19). The total catch comprised scalefish (n=120 species/taxa, incl. unknown), elasmobranchs (n=19), crustaceans (n=5) and molluscs (n=3). In addition, one interaction with a protected species was reported when a boat party incidentally caught and released a Loggerhead Turtle (*Caretta caretta*) in the Eastern Gulf. The three most commonly caught species were Pink Snapper, Blue Swimmer Crab and Grass Emperor comprising 71% of the total catch (kept and released).

At Denham, boat-based recreational fishers caught an estimated 83,900 individuals, of which approximately 18,400 were kept (22%) and 47,800 were released (78%; Appendix 16). The three most commonly caught species at Denham were Pink Snapper, Grass Emperor and Western Butterfish comprising 63% of the total catch (kept and released). At Monkey Mia, boat-based recreational fishers caught an estimated 96,200 individuals, of which approximately 44,100 were kept (46%) and 52,000 were released (54%; Appendix 17). The three most commonly caught species at Monkey Mia were Blue Swimmer Crab, Pink Snapper and Grass Emperor comprising 79% of the total catch (kept and released). At Nanga, boat-based recreational fishers caught an estimated 11,200 individuals, of which approximately 1,400 were kept (13%) and 9,800 were released (87%; Appendix 18). The three most commonly caught species at Nanga were Pink Snapper, Grass Emperor and Blackspot Tuskfish (*Choerodon schoenleinii*) comprising 91% of the total catch (kept and released).

6.2 Catch in numbers (inner Shark bay only)

The total boat based recreational catch (i.e. all ramps combined, inner Shark Bay only) was an estimated 159,000 individuals, of which approximately 58,000 were kept (36%) and 101,000 were released (64%; Figure 10). The total catch comprised scalefish (n=101 species/taxa, incl. unknown), elasmobranchs (n=19), crustaceans (n=4), molluscs (n=3) and the one protected species interaction (see above). The three most commonly caught species by number in inner Shark Bay were Blue Swimmer Crab, Pink Snapper and Grass Emperor comprising 72% of the total catch (kept and released) for those trips that occurred in inner Shark Bay. The percentage

released for Blue Swimmer Crab, Pink Snapper and Grass Emperor were 39%, 94% and 70%, respectively (Table 19; Figure 12).

At Denham, boat-based recreational fishers caught an estimated 52,200 individuals in inner Shark Bay, of which approximately 12,500 were kept (24%) and 39,600 were released (76%; Table 16). The three most commonly caught species at Denham were Pink Snapper, Grass Emperor and Western Butterfish comprising 72% of the total catch (kept and released) for those trips that occurred in inner Shark Bay (Table 16, Figure 10). At Monkey Mia, boat-based recreational fishers caught an estimated 95,800 individuals, of which approximately 44,000 were kept (46%) and 51,700 were released (54%) in inner Shark Bay. The three most commonly caught species at Monkey Mia were Blue Swimmer Crab, Pink Snapper and Grass Emperor comprising 79% of the total catch (kept and released) for those trips that occurred in inner Shark Bay (Table 17; Figure 11). At Nanga, boat-based recreational fishers caught an estimated 11,200 individuals, of which approximately 1,400 were kept (13%) and 9,800 were released (87%; Table 18) in inner Shark Bay. The three most commonly caught species at Nanga were Pink Snapper, Grass Emperor and Blackspot Tuskfish comprising 91% of the total catch (kept and released) for those trips that occurred in inner Shark Bay (Table 18; Figure 12).

Table 16. Estimated annual catch (kept, released and total numbers) and percentage released by boat-based recreational fishers at Denham between March 2018 and February 2019. Catches are for inner Shark Bay only. Values in bold indicate a relative standard error >40% (i.e. se >40% of the estimate).

Reporting Group	Common Name	Scientific Name	Kept	se	Rel	se	Total	se	% Rel
Bream	Frypan Bream	*Argyrops spinifer*	**45**	**45**	**36**	**36**	**81**	**81**	44
Bream	Pink Snapper	*Chrysophrys auratus*	1,454	186	20,309	2,271	21,763	2,356	93
Bream	Tarwhine	*Rhabdosargus sarba*	**13**	**10**	**23**	**20**	**36**	**30**	64
Bream	Western Yellowfin Bream	*Acanthopagrus morrisoni*	**184**	**151**	**317**	**297**	**500**	**446**	63
Catfish	Forktail Catfishes	*Ariidae - undifferentiated*	0	0	**3**	**3**	**3**	**3**	100
Cephalopod	Cuttlefish	*Sepia spp.*	**70**	**38**	**18**	**18**	**89**	**42**	21
Cephalopod	Octopuses	*Octopodidae - undifferentiated*	0	0	**3**	**3**	**3**	**3**	100
Cephalopod	Squid	*Order Teuthoidea - undifferentiated*	**2,207**	**1,288**	**789**	**756**	**2,996**	**2,027**	26
Cobia	Cobia	*Rachycentron canadum*	**9**	**5**	**4**	**4**	**13**	**7**	34
Cod	Birdwire Rockcod	*Epinephelus merra*	**5**	**3**	**1**	**1**	**6**	**4**	22
Cod	Blackspotted Rockcod	*Epinephelus malabaricus*	**14**	**9**	**1**	**1**	**15**	**10**	9
Cod	Chinaman Rockcod	*Epinephelus rivulatus*	**96**	**68**	**136**	**59**	**232**	**100**	59
Cod	Coral Rockcod	*Cephalopholis miniata*	**1**	**1**	0	0	**1**	**1**	0
Cod	Frostback Rockcod	*Epinephelus bilobatus*	0	0	**2**	**2**	**2**	**2**	100
Cod	Goldspotted Rockcod	*Epinephelus coioides*	176	56	**91**	**45**	267	75	34
Cod	Potato Rockcod	*Epinephelus tukula*	0	0	**3**	**3**	**3**	**3**	100
Cod	Rankin Cod	*Epinephelus multinotatus*	399	121	257	90	656	168	39
Cod	Temperate Basses & Rockcods	*Percichthyidae, Serranidae - undifferentiated*	0	0	**17**	**11**	**17**	**11**	100
Cod	Tomato Rockcod	*Cephalopholis sonnerati*	**1**	**1**	0	0	**1**	**1**	0
Cod	Yellowspotted Rockcod	*Epinephelus areolatus*	**15**	**13**	**3**	**3**	**18**	**14**	17
Coral Trout	Barcheek Coral Trout	*Plectropomus maculatus*	**95**	**41**	**15**	**13**	110	43	13
Coral Trout	Common Coral Trout	*Plectropomus leopardus*	**65**	**27**	**8**	**8**	73	28	11
Coral Trout	Yellowedge Coronation Trout	*Variola louti*	**3**	**3**	0	0	**3**	**3**	0
Crab	Blue Swimmer Crab	*Portunus armatus*	**31**	**21**	0	0	**31**	**21**	0
Eels	Eels	*Order Anguilliformes - undifferentiated*	0	0	**10**	**7**	**10**	**7**	100
Emperor	Bluespotted Emperor	*Lethrinus punctulatus*	0	0	**2**	**2**	**2**	**2**	100
Emperor	Grass Emperor	*Lethrinus laticaudis*	3,592	664	8,931	1,460	12,523	1,723	71
Emperor	Redthroat Emperor	*Lethrinus miniatus*	**70**	**37**	**112**	**49**	**182**	**77**	62
Emperor	Robinson's Seabream	*Gymnocranius grandoculis*	**7**	**7**	0	0	**7**	**7**	0
Emperor	Spangled Emperor	*Lethrinus nebulosus*	**67**	**27**	318	112	385	120	83

Reporting Group	Common Name	Scientific Name	Kept	se	Rel	se	Total	se	% Rel
Flathead	Flatheads	*Platycephalidae - undifferentiated*	**14**	**8**	**27**	**19**	**40**	**21**	66
Flathead	Northern Sand Flathead	*Platycephalus endrachtensis*	**9**	**5**	0	0	**9**	**5**	0
Flathead	Yellowtail Flathead	*Platycephalus westraliae*	214	48	183	70	397	85	46
Flounders	Flounders	*Bothidae, Psettodidae & Pleuronectidae*	**14**	**10**	**22**	**19**	**36**	**21**	**62**
Flounders	Smalltooth Flounder	*Pseudorhombus jenynsii*	**22**	**22**	0	0	**22**	**22**	0
Garfish	Garfishes	*Hemiramphidae - undifferentiated*	**33**	**26**	**37**	**28**	**69**	**44**	53
Garfish	Three-By-Two Garfish	*Hemiramphus robustus*	0	0	**5**	**5**	**5**	**5**	100
Giant Perch	Sand Bass	*Psammoperca waigiensis*	0	0	**15**	**11**	**15**	**11**	100
Goatfish	Goatfishes	*Mullidae - undifferentiated*	0	0	**4**	**4**	**4**	**4**	100
Grunter	Striped Grunters	*Terapontidae - undifferentiated*	0	0	**168**	**77**	**168**	**77**	100
Grunter	Yellowtail Grunter	*Amniataba caudavittata*	0	0	**227**	**135**	**227**	**135**	100
Grunter	Western Striped Grunter	*Pelates octolineatus*	**10**	**10**	**5**	**3**	**15**	**12**	32
Grunter Bream	Goldspotted Sweetlips	*Plectorhinchus flavomaculatus*	**36**	**36**	0	0	**36**	**36**	0
Grunter Bream	Grunter Breams	*Haemulidae - undifferentiated*	**4**	**4**	**25**	**18**	**28**	**18**	87
Grunter Bream	Painted Sweetlips	*Diagramma labiosum*	0	0	**16**	**12**	**16**	**12**	100
Gurnard	Gurnard Perches	*Neosebastidae - undifferentiated*	0	0	**6**	**6**	**6**	**6**	100
Gurnard	Searobins & Armour Gurnards	*Triglidae & Peristediidae - undifferentiated*	0	0	**2**	**2**	**2**	**2**	100
Leatherjacket	Horseshoe Leatherjacket	*Meuschenia hippocrepis*	**2**	**2**	**9**	**7**	**11**	**8**	83
Lizardfish	Common Saury	*Saurida tumbil*	**17**	**17**	**62**	**27**	**79**	**40**	79
Lizardfish	Lizardfishes & Deepsea Lizardfishes	*Bathysauridae, Synodontidae - undifferentiated*	**5**	**3**	**139**	**52**	**144**	**52**	97
Lobster	Western Rock Lobster	*Panulirus cygnus*	**20**	**15**	**11**	**11**	**31**	**25**	37
Longtom	Longtoms	*Belonidae - undifferentiated*	0	0	**2**	**2**	**2**	**2**	100
Mackerel	Mackerels	*Scombridae - undifferentiated*	0	0	**6**	**6**	**6**	**6**	100
Mackerel	School Mackerel	*Scomberomorus queenslandicus*	434	98	400	129	834	166	48
Mackerel	Shark Mackerel	*Grammatorcynus bicarinatus*	**42**	**22**	**36**	**20**	**78**	**36**	46
Mackerel	Spanish Mackerel	*Scomberomorus commerson*	**53**	**38**	**27**	**20**	**80**	**41**	34
Mackerel	Spotted Mackerel	*Scomberomorus munroi*	**7**	**4**	0	0	**7**	**4**	0
Morwong	Morwongs	*Cheilodactylidae - undifferentiated*	0	0	**4**	**4**	**4**	**4**	100
Mulloway	Mulloway	*Argyrosomus japonicus*	77	19	**156**	**74**	233	81	67
Pearl Perch	Northern Pearl Perch	*Glaucosoma buergeri*	**4**	**3**	0	0	**4**	**3**	0
Pike	Great Barracuda	*Sphyraena barracuda*	0	0	**15**	**15**	**15**	**15**	100

Reporting Group	Common Name	Scientific Name	Kept	se	Rel	se	Total	se	% Rel
Pike	Pikes	*Sphyraenidae - undifferentiated*	**88**	**59**	**38**	**18**	**125**	**63**	30
Pike	Snook	*Sphyraena novaehollandiae*	**56**	**32**	44	17	100	39	44
Pike	Yellowtail Barracuda	*Sphyraena obtusata*	**15**	**15**	**18**	**18**	**33**	**23**	55
Sea Mullet	Sea Mullet	*Mugil cephalus*	**3**	**3**	**4**	**4**	**6**	**5**	58
Sergeant Baker	Sergeant Baker	*Latropiscis purpurissatus*	0	0	**24**	**11**	**24**	**11**	100
Sharks	Blacktip Shark	*Carcharhinus, Loxodon & Rhizoprionodon spp.*	**3**	**3**	0	0	**3**	**3**	0
Sharks	Bronze Whaler	*Carcharhinus brachyurus*	0	0	**20**	**11**	**20**	**11**	100
Sharks	Dusky Whaler	*Carcharhinus obscurus*	0	0	**13**	**13**	**13**	**13**	100
Sharks	Hammerhead Sharks	*Sphyrnidae - undifferentiated*	0	0	**13**	**10**	**13**	**10**	100
Sharks	Lemon Shark	*Negaprion acutidens*	0	0	**4**	**4**	**4**	**4**	100
Sharks	Nervous Shark	*Carcharhinus cautus*	**5**	**5**	**5**	**5**	**11**	**11**	50
Sharks	Sandbar Shark	*Carcharhinus plumbeus*	**2**	**2**	**4**	**4**	**6**	**5**	61
Sharks	Tiger Shark	*Galeocerdo cuvier*	0	0	**10**	**8**	**10**	**8**	100
Sharks	Western Spotted Gummy Shark	*Mustelus stevensi*	0	0	**6**	**4**	**6**	**4**	100
Sharks	Whaler & Weasel Sharks	*Carcharhinidae, Hemigaleidae - undifferentiated*	**3**	**3**	215	81	218	81	99
Sharks	Whiskery Shark	*Furgaleus macki*	**2**	**2**	0	0	**2**	**2**	0
Sharks	Whitetip Reef Shark	*Triaenodon obesus*	0	0	**7**	**7**	**7**	**7**	100
Tailor	Tailor	*Pomatomus saltatrix*	**81**	**46**	**17**	**11**	**98**	**50**	17
Threadfin Bream	Western Butterfish	*Pentapodus vitta*	**472**	**262**	2,942	506	3,414	661	86
Toadfish	Silver Toadfish	*Lagocephalus sceleratus*	0	0	**352**	**69**	**352**	**69**	100
Toadfish	Toadfishes	*Tetraodontidae - undifferentiated*	0	0	**70**	**53**	**70**	**53**	100
Trevally	Bludger Trevally	*Carangoides gymnostethus*	**3**	**3**	**7**	**7**	**10**	**8**	71
Trevally	Diamond Trevally	*Alectis indica*	0	0	**1**	**1**	**1**	**1**	100
Trevally	Giant Trevally	*Caranx ignobilis*	0	0	**4**	**3**	**4**	**3**	100
Trevally	Golden Trevally	*Gnathanodon speciosus*	**8**	**5**	**30**	**13**	**38**	**15**	79
Trevally	Turrum	*Carangoides fulvoguttatus*	**1**	**1**	**10**	**8**	**11**	**9**	88
Tropical Snapper	Goldband Snapper	*Pristipomoides multidens*	**5**	**5**	0	0	**5**	**5**	0
Tropical Snapper	Golden Snapper	*Lutjanus johnii*	**3**	**3**	0	0	**3**	**3**	0
Tropical Snapper	Mangrove Jack	*Lutjanus argentimaculatus*	**1**	**1**	0	0	**1**	**1**	0
Tropical Snapper	Moses' Snapper	*Lutjanus russellii*	**18**	**14**	**26**	**20**	**44**	**25**	58
Tropical Snapper	Red Emperor	*Lutjanus sebae*	**44**	**27**	**16**	**16**	**59**	**41**	27
Tropical Snapper	Stripey Snapper	*Lutjanus carponotatus*	396	111	431	125	828	202	52
Tuna	Yellowfin Tuna	*Thunnus albacares*	**1**	**1**	0	0	**1**	**1**	0
Tuskfish & Wrasse	Baldchin Groper	*Choerodon rubescens*	**8**	**5**	**39**	**39**	**48**	**39**	83

Reporting Group	Common Name	Scientific Name	Kept	se	Rel	se	Total	se	% Rel
Tuskfish & Wrasse	Blackspot Tuskfish	*Choerodon schoenleinii*	221	77	940	182	1,162	207	81
Tuskfish & Wrasse	Blue Tuskfish	*Choerodon cyanodus*	**2**	**2**	**25**	**13**	**27**	**13**	92
Tuskfish & Wrasse	Bluebarred Parrotfish	*Scarus ghobban spp. complex*	**2**	**2**	0	0	**2**	**2**	0
Tuskfish & Wrasse	Bluespotted Tuskfish	*Choerodon cauteroma*	**21**	**17**	**18**	**11**	**39**	**25**	54
Tuskfish & Wrasse	Parrotfishes	*Scaridae - undifferentiated*	**1**	**1**	**19**	**13**	**21**	**13**	93
Tuskfish & Wrasse	Tuskfishes	*Choerodon spp.*	**6**	**6**	**15**	**11**	**21**	**12**	71
Tuskfish & Wrasse	Western King Wrasse	*Coris auricularis*	0	0	**13**	**13**	**13**	**13**	100
Tuskfish & Wrasse	Wrasses	*Labridae - undifferentiated*	0	0	**98**	**43**	**98**	**43**	100
Unknown	Unknown Species		**24**	**24**	**218**	**141**	**242**	**146**	90
Whiting	Goldenline Whiting	*Sillago analis*	0	0	**3**	**3**	**3**	**3**	100
Whiting	Western School Whiting	*Sillago vittata*	**200**	**200**	**10**	**10**	**211**	**201**	5
Whiting	Western Trumpeter Whiting	*Sillago burrus*	**45**	**45**	**236**	**121**	**281**	**129**	84
Whiting	Whitings	*Sillaginidae - undifferentiated*	**1,061**	**874**	**576**	**576**	**1,638**	**1,445**	35
Whiting	Yellowfin Whiting	*Sillago schomburgkii*	**101**	**101**	**52**	**37**	**153**	**134**	34

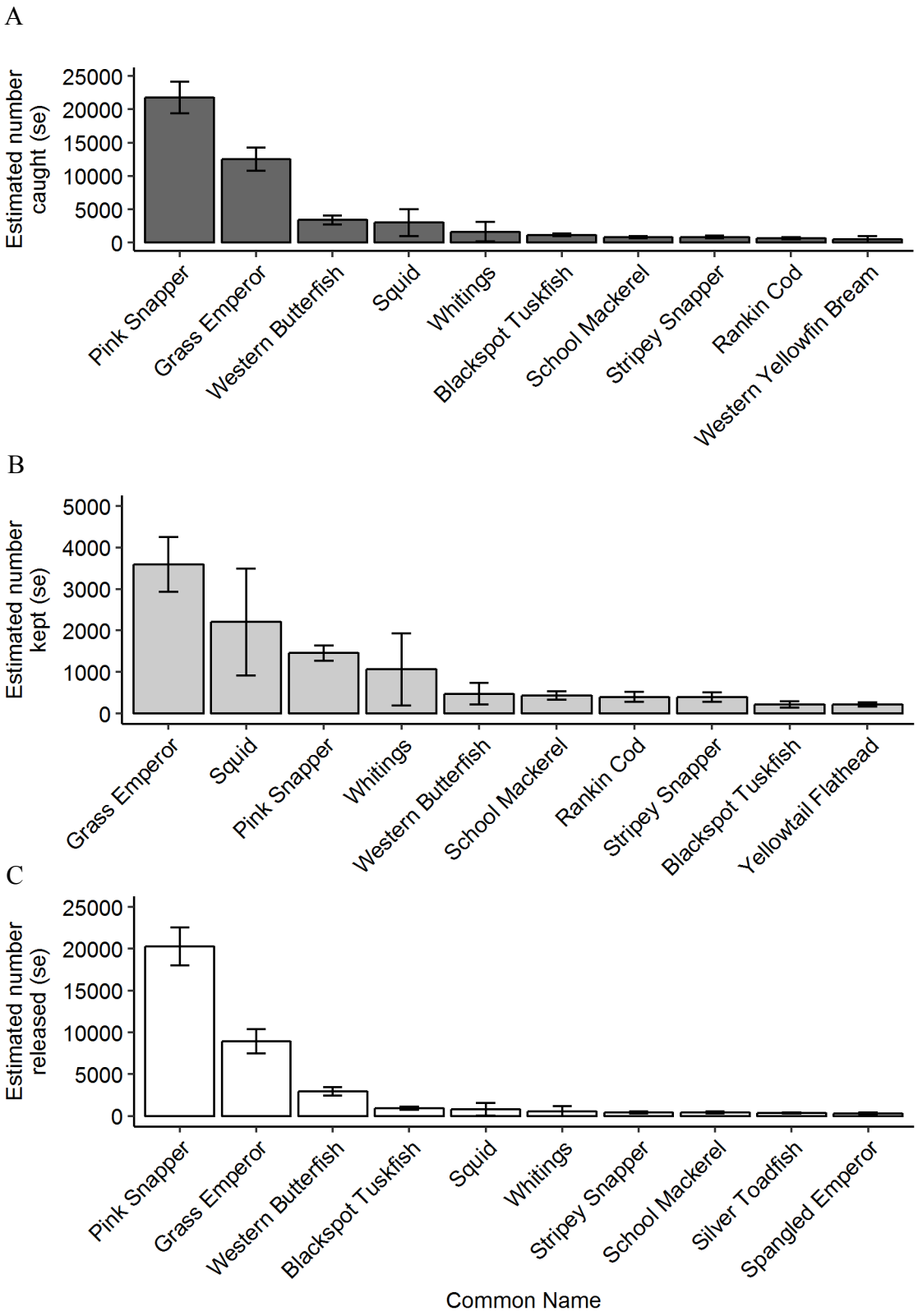


Figure 10. Estimated number of species that were A) caught, B) kept and C) released by boat-based recreational fishers at Denham between March 2018 and February 2019. Catches are displayed for inner Shark Bay only, inclusive of boats retrieving from the ramp between nautical sunrise and nautical sunset and are ranked to display the top 10 species or taxa (by number); se = standard error of the mean estimate.

Table 17. Estimated annual catch (kept, released and total numbers) and percentage released by boat-based fishers at Monkey Mia between March 2018 and February 2019. Catches are for inner Shark Bay only. Values in bold indicate a relative standard error >40% (i.e. se >40% of the estimate).

Reporting Group	Common Name	Scientific Name	Kept	se	Rel	se	Total	se	% Rel
Bonitos	Bonitos	*Sarda australis & Cybiosarda elegans*	0	0	**16**	**16**	**16**	**16**	100
Bream	Pink Snapper	*Chrysophrys auratus*	601	192	15,846	2,306	16,447	2,372	96
Bream	Western Yellowfin Bream	*Acanthopagrus morrisoni*	**48**	**32**	**306**	**177**	**354**	**180**	87
Catfish	Forktail Catfishes	*Ariidae - undifferentiated*	**53**	**27**	**673**	**295**	**726**	**301**	93
Catfish	Giant Sea Catfish	*Netuma thalassina*	**51**	**43**	**1,155**	**676**	**1,207**	**677**	96
Cephalopod	Squid	*Order Teuthoidea - undifferentiated*	**30**	**22**	0	0	**30**	**22**	0
Cobia	Cobia	*Rachycentron canadum*	0	0	**12**	**12**	**12**	**12**	100
Cod	Blackspotted Rockcod	*Epinephelus malabaricus*	**88**	**54**	**27**	**20**	**115**	**67**	23
Cod	Frostback Rockcod	*Epinephelus bilobatus*	**27**	**27**	**7**	**7**	**34**	**34**	20
Cod	Goldspotted Rockcod	*Epinephelus coioides*	**497**	**101**	440	119	937	202	47
Cod	Rankin Cod	*Epinephelus multinotatus*	**184**	**79**	**310**	**112**	**494**	**158**	63
Cod	Yellowspotted Rockcod	*Epinephelus areolatus*	**80**	**43**	**95**	**44**	**175**	**83**	54
Crab	Blue Swimmer Crab	*Portunus armatus*	33,143	3,889	21,097	3,290	54,239	5,933	39
Crab	Coral Crab	*Charybdis feriata*	0	0	**9**	**9**	**9**	**9**	100
Crab	Green Mud Crab	*Scylla serrata*	0	0	**4**	**4**	**4**	**4**	100
Emperor	Grass Emperor	*Lethrinus laticaudis*	1,607	372	3,588	846	5,195	1,139	69
Emperor	Spangled Emperor	*Lethrinus nebulosus*	**65**	**59**	**95**	**89**	**160**	**147**	59
Flathead	Flatheads	*Platycephalidae - undifferentiated*	**27**	**19**	**10**	**8**	**36**	**23**	27
Flathead	Yellowtail Flathead	*Platycephalus westraliae*	150	51	**167**	**70**	317	107	53
Grunter	Striped Grunters	*Terapontidae - undifferentiated*	0	0	**245**	**141**	**245**	**141**	100
Grunter	Yellowtail Grunter	*Amniataba caudavittata*	**279**	**251**	**347**	**144**	**626**	**288**	55
Grunter Bream	Painted Sweetlips	*Diagramma labiosum*	0	0	**4**	**4**	**4**	**4**	100
Leatherjacket	Fanbelly Leatherjacket	*Monacanthus chinensis*	0	0	**14**	**14**	**14**	**14**	100
Leatherjacket	Horseshoe Leatherjacket	*Meuschenia hippocrepis*	0	0	**3**	**3**	**3**	**3**	100
Lizardfish	Common Saury	*Saurida tumbil*	0	0	**165**	**139**	**165**	**139**	100

Reporting Group	Common Name	Scientific Name	Kept	se	Rel	se	Total	se	% Rel
Lizardfish	Lizardfishes & Deepsea Lizardfishes	*Bathysauridae, Synodontidae - undifferentiated*	**7**	**7**	**436**	**243**	**443**	**245**	98
Mackerel	School Mackerel	*Scomberomorus queenslandicus*	151	39	69	22	220	51	31
Mackerel	Spanish Mackerel	*Scomberomorus commerson*	**19**	**14**	**6**	**6**	**25**	**17**	25
Mackerel	Spotted Mackerel	*Scomberomorus munroi*	6	4	45	25	51	29	88
Mullet	Mullets	*Mugilidae - undifferentiated*	**1,391**	**927**	**503**	**503**	**1,894**	**1,403**	27
Mulloway	Mulloway	*Argyrosomus japonicus*	**80**	**37**	**166**	**101**	**246**	**130**	68
Pike	Pikes	*Sphyraenidae - undifferentiated*	0	0	**20**	**18**	**20**	**18**	100
Pike	Snook	*Sphyraena novaehollandiae*	0	0	**205**	**146**	**205**	**146**	100
Pike	Yellowtail Barracuda	*Sphyraena obtusata*	0	0	**3**	**3**	**3**	**3**	100
Rays	Guitarfishes	*Rhinobatidae - undifferentiated*	**4**	**4**	**78**	**34**	**82**	**34**	95
Rays	Stingrays	*Dasyatidae - undifferentiated*	0	0	**4**	**4**	**4**	**4**	100
Sea Mullet	Sea Mullet	*Mugil cephalus*	**297**	**192**	0	0	**297**	**192**	0
Sea Turtle	Loggerhead Turtle	*Caretta caretta*	0	0	**8**	**8**	**8**	**8**	100
Sharks	Blacktip Reef Shark	*Carcharhinus melanopterus*	0	0	**353**	**217**	**353**	**217**	100
Sharks	Blacktip Shark	*Carcharhinus, Loxodon & Rhizoprionodon spp.*	**2**	**2**	**35**	**29**	**37**	**29**	95
Sharks	Bronze Whaler	*Carcharhinus brachyurus*	0	0	**17**	**15**	**17**	**15**	100
Sharks	Bull Shark	*Carcharhinus leucas*	0	0	**12**	**12**	**12**	**12**	100
Sharks	Lemon Shark	*Negaprion acutidens*	0	0	**17**	**15**	**17**	**15**	100
Sharks	Sandbar Shark	*Carcharhinus plumbeus*	0	0	**8**	**8**	**8**	**8**	100
Sharks	Spinner Shark	*Carcharhinus brevipinna*	0	0	**38**	**29**	**38**	**29**	100
Sharks	Whaler & Weasel Sharks	*Carcharhinidae, Hemigaleidae - undifferentiated*	**21**	**15**	127	41	148	43	86
Sharks	Wobbegong	*Orectolobidae - undifferentiated*	**3**	**3**	0	0	**3**	**3**	0
Tailor	Tailor	*Pomatomus saltatrix*	280	100	**148**	**94**	**428**	**175**	35
Threadfin	King Threadfin	*Polydactylus macrochir*	**17**	**17**	**42**	**42**	**60**	**46**	71
Threadfin Bream	Western Butterfish	*Pentapodus vitta*	**240**	**126**	2,527	634	2,767	665	91
Toadfish	Silver Toadfish	*Lagocephalus sceleratus*	0	0	**16**	**10**	**16**	**10**	100
Toadfish	Toadfishes	*Tetraodontidae - undifferentiated*	0	0	**33**	**27**	**33**	**27**	100

Reporting Group	Common Name	Scientific Name	Kept	se	Rel	se	Total	se	% Rel
Trevally	Giant Trevally	*Caranx ignobilis*	0	0	**34**	**23**	**34**	**23**	100
Trevally	Golden Trevally	*Gnathanodon speciosus*	**18**	**15**	**77**	**47**	**95**	**49**	81
Tropical Snapper	Moses' Snapper	*Lutjanus russellii*	0	0	**22**	**22**	**22**	**22**	100
Tropical Snapper	Stripey Snapper	*Lutjanus carponotatus*	**41**	**23**	**19**	**10**	**60**	**25**	31
Tuna	Longtail Tuna	*Thunnus tonggol*	**6**	**6**	**42**	**31**	**48**	**34**	87
Tuskfish & Wrasse	Blackspot Tuskfish	*Choerodon schoenleinii*	707	165	671	137	1,378	241	49
Tuskfish & Wrasse	Bluespotted Tuskfish	*Choerodon cauteroma*	**40**	**33**	**41**	**28**	**81**	**51**	51
Tuskfish & Wrasse	Goldspot Pigfish	*Bodianus perditio*	0	0	**2**	**2**	**2**	**2**	100
Tuskfish & Wrasse	Surf Parrotfish	*Scarus rivulatus*	**62**	**50**	0	0	**62**	**50**	0
Tuskfish & Wrasse	Tuskfishes	*Choerodon spp.*	0	0	**9**	**9**	**9**	**9**	100
Tuskfish & Wrasse	Wrasses	*Labridae - undifferentiated*	0	0	**42**	**28**	**42**	**28**	100
Unknown	Unknown Species		0	0	**113**	**86**	**113**	**86**	100
Whiting	Western School Whiting	*Sillago vittata*	**206**	**128**	**148**	**74**	**354**	**184**	42
Whiting	Western Trumpeter Whiting	*Sillago burrus*	**3**	**3**	**59**	**53**	**62**	**54**	95
Whiting	Whitings	*Sillaginidae - undifferentiated*	**1,082**	**535**	**327**	**152**	**1,409**	**670**	23
Whiting	Yellowfin Whiting	*Sillago schomburgkii*	2,390	853	**586**	**331**	2,976	1,105	20

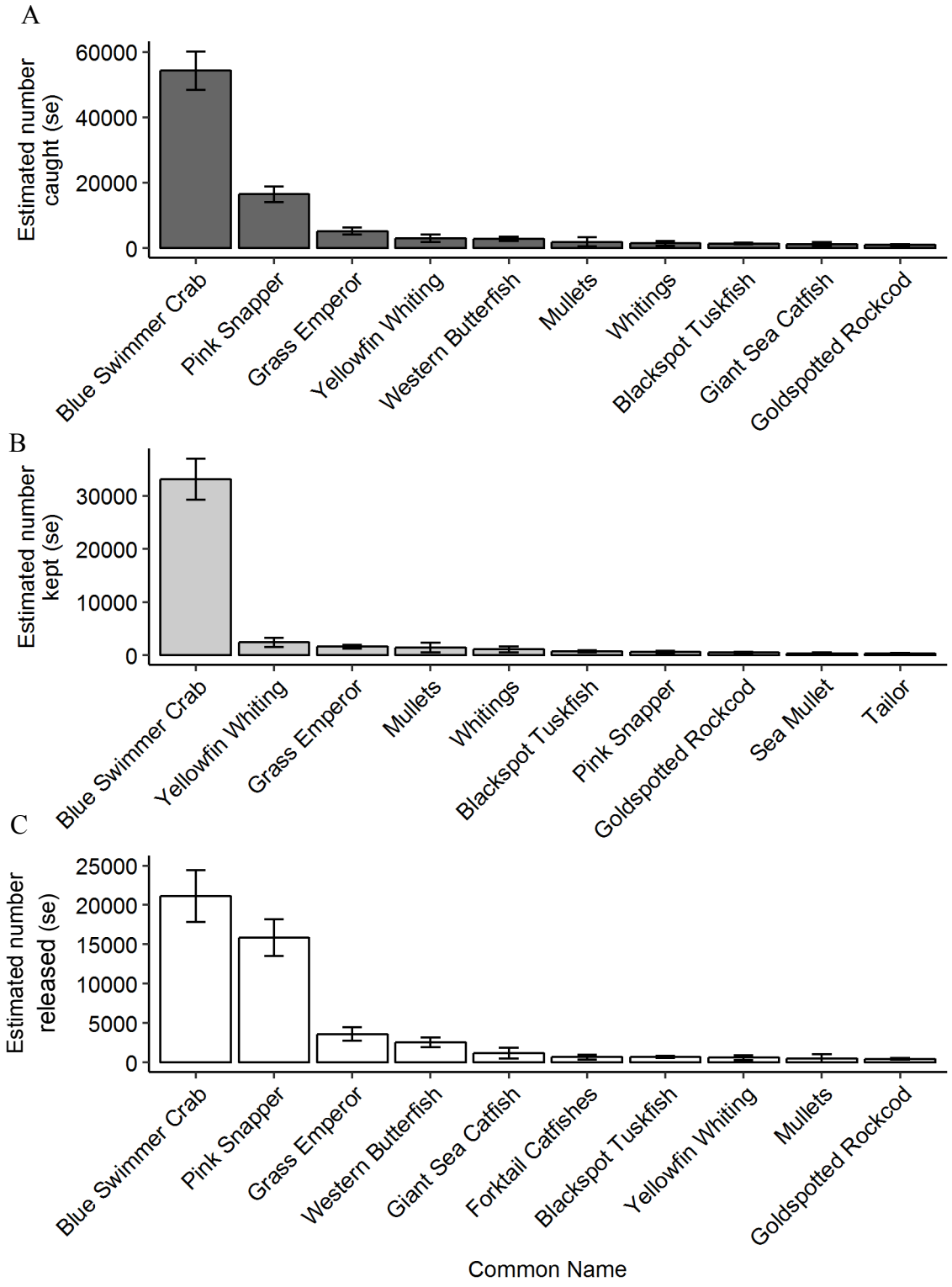


Figure 11. Estimated number of species that were A) caught, B) kept and C) released by boat-based recreational fishers at Monkey Mia between March 2018 and February 2019. Catches are displayed for inner Shark bay only, inclusive of boats retrieving from the ramp between nautical sunrise and nautical sunset and are ranked to display the top 10 species or taxa (by number); se = standard error of the mean estimate.

Table 18. Estimated annual catch (kept, released and total numbers) and percentage released by boat-based fishers at Nanga between March 2018 and February 2019. Catches are for inner Shark Bay only. Values in bold indicate a relative standard error >40% (i.e. se >40% of the estimate).

Reporting Group	Common Name	Scientific Name	Kept	se	Rel	se	Total	se	% Rel
Bream	Pink Snapper	*Chrysophrys auratus*	911	136	8,255	1,404	9,166	1,442	90
Bream	Western Yellowfin Bream	*Acanthopagrus morrisoni*	0	0	**4**	**4**	**4**	**4**	100
Cephalopod	Squid	*Order Teuthoidea - undifferentiated*	**63**	**38**	**5**	**5**	**69**	**39**	8
Cod	Goldspotted Rockcod	*Epinephelus coioides*	**1**	**1**	0	0	**1**	**1**	0
Eels	Eels	*Order Anguilliformes - undifferentiated*	0	0	**2**	**2**	**2**	**2**	100
Emperor	Grass Emperor	*Lethrinus laticaudis*	193	46	320	85	513	114	62
Emperor	Spangled Emperor	*Lethrinus nebulosus*	**3**	**3**	**254**	**254**	**258**	**258**	99
Flathead	Flatheads	*Platycephalidae - undifferentiated*	**5**	**5**	0	0	**5**	**5**	0
Flathead	Fringe-Eye Flathead	*Cymbacephalus nematophthalmus*	**1**	**1**	0	0	**1**	**1**	0
Flathead	Yellowtail Flathead	*Platycephalus westraliae*	**5**	**4**	**32**	**21**	**37**	**22**	86
Flounders	Smalltooth Flounder	*Pseudorhombus jenynsii*	0	0	**10**	**10**	**10**	**10**	100
Giant Perch	Sand Bass	*Psammoperca waigiensis*	**5**	**5**	**5**	**5**	**9**	**9**	50
Lizardfish	Lizardfishes & Deepsea Lizardfishes	*Bathysauridae, Synodontidae - undifferentiated*	0	0	**3**	**3**	**3**	**3**	100
Longtom	Longtoms	*Belonidae - undifferentiated*	0	0	**2**	**2**	**2**	**2**	100
Mackerel	School Mackerel	*Scomberomorus queenslandicus*	**8**	**4**	0	0	**8**	**4**	0
Mackerel	Shark Mackerel	*Grammatorcynus bicarinatus*	**2**	**2**	0	0	**2**	**2**	0
Mackerel	Spanish Mackerel	*Scomberomorus commerson*	0	0	**1**	**1**	**1**	**1**	100
Mulloway	Mulloway	*Argyrosomus japonicus*	**8**	**5**	**16**	**8**	**24**	**10**	66
Pike	Snook	*Sphyraena novaehollandiae*	**6**	**6**	**53**	**22**	**60**	**27**	89
Pike	Yellowtail Barracuda	*Sphyraena obtusata*	**7**	**7**	0	0	**7**	**7**	0
Rays	Guitarfishes	*Rhinobatidae - undifferentiated*	0	0	**12**	**10**	**12**	**10**	100
Sharks	Bronze Whaler	*Carcharhinus brachyurus*	**2**	**2**	0	0	**2**	**2**	0
Sharks	Dusky Whaler	*Carcharhinus obscurus*	**5**	**5**	0	0	**5**	**5**	0
Sharks	Nervous Shark	*Carcharhinus cautus*	0	0	**1**	**1**	**1**	**1**	100
Sharks	Port Jackson Shark	*Heterodontus portusjacksoni*	0	0	**1**	**1**	**1**	**1**	100
Sharks	Sandbar Shark	*Carcharhinus plumbeus*	0	0	**10**	**10**	**10**	**10**	100
Sharks	Whaler & Weasel Sharks	*Carcharhinidae, Hemigaleidae - undifferentiated*	**1**	**1**	**74**	**55**	**75**	**55**	98
Sharks	Wobbegong	*Orectolobidae - undifferentiated*	0	0	**6**	**6**	**6**	**6**	100
Tailor	Tailor	*Pomatomus saltatrix*	**110**	**91**	**5**	**5**	**115**	**92**	4
Threadfin Bream	Western Butterfish	*Pentapodus vitta*	**6**	**4**	**222**	**125**	**229**	**125**	97
Toadfish	Silver Toadfish	*Lagocephalus sceleratus*	0	0	**2**	**2**	**2**	**2**	100
Trevally	Golden Trevally	*Gnathanodon speciosus*	**1**	**1**	0	0	**1**	**1**	0

Reporting Group	Common Name	Scientific Name	Kept	se	Rel	se	Total	se	% Rel
Tuskfish & Wrasse	Blackspot Tuskfish	*Choerodon schoenleinii*	**48**	**35**	416	149	464	162	90
Tuskfish & Wrasse	Blue Tuskfish	*Choerodon cyanodus*	0	0	**2**	**2**	**2**	**2**	100
Tuskfish & Wrasse	Bluebarred Parrotfish	*Scarus ghobban spp. complex*	0	0	**40**	**28**	**40**	**28**	100
Tuskfish & Wrasse	Bluespotted Tuskfish	*Choerodon cauteroma*	0	0	**11**	**11**	**11**	**11**	100
Tuskfish & Wrasse	Wrasses	*Labridae - undifferentiated*	0	0	**2**	**2**	**2**	**2**	100
Unknown	Unknown Species		0	0	**5**	**4**	**5**	**4**	100
Whiting	Western Trumpeter Whiting	*Sillago burrus*	0	0	**13**	**13**	**13**	**13**	100

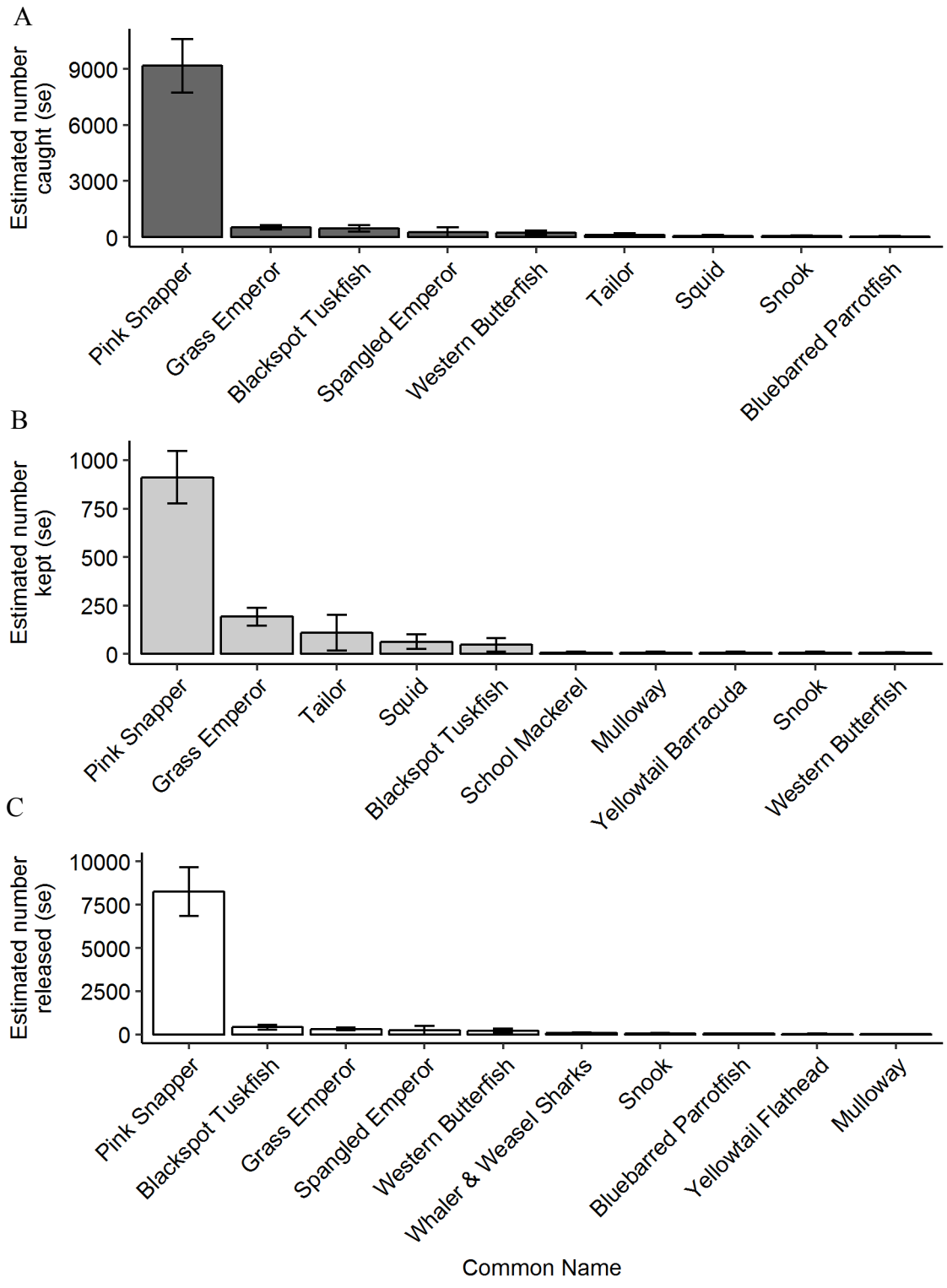


Figure 12. Estimated number of species that were A) caught, B) kept and C) released by boat-based recreational fishers at Nanga between March 2018 and February 2019. Catches are displayed for inner Shark bay only, inclusive of boats retrieving from the ramp between nautical sunrise and nautical sunset and are ranked to display the top 10 species or taxa (by number); se = standard error of the mean estimate.

Table 19. Combined estimated annual catch (kept, released and total numbers) and percentage released by boat-based recreational fishers at Denham, Monkey Mia and Nanga between March 2018 and February 2019. Catches are for inner Shark Bay only. Values in bold indicate a relative standard error >40% (i.e. se >40% of the estimate).

Reporting Group	Common Name	Scientific Name	Kept	se	Rel	se	Total	se	% Rel
Bonitos	Bonitos	*Sarda australis & Cybiosarda elegans*	0	0	**16**	**16**	**16**	**16**	100
Bream	Frypan Bream	*Argyrops spinifer*	**45**	**45**	**36**	**36**	**81**	**81**	44
Bream	Pink Snapper	*Chrysophrys auratus*	2,966	300	44,411	3,528	47,376	3,641	94
Bream	Tarwhine	*Rhabdosargus sarba*	**13**	**10**	**23**	**20**	**36**	**30**	64
Bream	Western Yellowfin Bream	*Acanthopagrus morrisoni*	**231**	**154**	**626**	**346**	**858**	**481**	73
Catfish	Forktail Catfishes	*Ariidae - undifferentiated*	**53**	**27**	**676**	**295**	**729**	**301**	93
Catfish	Giant Sea Catfish	*Netuma thalassina*	**51**	**43**	**1,155**	**676**	**1,207**	**677**	96
Cephalopod	Cuttlefish	*Sepia spp.*	**70**	**38**	**18**	**18**	**89**	**42**	21
Cephalopod	Octopuses	*Octopodidae - undifferentiated*	0	0	**3**	**3**	**3**	**3**	100
Cephalopod	Squid	*Order Teuthoidea - undifferentiated*	**2,301**	**1,289**	**794**	**756**	**3,094**	**2,028**	26
Cobia	Cobia	*Rachycentron canadum*	**9**	**5**	**17**	**13**	**25**	**14**	66
Cod	Birdwire Rockcod	*Epinephelus merra*	**5**	**3**	**1**	**1**	**6**	**4**	22
Cod	Blackspotted Rockcod	*Epinephelus malabaricus*	**103**	**55**	**28**	**20**	**130**	**68**	21
Cod	Chinaman Rockcod	*Epinephelus rivulatus*	**96**	**68**	**136**	**59**	**232**	**100**	59
Cod	Coral Rockcod	*Cephalopholis miniata*	**1**	**1**	0	0	**1**	**1**	0
Cod	Frostback Rockcod	*Epinephelus bilobatus*	**27**	**27**	**9**	**7**	**36**	**34**	25
Cod	Goldspotted Rockcod	*Epinephelus coioides*	674	115	531	127	1,205	216	44
Cod	Potato Rockcod	*Epinephelus tukula*	0	0	**3**	**3**	**3**	**3**	100
Cod	Rankin Cod	*Epinephelus multinotatus*	583	144	567	144	1,150	231	49
Cod	Temperate Basses & Rockcods	*Percichthyidae, Serranidae - undifferentiated*	0	0	**17**	**11**	**17**	**11**	100
Cod	Tomato Rockcod	*Cephalopholis sonnerati*	**1**	**1**	0	0	**1**	**1**	0
Cod	Yellowspotted Rockcod	*Epinephelus areolatus*	**95**	**45**	**98**	**44**	**193**	**84**	51
Coral Trout	Barcheek Coral Trout	*Plectropomus maculatus*	**95**	**41**	**15**	**13**	110	43	13
Coral Trout	Common Coral Trout	*Plectropomus leopardus*	**65**	**27**	**8**	**8**	73	28	11

Reporting Group	Common Name	Scientific Name	Kept	se	Rel	se	Total	se	% Rel
Coral Trout	Yellowedge Coronation Trout	*Variola louti*	**3**	**3**	0	0	3	3	0
Crab	Blue Swimmer Crab	*Portunus armatus*	33,174	3,889	21,097	3,290	54,271	5,933	39
Crab	Coral Crab	*Charybdis feriata*	0	0	**9**	**9**	**9**	**9**	100
Crab	Green Mud Crab	*Scylla serrata*	0	0	**4**	**4**	**4**	**4**	100
Eels	Eels	*Order Anguilliformes - undifferentiated*	0	0	**13**	**7**	**13**	**7**	100
Emperor	Bluespotted Emperor	*Lethrinus punctulatus*	0	0	**2**	**2**	**2**	**2**	100
Emperor	Grass Emperor	*Lethrinus laticaudis*	5,392	762	12,840	1,689	18,232	2,069	70
Emperor	Redthroat Emperor	*Lethrinus miniatus*	**70**	**37**	**112**	**49**	**182**	**77**	61
Emperor	Robinson's Seabream	*Gymnocranius grandoculis*	**7**	**7**	0	0	**7**	**7**	0
Emperor	Spangled Emperor	*Lethrinus nebulosus*	**135**	**65**	**668**	**292**	803	320	83
Flathead	Flatheads	*Platycephalidae - undifferentiated*	**45**	**21**	**36**	**21**	**81**	**32**	45
Flathead	Fringe-Eye Flathead	*Cymbacephalus nematophthalmus*	**1**	**1**	0	0	**1**	**1**	0
Flathead	Northern Sand Flathead	*Platycephalus endrachtensis*	**9**	**5**	0	0	**9**	**5**	0
Flathead	Yellowtail Flathead	*Platycephalus westraliae*	370	70	382	101	751	138	51
Flounders	Flounders	*Bothidae, Psettodidae & Pleuronectidae*	**14**	**10**	**22**	**19**	**36**	**21**	62
Flounders	Smalltooth Flounder	*Pseudorhombus jenynsii*	**22**	**22**	**10**	**10**	**32**	**24**	30
Garfish	Garfishes	*Hemiramphidae - undifferentiated*	**33**	**26**	**37**	**28**	**69**	**44**	53
Garfish	Three-By-Two Garfish	*Hemiramphus robustus*	0	0	**5**	**5**	**5**	**5**	100
Giant Perch	Sand Bass	*Psammoperca waigiensis*	**5**	**5**	**20**	**12**	**25**	**14**	81
Goatfish	Goatfishes	*Mullidae - undifferentiated*	0	0	**4**	**4**	**4**	**4**	100
Grunter	Striped Grunters	*Terapontidae - undifferentiated*	0	0	413	161	413	161	100
Grunter	Western Striped Grunter	*Pelates octolineatus*	**10**	**10**	**5**	**3**	**15**	**12**	32
Grunter	Yellowtail Grunter	*Amniataba caudavittata*	**279**	**251**	574	198	853	318	67
Grunter Bream	Goldspotted Sweetlips	*Plectorhinchus flavomaculatus*	**36**	**36**	0	0	**36**	**36**	0
Grunter Bream	Grunter Breams	*Haemulidae - undifferentiated*	**4**	**4**	**25**	**18**	**28**	**18**	87
Grunter Bream	Painted Sweetlips	*Diagramma labiosum*	0	0	**20**	**13**	**20**	13	100
Gurnard	Gurnard Perches	*Neosebastidae - undifferentiated*	0	0	**6**	**6**	**6**	**6**	100

Reporting Group	Common Name	Scientific Name	Kept	se	Rel	se	Total	se	% Rel
Gurnard	Searobins & Armour Gurnards	*Triglidae & Peristediidae - undifferentiated*	0	0	**2**	**2**	**2**	**2**	100
Leatherjacket	Fanbelly Leatherjacket	*Monacanthus chinensis*	0	0	**14**	**14**	**14**	**14**	100
Leatherjacket	Horseshoe Leatherjacket	*Meuschenia hippocrepis*	2	2	**12**	**7**	**14**	**9**	87
Lizardfish	Common Saury	*Saurida tumbil*	**17**	**17**	**227**	**142**	**243**	**145**	93
Lizardfish	Lizardfishes & Deepsea Lizardfishes	*Bathysauridae, Synodontidae - undifferentiated*	**12**	**8**	**578**	**248**	**591**	**251**	98
Lobster	Western Rock Lobster	*Panulirus cygnus*	**20**	**15**	**11**	**11**	**31**	**25**	37
Longtom	Longtoms	*Belonidae - undifferentiated*	0	0	**4**	**3**	**4**	**3**	100
Mackerel	Mackerels	*Scombridae - undifferentiated*	0	0	**6**	**6**	**6**	**6**	100
Mackerel	School Mackerel	*Scomberomorus queenslandicus*	593	106	469	131	1,063	173	44
Mackerel	Shark Mackerel	*Grammatorcynus bicarinatus*	**45**	**22**	**36**	**20**	**80**	**37**	45
Mackerel	Spanish Mackerel	*Scomberomorus commerson*	**72**	**40**	**34**	**21**	**106**	**45**	32
Mackerel	Spotted Mackerel	*Scomberomorus munroi*	**13**	**6**	**45**	**25**	**58**	**29**	78
Morwong	Morwongs	*Cheilodactylidae - undifferentiated*	0	0	**4**	**4**	**4**	**4**	100
Mullet	Mullets	*Mugilidae - undifferentiated*	**1,391**	**927**	**503**	**503**	**1,894**	**1,403**	27
Mulloway	Mulloway	*Argyrosomus japonicus*	**165**	**42**	337	125	502	154	67
Pearl Perch	Northern Pearl Perch	*Glaucosoma buergeri*	**4**	**3**	0	0	**4**	**3**	0
Pike	Great Barracuda	*Sphyraena barracuda*	0	0	**15**	**15**	**15**	**15**	100
Pike	Pikes	*Sphyraenidae - undifferentiated*	**88**	**59**	**58**	**26**	**145**	**66**	40
Pike	Snook	*Sphyraena novaehollandiae*	**62**	**33**	**302**	**149**	**365**	**154**	83
Pike	Yellowtail Barracuda	*Sphyraena obtusata*	**22**	**16**	**21**	**18**	**43**	**24**	49
Rays	Guitarfishes	*Rhinobatidae - undifferentiated*	**4**	**4**	**90**	**36**	**94**	**36**	96
Rays	Stingrays	*Dasyatidae - undifferentiated*	0	0	**4**	**4**	**4**	**4**	100
Sea Mullet	Sea Mullet	*Mugil cephalus*	**299**	**192**	**4**	**4**	**303**	**192**	1
Sea Turtle	Loggerhead Turtle	*Caretta caretta*	0	0	**8**	**8**	**8**	**8**	100
Sergeant Baker	Sergeant Baker	*Latropiscis purpurissatus*	0	0	**24**	**11**	**24**	**11**	100
Sharks	Blacktip Reef Shark	*Carcharhinus melanopterus*	0	0	**353**	**217**	**353**	**217**	100
Sharks	Blacktip Shark	*Carcharhinus, Loxodon & Rhizoprionodon spp.*	**5**	**3**	**35**	**29**	**40**	**29**	88

Reporting Group	Common Name	Scientific Name	Kept	se	Rel	se	Total	se	% Rel
Sharks	Bronze Whaler	*Carcharhinus brachyurus*	**2**	**2**	**37**	**19**	**39**	**19**	94
Sharks	Bull Shark	*Carcharhinus leucas*	0	0	**12**	**12**	**12**	**12**	100
Sharks	Dusky Whaler	*Carcharhinus obscurus*	**5**	**5**	**13**	**13**	**17**	**13**	73
Sharks	Hammerhead Sharks	*Sphyrnidae - undifferentiated*	0	0	**13**	**10**	**13**	**10**	100
Sharks	Lemon Shark	*Negaprion acutidens*	0	0	**21**	**15**	**21**	**15**	100
Sharks	Nervous Shark	*Carcharhinus cautus*	**5**	**5**	**6**	**5**	**12**	**11**	55
Sharks	Port Jackson Shark	*Heterodontus portusjacksoni*	0	0	**1**	**1**	**1**	**1**	100
Sharks	Sandbar Shark	*Carcharhinus plumbeus*	**2**	**2**	**21**	**13**	**24**	**13**	90
Sharks	Spinner Shark	*Carcharhinus brevipinna*	0	0	**38**	**29**	**38**	**29**	100
Sharks	Tiger Shark	*Galeocerdo cuvier*	0	0	**10**	**8**	**10**	**8**	100
Sharks	Western Spotted Gummy Shark	*Mustelus stevensi*	0	0	**6**	**4**	**6**	**4**	100
Sharks	Whaler & Weasel Sharks	*Carcharhinidae, Hemigaleidae - undifferentiated*	**25**	**15**	416	106	441	107	94
Sharks	Whiskery Shark	*Furgaleus macki*	**2**	**2**	0	0	**2**	**2**	0
Sharks	Whitetip Reef Shark	*Triaenodon obesus*	0	0	**7**	**7**	**7**	**7**	100
Sharks	Wobbegong	*Orectolobidae - undifferentiated*	**3**	**3**	**6**	**6**	**9**	**7**	68
Tailor	Tailor	*Pomatomus saltatrix*	471	143	**170**	**95**	641	204	27
Threadfin	King Threadfin	*Polydactylus macrochir*	**17**	**17**	**42**	**42**	**60**	**46**	71
Threadfin Bream	Western Butterfish	*Pentapodus vitta*	**719**	**291**	5,691	820	6,410	947	89
Toadfish	Silver Toadfish	*Lagocephalus sceleratus*	0	0	**370**	**69**	**370**	**69**	100
Toadfish	Toadfishes	*Tetraodontidae - undifferentiated*	0	0	**104**	**60**	**104**	**60**	100
Trevally	Bludger Trevally	*Carangoides gymnostethus*	**3**	**3**	**7**	**7**	**10**	**8**	71
Trevally	Diamond Trevally	*Alectis indica*	0	0	**1**	**1**	**1**	**1**	100
Trevally	Giant Trevally	*Caranx ignobilis*	0	0	**38**	**24**	**38**	**24**	100
Trevally	Golden Trevally	*Gnathanodon speciosus*	**27**	**16**	**108**	**48**	**135**	**51**	80
Trevally	Turrum	*Carangoides fulvoguttatus*	**1**	**1**	**10**	**8**	**11**	**9**	88
Tropical Snapper	Goldband Snapper	*Pristipomoides multidens*	**5**	**5**	0	0	**5**	**5**	0
Tropical Snapper	Golden Snapper	*Lutjanus johnii*	**3**	**3**	0	0	**3**	**3**	0
Tropical Snapper	Mangrove Jack	*Lutjanus argentimaculatus*	**1**	**1**	0	0	**1**	**1**	0

Reporting Group	Common Name	Scientific Name	Kept	se	Rel	se	Total	se	% Rel
Tropical Snapper	Moses' Snapper	*Lutjanus russellii*	**18**	**14**	**48**	**30**	**66**	**34**	72
Tropical Snapper	Red Emperor	*Lutjanus sebae*	**44**	**27**	**16**	**16**	**59**	**41**	27
Tropical Snapper	Stripey Snapper	*Lutjanus carponotatus*	437	113	450	125	888	203	51
Tuna	Longtail Tuna	*Thunnus tonggol*	**6**	**6**	**42**	**31**	**48**	**34**	87
Tuna	Yellowfin Tuna	*Thunnus albacares*	**1**	**1**	0	0	**1**	**1**	0
Tuskfish & Wrasse	Baldchin Groper	*Choerodon rubescens*	**8**	**5**	**39**	**39**	**48**	**39**	83
Tuskfish & Wrasse	Blackspot Tuskfish	*Choerodon schoenleinii*	976	185	2,027	272	3,004	356	67
Tuskfish & Wrasse	Blue Tuskfish	*Choerodon cyanodus*	**2**	**2**	**28**	**13**	**30**	**13**	93
Tuskfish & Wrasse	Bluebarred Parrotfish	*Scarus ghobban spp. complex*	**2**	**2**	**40**	**28**	**42**	**28**	95
Tuskfish & Wrasse	Bluespotted Tuskfish	*Choerodon cauteroma*	**61**	**37**	**70**	**32**	**132**	**58**	56
Tuskfish & Wrasse	Goldspot Pigfish	*Bodianus perditio*	0	0	**2**	**2**	**2**	**2**	100
Tuskfish & Wrasse	Parrotfishes	*Scaridae - undifferentiated*	**1**	**1**	**19**	**13**	**21**	**13**	93
Tuskfish & Wrasse	Surf Parrotfish	*Scarus rivulatus*	**62**	**50**	0	0	**62**	**50**	0
Tuskfish & Wrasse	Tuskfishes	*Choerodon spp.*	**6**	**6**	**23**	**14**	**29**	**15**	80
Tuskfish & Wrasse	Western King Wrasse	*Coris auricularis*	0	0	**13**	**13**	**13**	**13**	100
Tuskfish & Wrasse	Wrasses	*Labridae - undifferentiated*	0	0	143	51	143	51	100
Unknown	Unknown Species		**24**	**24**	**337**	**165**	**360**	**170**	93
Whiting	Goldenline Whiting	*Sillago analis*	0	0	**3**	**3**	**3**	**3**	100
Whiting	Western School Whiting	*Sillago vittata*	**406**	**238**	**159**	**75**	**565**	**272**	28
Whiting	Western Trumpeter Whiting	*Sillago burrus*	**48**	**45**	**308**	**133**	356	140	87
Whiting	Whitings	*Sillaginidae - undifferentiated*	**2,143**	**1,025**	**903**	**596**	**3,046**	**1,593**	30
Whiting	Yellowfin Whiting	*Sillago schomburgkii*	2,490	859	638	333	3,129	1,114	20

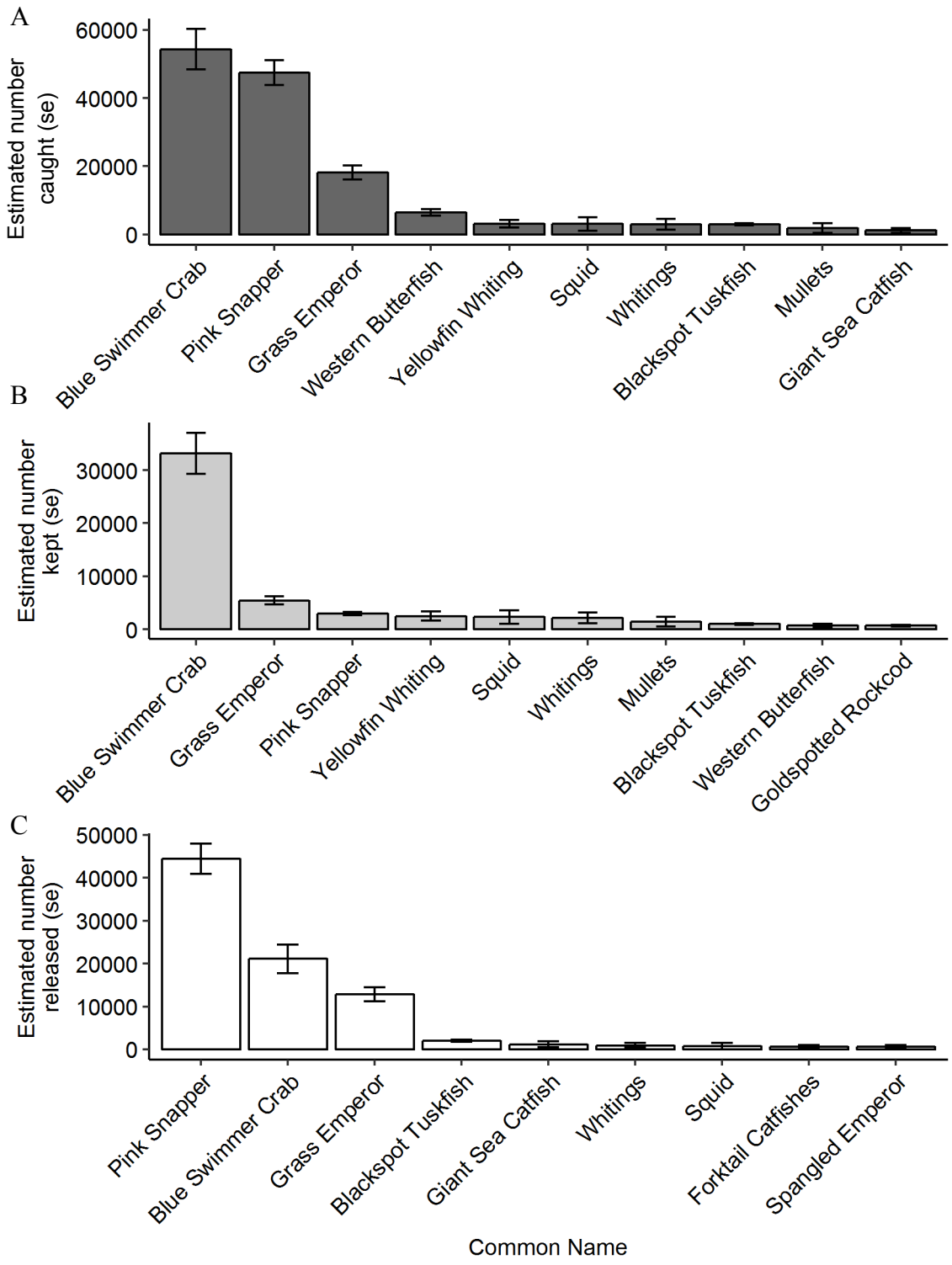


Figure 13. Estimated number of species that were A) caught, B) kept and C) released by boat-based recreational fishers at Denham, Monkey Mia and Nanga between March 2018 and February 2019. Catches are displayed for inner Shark bay only, inclusive of boats retrieving from the ramp between nautical sunrise and nautical sunset and are ranked to display the top 10 species or taxa (by number); se = standard error of the mean estimate.

6.3 Targeted catch

Fishers were asked whether or not their boat party was targeting a particular species. On those occasions where two different targeted species were reported, the first was assumed to be the main target species (Table 20). Overall, Pink Snapper and Blue Swimmer Crab were targeted by more than half of interviewed boat parties in inner Shark Bay; however, the importance of these target species varied between ramps. Pink Snapper was the main target species at Denham (45%) and Nanga (87%) while Blue Swimmer Crab was the main target species at Monkey Mia (46%; Table 20).

Table 20. Targeted species as reported by boat-based recreational fishers in inner Shark Bay between March 2018 and February 2019. Boat parties were interviewed at Denham, Monkey Mia and Nanga. Unsp=unspecified, Temp=temperate.

	All ramps		Denham		Monkey Mia		Nanga	
Targeted	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**
Pink Snapper	388	41.5	145	45.0	89	20.6	86.5	86.5
Blue Swimmer Crab	204	21.8	4	1.2	200	46.3	0.0	0.0
Unsp. demersal fish	104	11.1	57	17.7	40	9.3	3.9	3.9
Grass Emperor	64	6.8	37	11.5	22	5.1	2.8	2.8
Whitings	38	4.1	9	2.8	25	5.8	2.2	2.2
Squid	26	2.8	21	6.5	1	0.2	2.2	2.2
Tuskfishes	17	1.8	4	1.2	12	2.8	0.6	0.6
General fish	13	1.4	8	2.5	5	1.2	0.0	0.0
Blackspot Tuskfish	11	1.2	3	0.9	7	1.6	0.6	0.6
Mackerels	9	1.0	7	2.2	2	0.5	0.0	0.0
Temp. Basses & Rockcods	9	1.0	1	0.3	8	1.9	0.0	0.0
Mullets	8	0.9	0	0.0	8	1.9	0.0	0.0
Baldchin Groper	7	0.7	0	0.0	5	1.2	1.1	1.1
School Mackerel	5	0.5	4	1.2	1	0.2	0.0	0.0
Tailor	3	0.3	2	0.6	0	0.0	0.0	0.0
Western School Whiting	3	0.3	1	0.3	2	0.5	0.0	0.0
Coral Trout	4	0.4	4	1.2	0	0.0	0.0	0.0
Flatheads	2	0.2	1	0.3	1	0.2	0.0	0.0
Goldspotted Rockcod	2	0.2	0	0.0	2	0.5	0.0	0.0
Mulloway	2	0.2	0	0.0	0	0.0	0.0	0.0
Rankin Cod	2	0.2	2	0.6	0	0.0	0.0	0.0
Red Emperor	2	0.2	2	0.6	0	0.0	0.0	0.0
Spanish Mackerel	2	0.2	1	0.3	1	0.2	0.0	0.0
Unspec. pelagic fish	2	0.2	2	0.6	0	0.0	0.0	0.0
Barcheek Coral Trout	1	0.1	1	0.3	0	0.0	0.0	0.0
Breams	1	0.1	1	0.3	0	0.0	0.0	0.0
Crab	1	0.1	0	0.0	0	0.0	0.0	0.0
Longtail Tuna	1	0.1	0	0.0	1	0.2	0.0	0.0
Octopuses	1	0.1	1	0.3	0	0.0	0.0	0.0
Pikes	1	0.1	1	0.3	0	0.0	0.0	0.0
Spotted Mackerel	1	0.1	1	0.3	0	0.0	0.0	0.0
West Australian Dhufish	1	0.1	1	0.3	0	0.0	0.0	0.0
Western Butterfish	1	0.1	1	0.3	0	0.0	0.0	0.0
	936		322		432		178	

6.4 Non-zero catches

The percentage of boat parties that went recreational fishing in inner Shark Bay and caught an animal (kept and released) is reported below to assist in evaluating the relative success of recreational fishers in Shark Bay (Table 21). The majority of boat parties caught one or more animals during their fishing trip (90%). The percentage of trips where a catch occurred was highest at Monkey Mia (92%) and lowest at Nanga (86%; Table 21).

Table 21. Number of interviews where a catch was reported by fishing boat parties in inner Shark Bay expressed as a percentage of all interviews between March 2018 and February 2019. Data are for inner Shark bay only.

Ramp	No. interviews with catch	No. interviews	% with a catch
Denham	571	633	90
Monkey Mia	501	544	92
Nanga	192	224	86
All	1,264	1,401	90

6.5 Fishing methods

Line fishing was the dominant fishing method in inner Shark Bay at all three ramps (83%), particularly at Denham (97%) and Nanga (100%). At Monkey Mia, 37% of boat parties used a drop net while this method was rarely used at Denham and not used at Nanga (Table 22). The number of fishing methods reported was greater than the number of interviewed fishing boat parties due to the use of multiple gear types.

Table 22. Fishing methods reported by boat-based fishers in inner Shark Bay between March 2018 and February 2019. Data are for inner Shark bay only.

	All ramps		Denham		Monkey Mia		Nanga	
Method	No.	%	No.	%	No.	%	No.	%
Lines	1,203	82.6	619	96.7	360	60.9	224	99.6
Drop nets	220	15.1	4	0.6	216	36.5	0	0.0
Speargun	16	1.1	11	1.7	4	1.5	1	0.4
Gill net	10	0.7	1	0.2	9	0.7	0	0.0
Other	7	0.5	5	0.8	2	0.3	0	0.0

6.6 Catch distributions

6.6.1 Blue Swimmer Crab

Approximately 38% of interviewed boat parties at Monkey Mia had kept one or more crabs in inner Shark Bay and 17% of boat parties kept between 21–40 crabs (Table 23). No interviewed boat parties at Monkey Mia had kept more than the boat limit of 40 crabs while boat parties at this location had caught (kept and released) up to 140 Blue Swimmer Crabs in inner Shark Bay. Only four interviewed boat parties at Denham had caught Blue Swimmer Crabs in inner Shark Bay (2−6 crab per boat party. No Blue Swimmer Crabs were caught at Nanga (Table 23).

Table 23. Blue Swimmer Crab catch distribution for the number of crabs kept per boat and total (kept and release) per boat in inner Shark Bay at Denham, Monkey Mia and Nanga between March 2018 and February 2019.

	Denham		Monkey Mia		Nanga	
No. crabs per boat	% Kept	% Total	% Kept	% Total	% Kept	% Total
0	99.4	99.4	61.8	61.2	100.0	100.0
1	0.0	0.0	0.4	0.7	0.0	0.0
2	0.5	0.5	1.1	0.4	0.0	0.0
3	0.0	0.0	0.9	1.1	0.0	0.0
4	0.0	0.0	1.1	0.4	0.0	0.0
5	0.0	0.0	0.6	0.2	0.0	0.0
6	0.2	0.2	1.5	0.7	0.0	0.0
7	0.0	0.0	0.9	0.2	0.0	0.0
8	0.0	0.0	1.5	0.6	0.0	0.0
9	0.0	0.0	1.1	0.6	0.0	0.0
10	0.0	0.0	1.8	0.6	0.0	0.0
11	0.0	0.0	0.6	0.4	0.0	0.0
12	0.0	0.0	2.2	0.9	0.0	0.0
13	0.0	0.0	0.2	0.6	0.0	0.0
14	0.0	0.0	1.5	1.7	0.0	0.0
15	0.0	0.0	1.7	0.9	0.0	0.0
16	0.0	0.0	0.4	0.4	0.0	0.0
17	0.0	0.0	0.6	0.4	0.0	0.0
18	0.0	0.0	1.5	0.2	0.0	0.0
19	0.0	0.0	0.4	0.7	0.0	0.0
20	0.0	0.0	5.3	1.5	0.0	0.0
21–40	0.0	0.0	13.2	17.3	0.0	0.0
41–99	0.0	0.0	0.0	8.5	0.0	0.0
100–149	0.0	0.0	0.0	0.2	0.0	0.0

6.6.2 Pink Snapper

Approximately 22% of interviewed boat parties at Denham had kept one or more Pink Snapper caught in inner Shark Bay while this figure was 7% at Monkey Mia and 56% at Nanga. The maximum reported kept catch in inner Shark Bay was 10 at Denham, 6 at Monkey Mia and 12 at Nanga (Table 24). The percentage of interviewed boat parties that had kept two or more Pink Snapper caught in inner Shark Bay (individual daily bag limit=2, Shark Bay) was 13% (Denham), 4% (Monkey Mia) and 38% (Nanga). Interviewed boat parties at Denham caught (kept and released) up to 75 Pink Snapper while at Monkey Mia and Nanga, interviewed boat parties caught up to 86 and 108 Pink Snapper, respectively in inner Shark Bay (Table 24).

Table 24. Pink Snapper catch distribution for the number of fish kept per boat and total (kept and release) per boat in inner Shark Bay at Denham, Monkey Mia and Nanga between March 2018 and February 2019.

	Denham		Monkey Mia		Nanga	
No. fish per boat	% Kept	% Total	% Kept	% Total	% Kept	% Total
0	78.4	46.6	93.0	66.5	44.2	24.6
1	8.4	5.5	2.8	3.5	17.4	4.0
2	4.4	3.6	2.0	4.2	10.7	4.0
3	2.4	3.3	0.9	2.2	4.9	4.5
4	3.6	2.8	0.6	1.8	10.7	4.9
5	1.1	2.8	0.0	2.0	1.3	4.9
6	1.1	4.1	0.7	3.1	5.8	6.7
7	0.0	0.5	0.0	1.7	0.9	1.3
8	0.5	1.4	0.0	1.1	3.1	3.6
9	0.0	0.6	0.0	0.4	0.0	1.8
10	0.2	4.1	0.0	1.8	0.4	1.8
11	0.0	1.1	0.0	0.2	0.0	0.0
12	0.0	3.0	0.0	1.7	0.4	3.1
13	0.0	0.9	0.0	0.0	0.0	0.9
14	0.0	0.3	0.0	0.0	0.0	1.3
15	0.0	1.6	0.0	0.2	0.0	0.9
16	0.0	0.8	0.0	0.2	0.0	1.3
17	0.0	0.6	0.0	0.0	0.0	0.0
18	0.0	0.6	0.0	0.0	0.0	1.3
19	0.0	0.0	0.0	0.0	0.0	0.9
20	0.0	2.8	0.0	2.9	0.0	1.3
21-40	0.0	8.8	0.0	4.6	0.0	17.0
41-99	0.0	3.8	0.0	1.8	0.0	8.0
100-149	0.0	0.0	0.0	0.0	0.0	1.8

6.6.3 Grass Emperor

Approximately 33% of interviewed boat parties at Denham had kept one or more Grass Emperor in inner Shark Bay while this figure was 14% at Monkey Mia and 27% at Nanga. Interviewed boat parties at Denham kept up to 20 Grass Emperor while at Monkey Mia and Nanga, boat parties kept up to 16 and 8 Grass Emperor in inner Shark Bay, respectively (Table 25). The percentage of interviewed boat parties that had kept five or more Grass Emperor (individual daily bag limit=5, Gascoyne Bioregion) was 10% (Denham), 3% (Monkey Mia) and 7% (Nanga). Interviewed boat parties at Denham caught (kept and released) up to 100 Grass Emperor in inner Shark Bay while at Monkey Mia and Nanga, interviewed boat parties caught up to 66 and 19 Grass Emperor, respectively (Table 25).

Table 25. Grass Emperor catch distribution for the number of fish kept per boat and total (kept and release) per boat in inner Shark Bay at Denham, Monkey Mia and Nanga between March 2018 and February 2019.

	Denham		Monkey Mia		Nanga	
No. fish per boat	% Kept	% Total	% Kept	% Total	% Kept	% Total
0	67.0	56.9	85.7	79.6	82.6	73.2
1	11.4	8.5	5.1	3.9	10.3	11.6
2	5.9	4.1	3.7	4.8	3.1	6.3
3	4.0	3.8	1.1	2.0	1.3	1.3
4	2.2	3.0	1.1	1.3	0.9	0.9
5	2.2	1.7	1.3	0.9	0.9	1.3
6	1.4	2.1	0.7	0.7	0.4	0.9
7	1.4	1.4	0.2	0.6	0.0	0.4
8	1.6	1.3	0.4	1.3	0.4	1.3
9	1.3	1.4	0.4	0.2	0.0	0.0
10	0.3	1.9	0.0	0.2	0.0	0.4
11	0.2	2.1	0.0	0.6	0.0	0.0
12	0.5	1.4	0.2	0.4	0.0	0.4
13	0.2	0.9	0.0	0.0	0.0	0.0
14	0.0	0.3	0.0	0.4	0.0	0.0
15	0.3	2.1	0.0	0.6	0.0	0.9
16	0.0	0.6	0.2	0.4	0.0	0.4
17	0.2	0.5	0.0	0.2	0.0	0.0
18	0.0	0.0	0.0	0.2	0.0	0.0
19	0.0	0.3	0.0	0.2	0.0	0.4
20	0.2	1.1	0.0	0.0	0.0	0.0
21-40	0.0	3.8	0.0	1.3	0.0	0.0
41-99	0.0	0.5	0.0	0.6	0.0	0.0
100-149	0.0	0.3	0.0	0.0	0.0	0.0

6.7 Measured fish

The majority of measured fish were Pink Snapper, which ranged in size from 450mm TL to 900mm TL (Table 26). Four of the measured Pink Snapper (1%) were under the legal size of 500mm TL. The overall mean length for Pink Snapper was 662 mm TL which included those undersize fish (Figure 14). The mean length of Pink Snapper at Nanga (677mm TL) was slightly higher than at Denham (649mm TL) and considerably higher than at Monkey Mia (584mm TL), noting that the sample size was smaller at Monkey Mia (Figure 14). Overall, 34% of measured Pink Snapper were greater than 700mm TL which was the previous maximum legal size (prior to January 2016). The percentage of Pink Snapper greater than 700mm TL was 32% at Denham, 3% at Monkey Mia and 42% at Nanga.

Table 26. The number of measured fish, mean total length, median total length (Med), minimum total length (Min) and maximum total length (Max) of fish kept by boat-based recreational fishers between March 2018 and February 2019.

Common Name	n	Mean TL (mm)	Med TL (mm)	Min TL (mm)	Max TL (mm)
Pink Snapper	493	662	662	450	900
Grass Emperor	108	434	423	302	600
Goldspotted Rockcod	27	562	544	410	820
Blackspot Tuskfish	22	542	525	427	740
Rankin Cod	17	568	600	400	750
Stripey Snapper	14	395	388	310	455
School Mackerel	13	643	640	550	750
Spangled Emperor	11	475	462	355	580
Baldchin Groper	8	602	600	445	700
Barcheek Coral Trout	7	626	570	500	800
Mulloway	6	791	845	580	1,035
Yellowtail Flathead	3	402	383	363	460
Redthroat Emperor	2	486	486	452	520
Spanish Mackerel	2	982	982	937	1,026
Yellowedge Coronation Trout	2	708	708	677	738
Yellowspotted Rockcod	2	503	503	356	650
Bluebarred Parrotfish	1	589	589	589	589
Bluestriped Goatfish	1	700	700	700	700
Bronze Whaler	1	690	690	690	690
Cobia	1	1,200	1,200	1,200	1,200
Flounders	1	350	350	350	350
Fringe-Eye Flathead	1	420	420	420	420
Frostback Rockcod	1	740	740	740	740
Golden Trevally	1	800	800	800	800
Mahi Mahis	1	1,200	1,200	1,200	1,200
Moses' Snapper	1	450	450	450	450
Northern Sand Flathead	1	360	360	360	360
Parrotfishes	1	560	560	560	560
Red Emperor	1	725	725	725	725
Shark Mackerel	1	784	784	784	784
Snook	1	320	320	320	320
Tailor	1	340	340	340	340
Western Butterfish	1	205	205	205	205
Western School Whiting	1	220	220	220	220
Whiskery Shark	1	878	878	878	878
Yellowfin Tuna	1	895	895	895	895

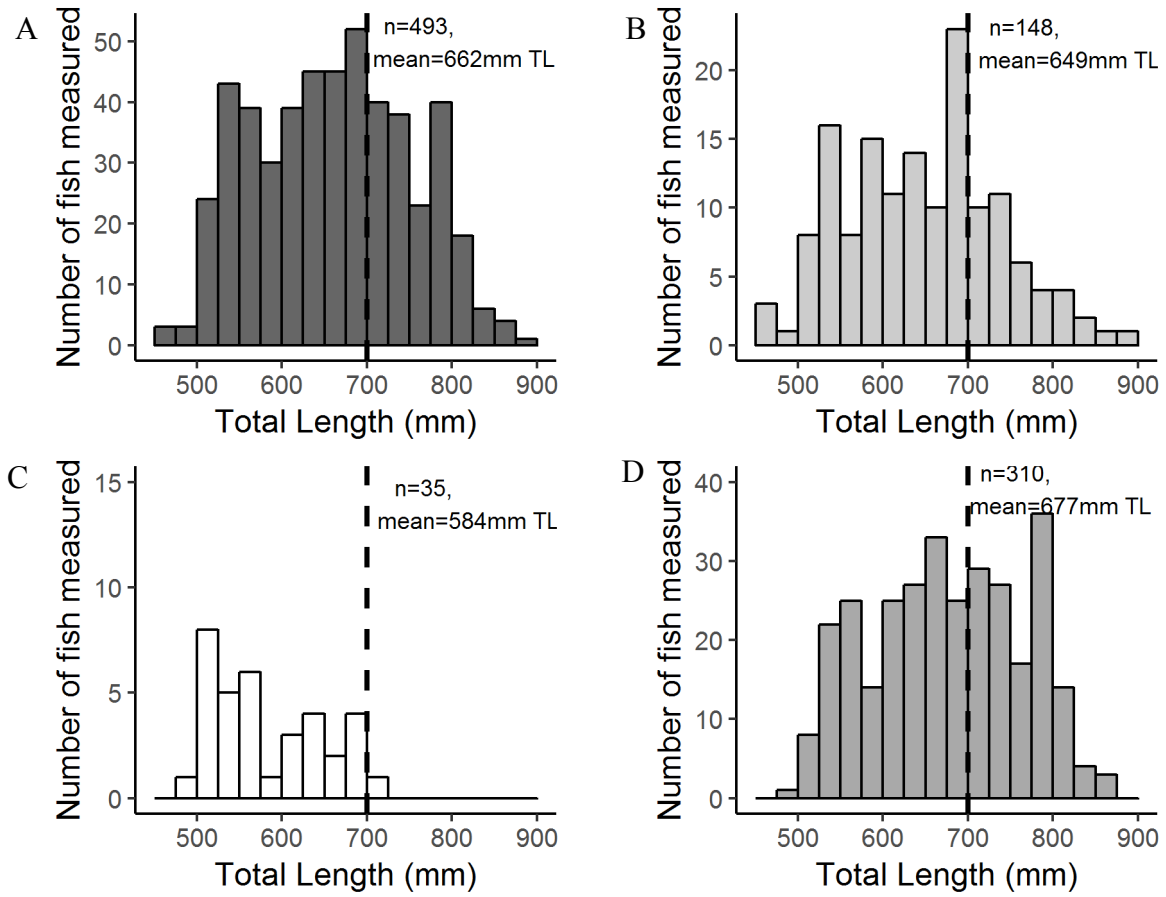


Figure 14. Length-frequency data for Pink Snapper for A) all locations, B) Denham, C) Monkey Mia and D) Nanga between March 2018 and February 2019. Dotted line represents the maximum legal length of 700mm total length that was in place between 1997 and 2016.

6.8 Pink Snapper kept catch by weight for ramps

To determine the Pink Snapper kept catch by weight (in tonnes, t), the estimated kept catch in numbers was multiplied by the average Pink Snapper weight (Table 27), after taking into consideration the variance of both estimates (Appendix 7) and only those trips that occurred within inner Shark Bay. The estimated kept catch of Pink Snapper at Denham was 4.6t (95% CI 3.4−5.9). The estimated kept catch of Pink Snapper at Monkey Mia was 2.1t (95% CI 0.8−3.4) while at Nanga the estimated kept catch of Pink Snapper was 3.2t (95% CI 2.3−4.2; Table 27). The estimation of the kept catch by weight included the ramp-based average weight of Pink Snapper kept by interviewed boat parties at Denham (n=52, average weight=3.2kg) and Nanga (n=291, average weight=3.6kg). At Monkey Mia, only 10 out of the 35 Pink Snapper measured were weighed; therefore, the combined average weight from all three ramps (n=291) was used in the calculation of the kept catch by weight for this ramp (Table 27).

Table 27. Estimated Pink Snapper annual kept catch (numbers and weight) at Denham, Monkey Mia and Nanga between March 2018 and February 2019. Av TL = average total length, Meas n = the number of Pink Snapper measured, Wt n = the number of Pink Snapper weighed.

	Kept	Av TL (mm)	Meas n	Av wt (kg)	Wt n	Total kept (t)	se	95% CI
Denham	1,454	649	148	3.2	52	4.6	0.6	3.4−5.9
Monkey Mia	601	662	493	3.5	353	2.1	0.7	0.8−3.4
Nanga	911	677	310	3.6	291	3.2	0.5	2.3−4.2

7. Freycinet Estuary Integrated Survey

7.1 Fishing effort for Freycinet Estuary

The estimation of fishing effort for Freycinet Estuary between March and August 2018 was based on the counts of boats observed to be fishing during the 28 valid days on which aerial surveys occurred (refer to 2.2.2). Because environmental conditions (e.g. strong winds) meant that the actual flight time on a given day was sometimes different to the expected flight time it was necessary to adjust the counts of the number of boats to the standard 120 minute format (Refer to Equation 1 in Appendix 8). Depending on the discrepancy between the expected vs actual flight time, these adjustments resulted in some daily values being increased and others decreased (Figure 15). Subsequent analysis focussed on these revised estimates.

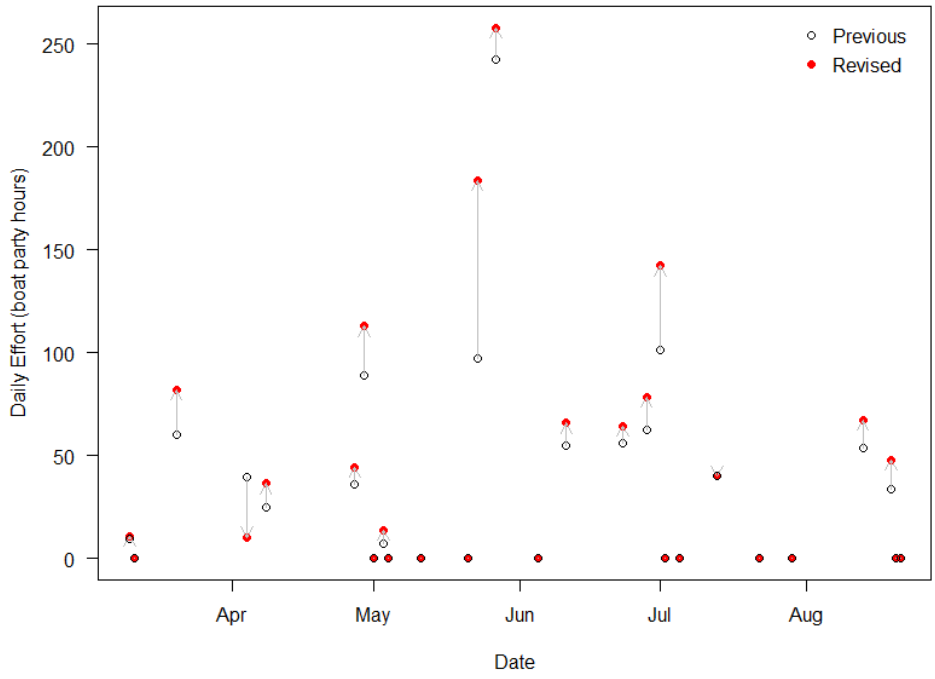


Figure 15. Previous and revised estimates of daily fishing effort obtained from the aerial survey. The revised estimates account for the fact that on some days, the actual flight time differed to the scheduled 120 minutes.

Boat-based recreational fishing effort levels for Freycinet Estuary were for the entire water-body, including boats that did not use the boat ramp at Nanga. An estimated 7,988 boat party hours (se=2,176) occurred between March and August 2018 during the scheduling of the aerial survey (07:00−17:00; Table 28). This estimate was adjusted to account for fishing effort that occurred before 07:00 or after 17:00, between nautical sunrise and nautical sunset (refer to Appendix 9). After applying this adjustment, an estimated 8,646 boat party hours (se=2,346) occurred during the 6-month period. This adjusted estimate was 8% higher than the original and was consistent between autumn and winter (Table 28).

The unit of measurement for adjusted fishing effort (boat party hours) was converted to boat trips to provide comparability with the harvest rate information obtained from the Supplementary Access Point Survey (refer to Appendix 9). An estimated 3,439 boat trips (se=1,000) occurred between March and August 2018. The estimated number of boat trips for autumn had a relative standard error >0.4, therefore caution is advised in interpreting this seasonal estimate.

Table 28. Recreational fishing effort (boat party hours), adjusted fishing effort (boat party hours) and adjusted effort (boat trips) by season for Freycinet Estuary between March and August 2018. Values in bold indicate relative standard error>0.4, caution advised in interpreting these estimates

Season	Effort (boat party hours)	se	Adjusted effort (boat party hours)	se	% increase	Adjusted effort (boat trips)	se
Aut	4,803	1,917	5,167	2,057	8	**2,221**	**915**
Win	3,185	1,029	3,479	1,127	9	1,218	405
6-month Total	7,988	2,176	8,646	2,346	8	3,439	1,000

7.2 Pink Snapper harvest estimate for Freycinet Estuary

The adjusted estimates of fishing effort for each stratum were multiplied by the estimated harvest rates from interviewed boat parties at Nanga to provide a harvest estimate for boat-based recreational fishing in Freycinet Estuary between March and August 2018 (refer to Appendix 9). This estimate was confined to the 6-month period because the aerial survey formed the basis of the expansion of the ramp-based estimates. The estimated kept catch of Pink Snapper in Freycinet Estuary between March and August 2018 was 3,233 (se=1,027) fish which, when expressed by weight, was 11.5t (95% CI 4.3−18.7). This estimate was inclusive of those Pink Snapper kept by fishers at Nanga (refer to Pink Snapper kept catch by weight for ramps). An estimated 96% of the kept catch at Nanga (3.2t, 95% CI 2.3−4.2; Table 27) occurred between March and August 2018; therefore the missing component of the kept catch for Freycinet Estuary (i.e. September to February) is assumed to be minimal.

7.3 Pink Snapper harvest estimates for all inner Shark Bay gulfs

The estimated kept catch of Pink Snapper for all three inner gulfs (Denham Sound, the Eastern Gulf and Freycinet Estuary) was 17.9t (95% CI 10.5−25.3). This was based on summing the kept catch at Denham, Monkey Mia and for Freycinet Estuary. Prior to calculating this estimate it was necessary to filter out those boat parties that used the ramp at Denham and caught Pink Snapper in Freycinet Estuary (15 fishing trips, 2% of fishing trips). This is because the estimated kept catch for Freycinet Estuary was for the entire water body which includes those boats that used the ramp at Denham but retained a Pink Snapper caught in Freycinet Estuary.

8. Fishers' characteristics

8.1 Gender and age

The majority of fishers were males (79%) and the highest percentage of female and male fishers were in the 45–59 year age group (32% of females, 36% of males; Figure 16). The percentage of fishers within each of the age groups was broadly consistent between genders, with more males than females fishing (Figure 16).

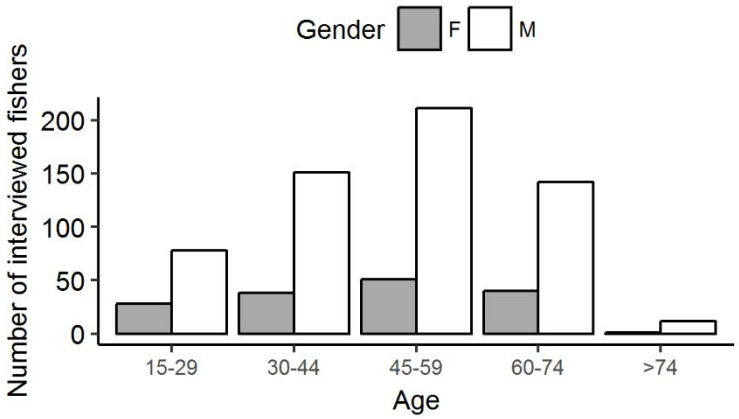


Figure 16. Number of fishers interviewed at Denham, Monkey Mia and Nanga between March 2018 and February 2019 by age group and gender (n=752 interviews).

8.2 Residence

Visiting fishers (i.e. not residing in postcode 6537) dominated the number of fishers interviewed in each of the seasons (Figure 17). In total, 92% of fishers were tourists (i.e. not Shark Bay residents).

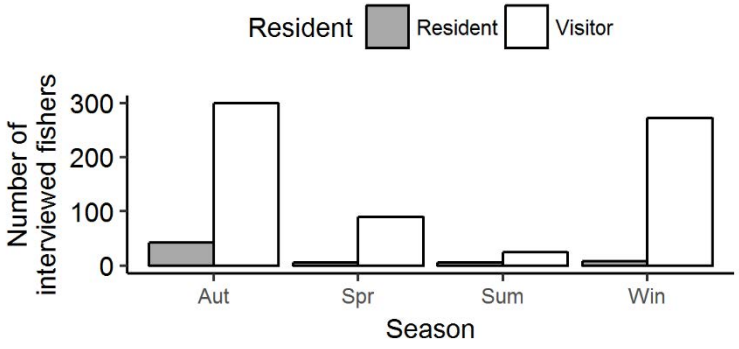


Figure 17. Number of resident and visiting fishers interviewed at Denham, Monkey Mia and Nanga between March 2018 and February 2019. Resident fishers had a postcode of 6537 (n=752 interviews).

8.3 Avidity

The number of days fished in Western Australia (by recall) in the 12 months prior to interview is a measure of fishing avidity. The largest percentage of interviewed fishers had fished between 10 and 19 days in the previous 12 months (38%) and the smallest percentage of fishers had fished more than 29 days in the previous 12 months (16%; Figure 18).

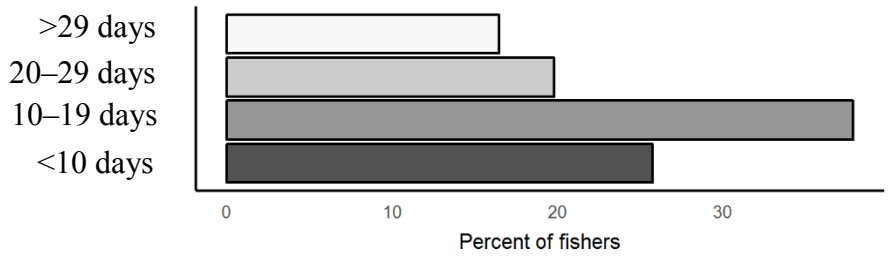


Figure 18. Percentage of days fished by avidity class obtained from fishers interviewed at Denham, Monkey Mia and Nanga between March 2018 and February 2019 (n=752 interviews).

8.4 Awareness of fishing regulations

The majority of interviewed fishers (82%) were able to accurately recall the minimum legal size limit for Pink Snapper in Shark Bay (500 mmTL; Figure 19). A small percentage of fishers (13%) were aware that a minimum legal size applied to Pink Snapper but were unable to recall the correct size (aware (aided); Figure 19). The remainder of fishers were unaware of this regulation (4%). A nearly identical trend was apparent for fishers' recollection of the daily bag limit for Pink Snapper in Shark Bay. The majority of fishers (82%) were able to accurately recall the daily bag limit for Pink Snapper (2 per day; Figure 19). A small percentage (14%) were aware that a daily bag limit applied to Pink Snapper but were unable to recall the correct limit (aware (aided); Figure 19) while the remainder (4%) were unaware of this regulation.

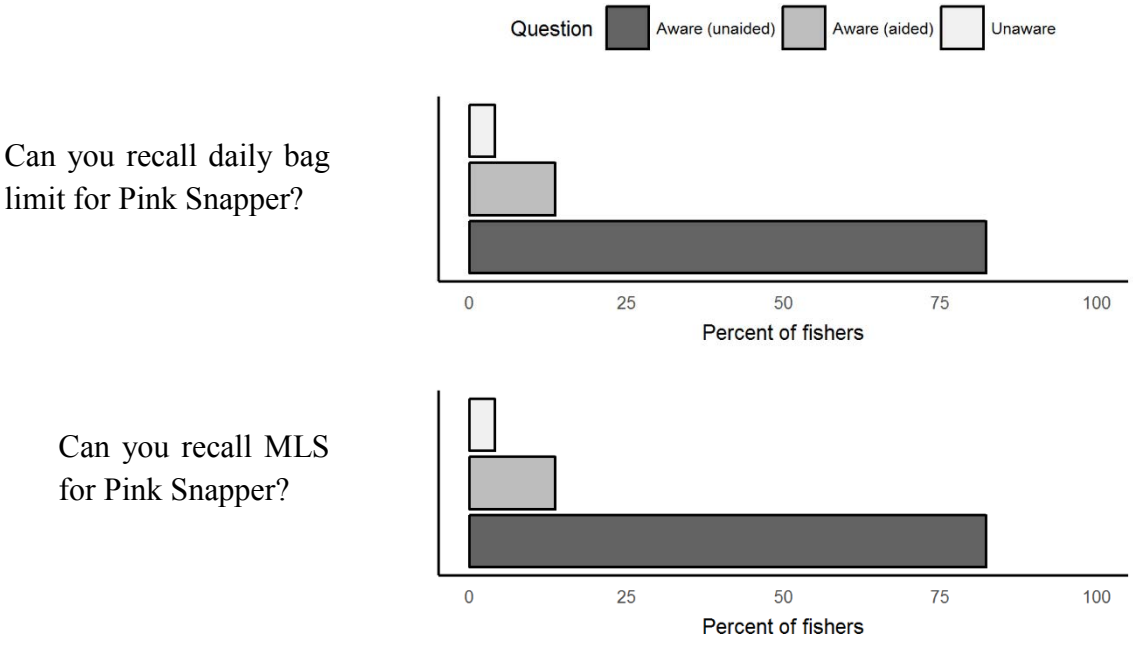


Figure 19. Interviewed fishers' awareness of the minimum legal size (MLS) and the daily bag limit for Pink Snapper. Fishers were interviewed at Denham, Monkey Mia and Denham between March 2018 and February 2019 (n=752 interviews).

8.5 Attitudes towards fishing regulations

The majority of interviewed fishers agreed with the daily bag limit for Pink Snapper (91%) and the minimum legal size (77%; Figure 20). A similar percentage of fishers were unsure about their attitude towards the two regulations. Approximately 17% of fishers thought that the minimum legal size should be lower and 4% thought that the bag limit should be higher (Figure 20).

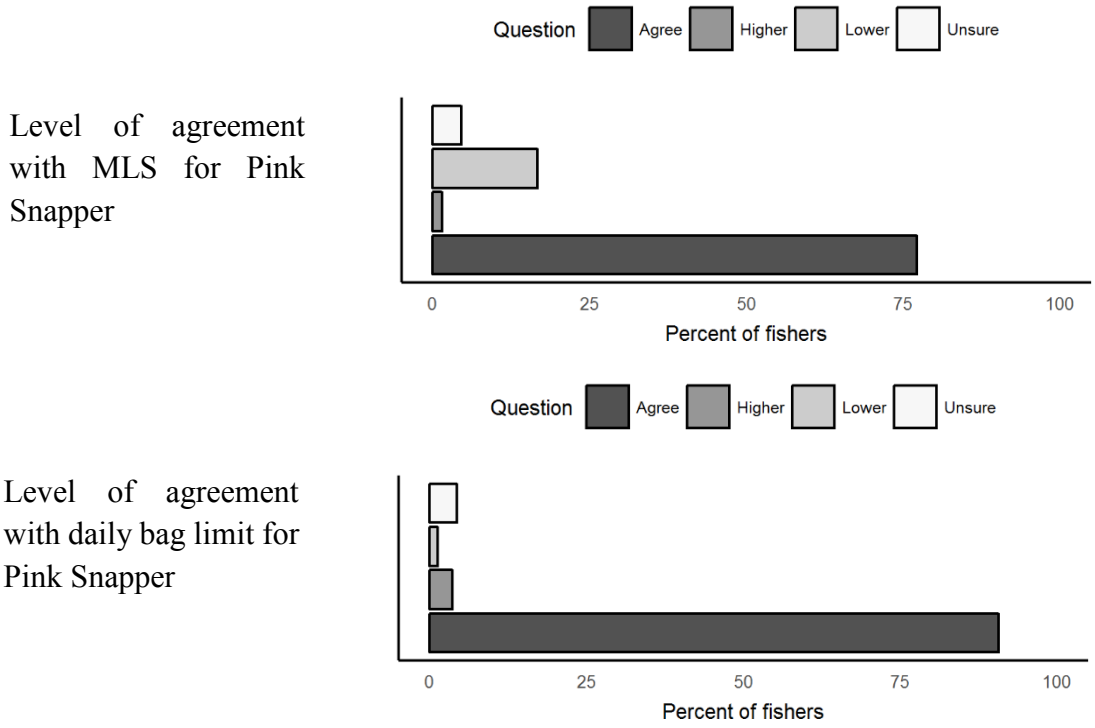
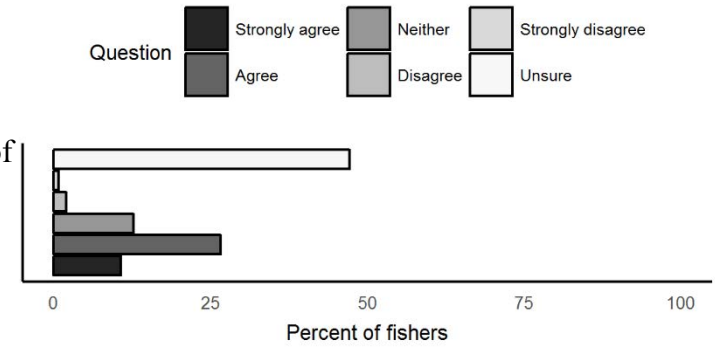


Figure 20. Interviewed fishers' levels of agreement with the minimum legal size (MLS) and the daily bag limit for Pink Snapper. Fishers were interviewed at Denham, Monkey Mia and Denham between March 2018 and February 2019 (n=752 interviews).

Overall, 47% of fishers were unsure whether they agreed with the recent removal of the harvest tag system for Pink Snapper while 27% agreed, 13% neither agreed nor disagreed, 11% strongly agreed, 2% disagreed and <1% strongly disagreed (Figure 21). Stronger levels of support for the removal of the harvest tag system were reported by fishers at Nanga which was the only surveyed location within Freycinet Estuary (Figure 1; Figure 21). At this ramp, 43% of fishers agreed and 21% strongly agreed with the removal of the harvest tag system (Figure 21).

Level of agreement with removal of the harvest tag system - **All**



Level of agreement with removal of the harvest tag system - **Nanga**

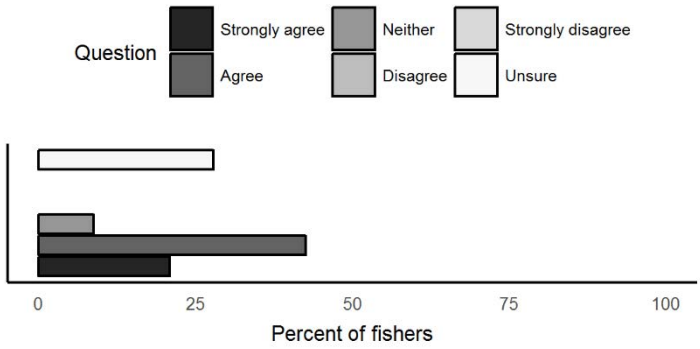


Figure 21. Interviewed fishers' levels of agreement with the removal of the harvest tag system for Pink Snapper in Freycinet Estuary displayed for all fishers (n=752 interviews) and only those interviewed at Nanga (n=115). Fishers were interviewed at Denham, Monkey Mia and Nanga between March 2018 and February 2019.

9. Historical trends in recreational fishing for Pink Snapper

This chapter examines existing information on recreational fishing in inner Shark Bay in relation to Pink Snapper, particularly for Freycinet Estuary. Alternative lines of evidence are presented below to provide an overview of trends in fishing activity and to inform recommendations for future monitoring.

9.1 Boat ramp surveys

Since 1998/99, 13 boat ramp surveys have been conducted at Denham, Monkey Mia and Nanga (Table 29). The results from these surveys have enabled trends in fishing effort and catches to be determined for each of the Pink Snapper stocks and have assisted in examining the effects of management changes on recreational catch levels. Although changes and improvements to the design and analysis of those surveys post 2016/17 have occurred (refer to Taylor *et al.*, 2018), the results from all 13 surveys provide relative trends on recreational fishing activity. Recreational fishing effort in inner Shark Bay at Denham, Monkey Mia and Nanga peaked in 1998/99 at 69,581 boat party hours (se=5,541). Between 2000 and 2010, annual fishing effort varied from 36,873 (se=2,462) in 2006 to 45,206 (se=2,588) in 2005 (Figure 22; Wise *et al.*, 2012). The estimated level of recreational fishing effort for inner Shark Bay obtained from the current study was 40,870 boat party hours (se=1,434), based on converting the unit of measurement from boat trips to boat party hours, in comparison to 33,299 boat party hours (se=3,961) in 2016/17. Therefore, recreational fishing effort in inner Shark Bay in 2018/19 remains well below the historical peak.

Both the 2016/17 survey and the current survey were implemented in direct response to the changes to management measures for Pink Snapper introduced in January 2016, including the removal of the harvest tags in Freycinet Estuary (Appendix 1). The estimated level of recreational fishing effort at Nanga in 2018/19 was 37% higher than in 2016/17. An estimated 926 boat trips (se=28) occurred in 2018/19 in comparison to 674 boat trips (se=31) in 2016/17. Expressed in boat party hours, fishing effort at Nanga in 2018/19 (4,158 boat party hours, se=220) and 2016/17 (3,083 boat party hours, se=225; Taylor *et al.*, 2018) was 17% and 13% of the historical peak in 1998 (24,020 boat party hours, se =3,436). Therefore, recreational fishing effort at Nanga remains well below the historical peak in 1998/99 but has risen between 2016/17 and 2018/19. Recreational fishing effort levels prior to 1998/99 cannot be accurately quantified.

Table 29. Overview of the scheduling and design for all Shark Bay boat ramp surveys. Details on those surveys undertaken between 1998/99 and 2010 is provided in Wise *et al*., (2012). An overview of the 2016/17 survey is provided in Taylor *et al*., (2018). The 2016/17 survey used a bus-route design to estimate effort and catches for all three ramps combined and a Supplementary Access Point Survey (SAPS) to estimate ramp-based totals.

Year	Time Period	Scheduling of shifts	Number of shifts	Design
1998/99	Apr 98–Mar 99	11:00 – 18:00	86	Bus-route
2000/01	May 00– Apr 01	11:00 – 18:00	101	Bus-route
2001/02	May 01– Apr 02	11:00 – 18:00	107	Bus-route
2002	Jan 02– Dec 02	11:00 – 18:00	101	Bus-route
2003	Jan 03– Dec 03	11:00 – 18:00	143	Bus-route
2004	Jan 04– Dec 04	11:00 – 18:00	151	Bus-route
2005	Jan 05– Dec 05	11:00 – 18:00	159	Bus-route
2006	Jan 06–Dec 06	11:00 – 18:00	163	Bus-route
2007	Jan 07– Dec 07	11:00 – 18:00	99	Bus-route
2007/08	Apr 07–Mar 08	11:00 – 18:00	96	Bus-route
2010	Jan 10– Dec10	10:00 – 18:00	126	Bus-route
2016/17	Mar 16–Feb 17	10:00 – 18:00	137	Bus-route & SAPS
2018/19	Mar 18–Feb 19	10:00 – 18:00	228	SAPS

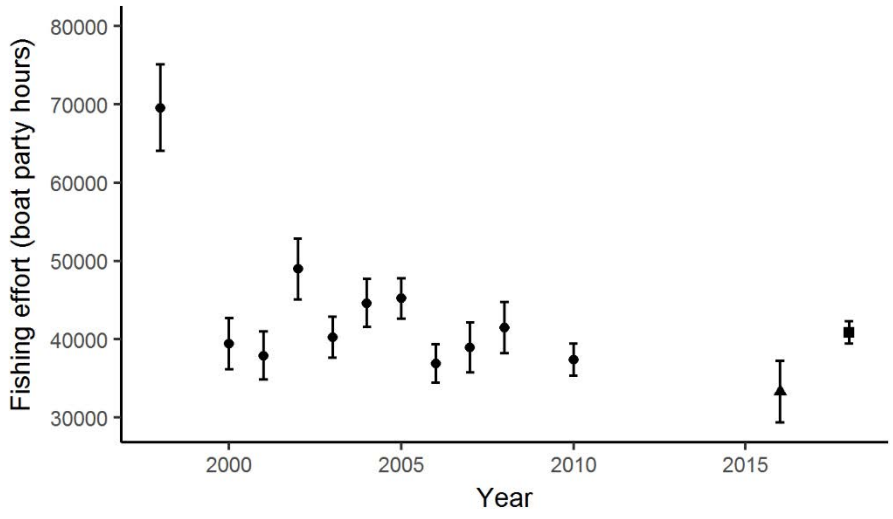


Figure 22. Comparison of recreational fishing effort (boat party hours) obtained from 13 boat ramp surveys conducted in inner Shark Bay between 1998/99 and 2018/19. Black circles denote the previous bus-route surveys, black triangle denotes the 2016/17 bus-route survey and the black square denotes the 2018/19 Supplementary Access Point Survey. Error bars are the standard error of the mean.

The overall trend in the estimated kept catch at Nanga is similar to that for fishing effort. The estimated number of Pink Snapper kept in 2018/19 (911 fish kept, se=136; Table 18) was 29% higher than in 2016/17 (709 fish kept, se=162). However, these estimates were only 14% and 11% of the peak in kept catch in 1998/99 (6,603, se=1,320), substantially lower than those between 2000/01 and 2002 and broadly consistent with those between 2003 and 2010 (Figure 23). Therefore, the estimated kept catch of Pink Snapper at Nanga remains well below the historical peak in 1998/99 but has risen between 2016/17 and 2018/19.

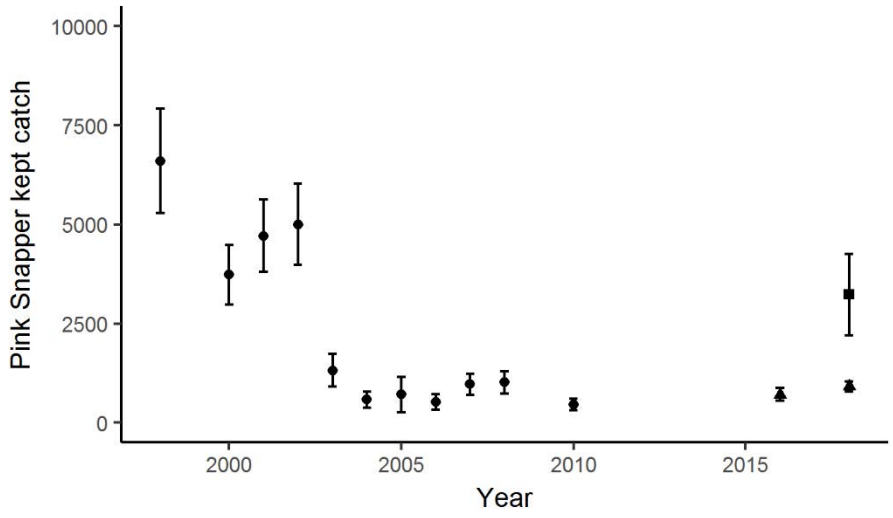


Figure 23. Comparison of the estimated kept catch of Pink Snapper at Nanga obtained from 13 boat ramp surveys between 1998/99 and 2018/19. Black circles denote the bus-route surveys, black triangles denote Supplementary Access Point Surveys. In 2018/19, the kept catch for Freycinet Estuary was estimated (inclusive of the Nanga kept catch) and is denoted by the black square. Error bars are the standard error of the mean.

The 2018/19 estimated kept catch of Pink Snapper for Freycinet Estuary indicates that less than a third of the contemporary catch is now landed at Nanga. Between 2003 and 2015, a limited number of harvest tags were issued each year (~900). Based on examination of compliance statistics, the majority of recreational fishers adhered to the regulation on harvest tags (Jackson *et al.*, 2016) so this regulation provided a means to restict the number of Pink Snapper kept. Considering the number of harvest tags issued each year and the fact that the estimated kept catch of Pink Snapper at Nanga between 2003 and 2010 ranged from 1,318 (se=407) in 2003 to 521 (se=196) in 2006, it is likely a higher proportion of the Freycinet catch was taken at Nanga between 2003 and 2015. The proportion of the Pink Snapper kept catch taken by boat-based fishers at Nanga prior to the implementation of harvest tags cannot be reliably quantifed; however, it is believed to be greater than that in 2018/19. This is because road access to the remote pastoral stations in Freycinet Estuary has improved and in recent years, both Tamala and Carrarang Station (now closed for camping) have had dedicated websites and online bookings that have marketed the pastoral stations as recreational fishing locations. As the estimated kept catch of 3,233 (se=1,027) Pink Snapper in 2018/19 for Freycinet Estuary was

49% of the estimated total for Nanga in 1998/99, it can be concluded that the current kept catch for Freycinet Estuary is below the historical peak in 1998/99.

9.2 Remote camera surveys

Estimates of the number of powerboat retrievals at Denham, Monkey Mia and Nanga provide a good proxy for recreational fishing effort because a high proportion of interviewed boat parties at these ramps had been recreational fishing (Table 13, Table 14, Taylor *et al.*, 2018). Estimates of the number of powerboat retrievals at Denham do not provide clear evidence of an increase in activity between 2011/12, 2013/14, 2016/17 and 2018/19 (Table 30), noting that the 2016/17 estimate was restricted to a 9-month period due to a camera outage. The number of powerboat retrievals at Monkey Mia in 2018/19 was higher than in 2016/17 but lower than in 2013/14. The number of powerboat retrievals at Nanga was higher in 2018/19 in comparison to 2016/17, noting that activity levels at this ramp remain well below those for the other two ramps (Table 30). Long term remote camera data are not available at Nanga so this line of evidence cannot be used to corroborate historical fishing effort and catch levels at this location.

Table 30. Comparison of the number of powerboat retrievals (full 24-hrs) recorded from the remote cameras at Denham, Monkey Mia and Nanga. 2011/12 and 2013/14 estimates are reported in Ryan *et al*., (2013) and Ryan *et al*., (2015). 2016/17 estimates are from Taylor *et al*., (2018). Numbers in brackets for Denham are the number of powerboat retrievals excluding July, August and September.

	Year							
Location	**2011/12**	**se**	**2013/14**	**se**	**2016/17**	**se**	**2018/19**	**se**
Denham	4,564	17	5,191	124	4,166*	132	5,037	0
	(3,213)		(3,560)					
Monkey Mia	3,207	21	6,365	401	4,075	25	4,710	58
Nanga	-	-	-	-	781	15	1,005	13

*Denham total does not include catch in Jul, Aug and Sep 2016 data due to major camera outage. Numbers in brackets for Denham represent the annual catch excluding Jul, Aug and Sep for comparative purposes.

9.3 Aerial surveys

Although the main aim of the aerial survey was to estimate boat-based recreational fishing effort in Freycinet Estuary, shore-based activity identified from this survey was compared to that collected from an earlier aerial survey in 2012. Both surveys tracked along the coastline at Tamala Station and Carrarang Station as part of a randomised design, sampling in autumn and winter in 2018 and winter in 2012. Each observation identified during a flight was categorised as a camp, boat, shore or unattended vessel (Appendix 6). This section provides a comparison of the mean daily number of camps and unattended vessels by season for 2018 and 2012. Unattended vessels were defined as those vessels that were moored/anchored or on the beach that were not participating in a recreational activity (i.e. no people on board).

Table 31. Comparison between the design and data collected in the 2012 and 2018 aerial surveys. WD=Week days, WE/PH = Weekend days and public holidays.

Survey element	2012	2018
Design		
Time period	June – August 2012	March – August 2018
Spatial extent	Shark Bay [Nanga/Tamala subsection an approximate equivalent to Freycinet]	Freycinet Estuary
Survey days	18	29
Plane	Cessna 172	Cessna 172
Flight path	Coastal track	Coastal track & overwater transects
Strata		
Season or month	Month	Season
Time of day	AM/PM Morning (8am – 12.30pm) Afternoon (12.30am – 5pm)	2 hr time blocks assigned proportionally due to expected activity level from 7am – 5pm
Day type	WD, WE/PH	WD, WE/PH
Randomisation		
Starting location	Randomly selected	Randomly selected
Direction of travel	Randomly selected	Randomly selected
Data collection		
Extractive shore activities	Y	Y
Other shore activity	Y	Y
Extractive boat activities	N	Y
Other boat activity	N	Y
Moored/anchored vessels	Y	Y
Boats on beach	Y	Y
Camps	Y	Y
Boat trailers	Y	N
Vehicles	Y	N

The mean daily number of camps at Carrarang Station in winter 2018 (5.8 camps, se=2.8) was lower than in 2012 (14.3 camps, se=5.9) which likely reflects the fact that this station was closed for the general public in January 2018, except for those that had booked their trip prior to the closure. The mean daily number of camps at Tamala Station in winter 2018 (29.1 camps, se=12.8) was consistent with that for the same season in 2012 (25.9 camps, se=11.2) and for autumn 2018 (26.5 vessels, se=15.0). The mean daily number of unattended vessels at Carrarang Station in winter 2018 (4.5 vessels, se=2.2) was slightly lower than for the same season in 2012 (6.6 vessels, se=2.7). The mean number of unattended vessels at Tamala in winter 2018 (12.0 vessels, se=6.8) was slightly higher than in winter 2012 (8.3 vessels, se=4.7) but lower than in autumn 2018 (15.1 vessels, se=7.4). Overall, the information collected on the number of camps and unattended vessels does not support the notion of an increase in activity between the two survey years. However, the estimates for Tamala Station in particular were highly uncertain which makes it difficult to assess differences between years and seasons.

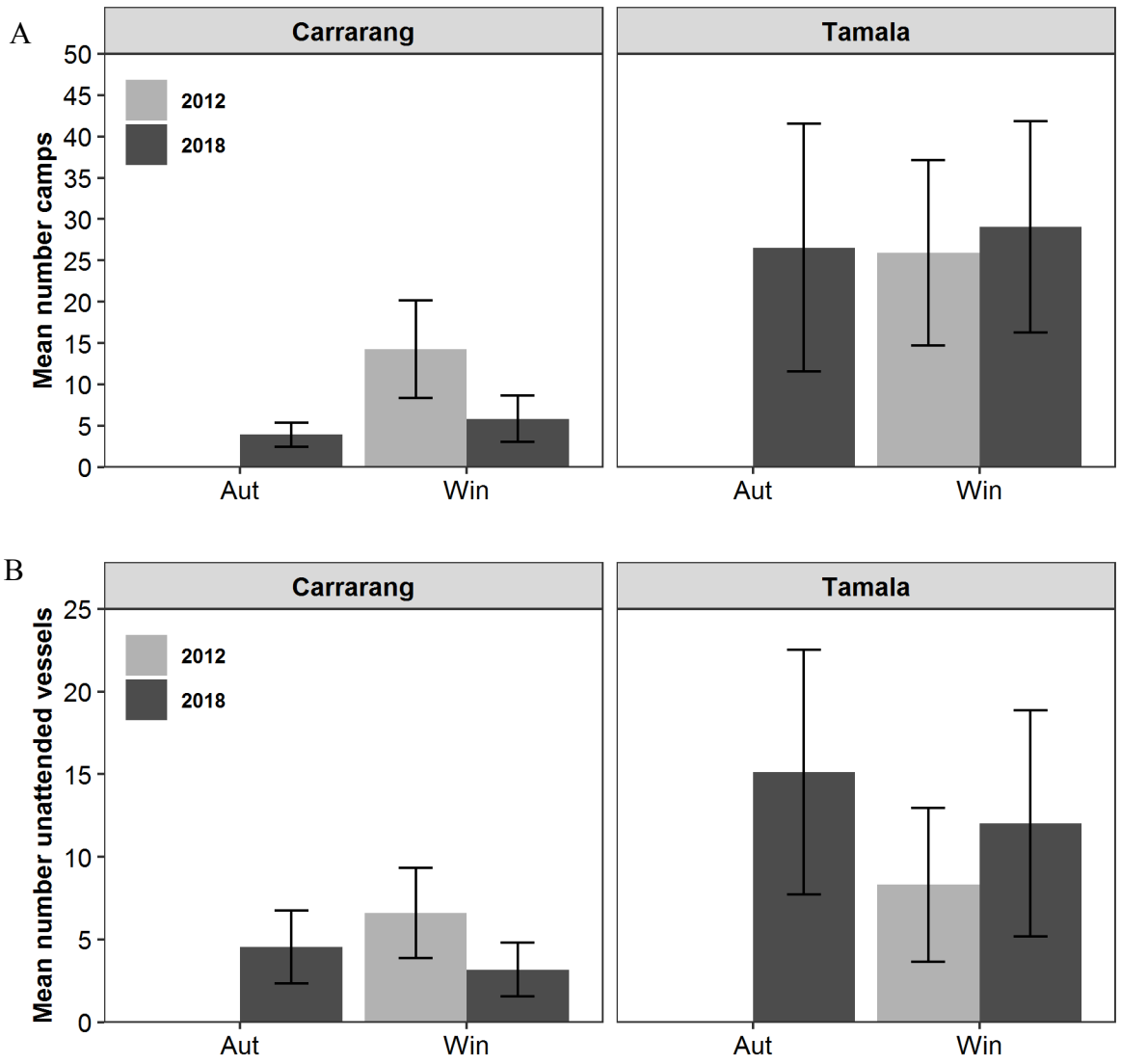


Figure 24. Mean number of A) camps and B) unattended vessels observed at Carrarang Station and Tamala Station in Freycinet Estuary during the 2012 and 2018 aerial surveys. Error bars represent the standard error of the mean estimates.

9.4 Interviews with camps at Tamala Station

Between 2001 and 2003, people camping at six of the beaches at Tamala Station were interviewed to provide initial observations on recreational fishing activity. In total, 54 survey days occurred over the three years (n=19 in 2001, n=18 in 2002, n=17; Table 32). At Tamala Station there are approximately 20 beaches from which shore and boat-based fishers can access the fishery. The catch information collected from camps at Tamala Station was not expanded to population totals because interviews only occurred at some of the beaches within Tamala Station (i.e. a subset), catches may have included boat-based and shore-based fishing and in some cases, the catch data reported by fishers appears to have related to multi-day trips rather than a daily catch rate. Instead, raw Pink Snapper catch information from interviewed fishers is presented as a line of evidence to be considered when examining historical trends in fishing activity (Table 32).

To some extent, the raw catch information from Tamala Station supports the assumption made in the current analysis whereby the harvest rate at Nanga was used to estimate the kept catch for both Nanga and Freycinet Estuary. Firstly, 52% of those interviewed fishers who provided information on their targeted catch at Tamala Station between 2001 and 2003 (n=225 interviews) were targeting Pink Snapper, a higher percentage than for any other species. Furthermore, of the 31 different species or groupings recorded in the kept catches, Pink Snapper comprised 22% of the kept catch of interviewed fishers, although this percentage varied considerably between years (Table 32). In 2003, the year in which the harvest tags were introduced, Pink Snapper comprised only 14% of the kept catch of those interviewed fishers. In contrast, Pink Snapper comprised a larger percentage of the catch (i.e. kept and released) between 2001 and 2003 although this percentage also declined between the three years. Although it is not feasible to estimate either the kept catch at Tamala Station or for Freycinet Estuary between 2001 and 2003, the raw catch data collected at Tamala Station confirm that the Pink Snapper catch at this time was not restricted to Nanga.

Table 32. Interviews with camps at Tamala between 2001 and 2003 and the raw catch information from interviewed fishers.

Year	Months	Raw catch information from interviewed fishers						
		No. interview days	No. Pink Snapper kept	No. fish kept	% of kept catch	No. Pink Snapper caught	No. fish caught	% of catch
2001	May, Jun, Jul, Aug, Oct	19	52	174	30	539	768	70
2002	May, Jun, Jul, Aug, Oct	18	46	170	27	328	556	59
2003	Apr, May, Jun, Jul, Aug	17	43	300	14	210	539	39
All	Apr, May, Jun, Jul, Aug, Oct	54	141	644	22	1,077	1,863	58

9.5 Visitation records for Tamala Station

Visitation records for Tamala Station are available for the 2015/16 financial year onwards, over a decade after camps were interviewed at this site (refer to Section 9.4). These visitation records are considered to provide reliable information on the total number of paid visitors at Tamala Station because a series of gates and keys (provided at check in) are required to access the different beaches within the station. As the management changes in Freycinet Estuary were introduced during the 2015/16 financial year, these records provide an indication of the number of visitors immediately after the removal of the harvest tags. The number of visitors increased by 52% from 3,950 in 2015/16 (average of 11 visitors a day) to 5,704 in 2017/18 (average of 16 visitors a day). Visitation rates were highest during autumn and winter (67% to 73% per

year) and peaked in April during each year. Anecdotal reports from compliance staff and from the station manager suggest that the majority of visitors go recreational fishing. Therefore, this line of evidence suggests that fishing effort at Tamala Station has recently increased following the removal of the harvest tags.

Table 33. The number of visitors at Tamala Station by financial year and month.

	Number of visitors							
Financial year	**Jul**	**Aug**	**Mar**	**Apr**	**May**	**Jun**	**6-month total**	**Financial year total**
2015/16	543	204	492	795	535	330	2,899	3,950
2016 /17	775	274	168	1087	471	511	3,286	4,499
2017/18	888	318	551	1013	731	552	4,053	5,704
2018/19	951	437	229	1172	773	436	3,998	6,012

9.6 State-wide surveys of boat-based recreational fishing

State-wide surveys of boat-based recreational fishing have been completed in 2011/12, 2013/14, 2015/16 and 2017/18 (Ryan et al., 2013, 2015, 2017, 2019). These Phone-Diary Surveys are designed to provide robust estimates of recreational catch at state-wide, bioregion and zone levels. Finer scale disaggregation can produce estimates that are not robust (i.e. low sample sizes and high relative standard error).

Shark Bay sits within the Gascoyne Coast bioregion and Carnarvon/Shark Bay zone. Robust annual estimates of catch for Pink Snapper can be provided for this zone for each survey year (Table 34). These results reveal that the release rate of Pink Snapper has been high (between 77% and 86%) and the total catch has decreased through time (Table 34). Further disaggregation to the scale of inner Shark Bay and the Shark Bay stock boundaries are ongoing to ascertain the most appropriate methods for finer-scale disaggregation. This will include a direct comparison of the estimated catch of Pink Snapper obtained from the 2017/18 state-wide survey of boat based fishing and the current survey which operated over the same Pink Snapper season (between March and August 2018). However, preliminary data exploration indicate that the state-wide survey cannot provide robust estimates for the Freycinet Estuary Pink Snapper stock due to the small number of recreational fishers and diarists (fewer than 30) that fish in this area.

Table 34 Estimated catch (kept, released and total numbers) of Pink Snapper for the Carnarvon/Shark Bay Zone estimated from state-wide surveys of boat based fishing.

Zone	Survey	Estimated kept catch (by numbers)	se	Estimated released catch (by numbers)	se	Estimated total catch (by numbers)	se
Carnarvon / Shark Bay	2011-12	11,309	1,499	71,387	11,260	82,697	11,922
Carnarvon / Shark Bay	2013-14	9,443	1,147	64,054	9,344	73,497	9,991
Carnarvon / Shark Bay	2015-16	12,250	1,925	41,389	7,122	53,639	8,405
Carnarvon / Shark Bay	2017-18	7,750	1,358	34,707	11,956	42,457	12,972

9.7 Summary of historical information

The 2018/19 integrated survey has provided an additional snap shot of recreational fishing activity for inner Shark Bay in addition to an estimate of the Pink Snapper kept catch for Freycinet Estuary (i.e. not just for Nanga). While it is not possible to accurately adjust those estimated ramp-based totals for Pink Snapper caught at Nanga between 1998/99 and 2016/17 to account for fish that were landed elsewhere, the following observations can be made after examining the different lines of evidence examined in this chapter:

Inner-Shark Bay

- Both recreational fishing effort and the contemporary kept catch of Pink Snapper are below historical levels observed in 1998/99;
- The estimated kept catch of Pink Snapper in Denham Sound and the Eastern Gulf are well within the acceptable range (TARC=11.25t for both stocks) but the estimated kept catch of Pink Snapper in Freycinet Estuary is considerably above the acceptable limit (TARC=3.75t).

Freycinet Estuary

- Both recreational fishing effort and the contemporary kept catch of Pink Snapper are below historical levels that were estimated in 1998/99 through to the early 2000s.
- Recreational fishing effort at Nanga has recently increased as has the number of visitors at Tamala Station; however, the estimated number of camps identified at the latter site in 2018 was broadly consistent with that observed in 2012 (i.e. high visitation levels at Tamala Station pre-date Pink Snapper management changes in January 2016);
- Less than a third of the contemporary kept catch of Pink Snapper in Freycinet Estuary is taken by recreational fishers at Nanga. The majority of the kept catch of this species appears to come from Tamala Station (and likely Carrarang Station prior to the recent closure to camping);

- The harvest tag system provided a very effective means to cap the number of Pink Snapper kept and it is likely that the proportion of the catch taken at Nanga was greater during this time.

10. Summary and recommendations for future monitoring

10.1 Summary

This report has provided detailed information on recreational fishing in inner Shark Bay and an additional snapshot of the recreational catch following the introduction of management changes in January 2016. Regular and reliable recreational catch estimates are required for this remote fishery to address the current governance system, in addition to the fact that recreational fishing occurs within a World Heritage Area and a Marine Park. The integrated survey outlined in this report required the use of innovative sampling methods, involving concurrent boat ramp, remote camera and fixed-wing aerial surveys.

Fishers demonstrated strong support for the boat ramp surveys, as evident by the very high response rates achieved from interviewing boat parties at Denham, Monkey Mia and Nanga. Where there are no missing data and footage is read, the analysis of the remote camera data provides a census of all those boats returning to the ramps. In the current study, very few outages were encountered and the estimates of boating activity and fishing effort were accurate. The reading of the remote camera data also enabled recent trends in fishing effort to be established at the three ramps (refer to 9.2).

The requirement to estimate Pink Snapper catches separately for Denham Sound, the Eastern Gulf and Freycinet Estuary has enabled the behaviour of recreational fishers and the composition of their catches to be compared between the three inner gulfs. Substantial differences were apparent in regards to the catch and fisher behaviour between ramps. Blue Swimmer Crab was the most commonly caught species overall and in comparison to previous surveys, the catch during 2018/19 appeared to be high (Wise *et al.*, 2012; Taylor *et al.*, 2018). This is likely due to the fact that the Blue Swimmer Crab stock in Shark Bay has recovered following mortality events and impaired recruitment that was attributed to a marine heatwave (Chandrapavan *et al.*, 2019).

Nearly all of the Blue Swimmer Crab caught in inner Shark Bay were taken by recreational fishers using the ramp at Monkey Mia and nearly half of the boat parties at this ramp were targeting Blue Swimmer Crab. In contrast, a high percentage of fishers at Denham and Nanga were targeting Pink Snapper. This demonstrates that the targeting behaviour of recreational fishers can vary over small spatial scales. The estimated kept catch of Pink Snapper was highest at Denham (1,454 fish, se=186); however, while the estimated kept catch at Nanga (911 fish, se=136) was 37% less than Denham, the estimated level of annual fishing effort at Nanga was only a fifth of that at Denham. Harvest rates were highest at Nanga and in addition, the average size of those Pink Snapper kept at this ramp was higher than at Denham and Monkey Mia, with 34% of measured fish being above the previous maximum legal size of 700mm TL.

The availability of Pink Snapper stocks and satisfaction among recreational fishers is likely to be linked to both the economic health of the fishery and the local economy because a large proportion of fishers in the study were non-residents. Overall, fishers were well-informed and expressed strong levels of support for contemporary management arrangements for Pink

Snapper. While a high percentage (64%) of fishers at Nanga (in Freycinet Estuary) expressed support for the recent removal of the harvest tags, it is unknown whether or not this management change influenced their decision to fish at this location. However, the fact that fishing effort increased at Nanga between the 2016/17 and 2018/19 surveys demonstrates that the management change has led to a change in the behaviour of some fishers.

10.2 Recommendations

To assist in evaluating whether the fishing activities in inner Shark Bay are managed at sustainable levels, ongoing monitoring of recreational catches is required. This is particularly important for Pink Snapper because for this species the recreational catch surpasses the commercial catch. For example, commercial catches of Pink Snapper in the inner gulfs are approximately 2–3t a year and limited to bycatch taken by the Shark Bay Beach Seine and Mesh Net Managed Fishery (Jackson *et al*., 2018) while charter boat-based recreational catches (included in the TARC) are approximately 2.5t a year (Jackson *et al*., 2017) in comparison to the estimated private boat-based recreational catch of 17.9t (kept, 95% CI 10.5−25.3) from the present study (refer to Section 7.3). Therefore, trends in commercial and charter boat catches derived from statutory fishing returns do not accurately reflect trends in total fishing mortality.

The recreational fishery in inner Shark Bay is managed by a series of output controls, including daily bag, possession, size and gear limits, and a seasonal closure for Pink Snapper in the Eastern Gulf and Freycinet Estuary. Boat-based recreational fishers are required to possess a current Recreational Boat Fishing Licence (RBFL) while net fishers require a Recreational Net Fishing Licence. In addition, Pink Snapper stocks are managed to the following notional maximum acceptable catch limits for recreational fishing (Total Allowable Recreational catch, TARC) which includes catches from charter boat-based recreational fishing: Denham Sound (TARC=11.25t), the Eastern Gulf (TARC=11.25t) and Freycinet Estuary (TARC=3.75t).

The estimated kept catch by weight at Denham (4.6 t, 95% CI=3.4−5.9) and Monkey Mia (2.7 t, 95% CI=0.8−3.4) are well below the TARC for Denham Sound and the Eastern Gulf. Even after consideration of potential ‘out of scope’ Pink Snapper kept catches (e.g. shore-based fishers, catches on-board charter vessels, boat-based trips at night and over multiple days, from boats held on moorings or from boats launched from the beach), the contemporary kept catch would be below the TARC in these two gulfs. Furthermore, the 3-month spawning closure for Pink Snapper in the Eastern Gulf provides a further means to limit the harvest of this species in the Eastern Gulf. In light of these catch estimates under the current governance system in place, a lower level of ongoing monitoring could be justified for these two stocks in comparison to Freycinet Estuary (see below).

The estimated kept catch by weight for Freycinet Estuary (11.5t, 95% CI 4.3−18.7) is substantially above the TARC (3.75t), noting that the lower 95% CI for this estimate is also above the TARC and excludes catches from charter tour operators. In light of the current governance system and the catch estimates generated from this study, it is clear that the management arrangements in Freycinet Estuary need to be reviewed.

Estimating recreational fishing activity for Freycinet Estuary is challenging because of the remote nature of the fishery and the relatively small number of fishers involved. Various monitoring options could be applied to Freycinet Estuary, each of which differ in their cost, assumptions and coverage of recreational fishing activities. Analysis undertaken as part of this project confirmed that ongoing state-wide surveys of boat-based recreational fishing cannot provide accurate kept catch estimates for Freycinet Estuary. This is by virtue of the relatively small number of recreational fishers randomly sampled from the RBFL that fish in Freycinet Estuary. Given that a high percentage of recreational fishers in Freycinet Estuary are tourists, it is not feasible to oversample RBFL holders that are local residents in an attempt to improve sample sizes of diarists that fish and catch Pink Snapper in Freycinet Estuary (and thus improve catch estimates). Therefore, another approach is required for the ongoing monitoring of recreational fishing in Freycinet Estuary. However, if a specific licence frame existed for recreational fishers in Freycinet Estuary this frame could be used to cost-effectively select a random sample of recreational fishers. Elsewhere in Western Australia, boat parties are required to provide a notification of travel to the Abrolhos Islands Fish Habitat Protection Area online and this approach could be applied to not only collect retrospective data on recreational catches off the Abrolhos Islands but also to Freycinet Estuary. For example, a random sample of fishers could be contacted by phone shorty after their visit to Freycinet Estuary to provide retrospective data on Pink Snapper catches, but within a short time frame to minimise recall bias.

In the absence of a licence frame for recreational fishers in Freycinet Estuary, it is recommended that the integrated boat ramp, remote camera and aerial survey outlined in this report be repeated. This will enable trends in recreational fishing activity in Freycinet Estuary to be monitored in response to current and future management settings. While the three components of this survey have been integrated in the current survey, depending on future management objectives and fiscal constraints, one or more parts of the survey could be operated across different time scales. For example, the maintenance and reading of the data from the remote camera at Nanga provides a means to monitor annual trends in recreational fishing effort for less than $10,000 a year. Should a rapid increase or decrease in fishing effort be identified, this would strengthen the need for future integrated surveys involving interviews with fishers at Nanga and aerial surveys of Freycinet Estuary. Further interrogation of the remote camera data could also assist in improving the accuracy of those estimates of fishing effort obtained from the aerial survey that form the basis of the estimation of the Freycinet Estuary Pink Snapper kept catch.

Where possible it is recommended that future estimates of the Pink Snapper kept catch are aligned to coincide with the state-wide surveys of boat-based fishing to assist in the corroboration of survey results. Work is ongoing to estimate the inner Shark Bay kept catch of Pink Snapper from the state-wide surveys of boat-based fishing, in addition to the catch estimates for Denham Sound and the Eastern Gulf. If those estimates for the Pink Snapper kept catch for inner Shark Bay align closely with those from the current integrated survey, one option would be to apply the proportional catch estimates for the three inner gulfs obtained from periodic onsite surveys to the ongoing state-wide surveys of boat-based recreational fishing that are scheduled to occur every 3-years. Proportional changes in annual fishing effort

levels identified by reading data from the remote cameras at Denham, Monkey Mia and Nanga could be used to adjust the catch estimates for each of the gulfs. Ongoing work is focussing on sub-sampling approaches for reading the remote camera data and this will assist in determining a suitable number of day's footage to read at each ramp to enable trends in fishing effort to be monitored. Thus, it is recommended that the remote camera network be maintained at these three ramps.

References

Blight, S., and Smallwood, C. 2015. Technical manual for camera surveys of boat- and shore-based recreational fishing in Western Australia. Fisheries Occasional Publication No. 121. Government of Western Australia. Department of Fisheries. 32 pp.

Chandrapavan, A., Caputi, N., and Kangas, M. I. 2019. The Decline and Recovery of a Crab Population From an Extreme Marine Heatwave and a Changing Climate. Frontiers in Marine Science, 6: 1–12. https://www.frontiersin.org/article/10.3389/fmars.2019.00510/full.

Desfosses, C., Adams, P., Blight, S., Smallwood, C., and Taylor, S. 2019. The feasibility of using remotely piloted aircraft systems (RPAS) for recreational fishing surveys in Western Australia. Fisheries Occassional Publication No. 137, Department of Primary Industries and Regional Development, Western Australia, 39 pp.

Goodman, L. A. 1960. On the exact variance of products. Journal of the American Statistical Association, 55: 708–713.

Grolemund, G., and Wickham, H. 2011. Dates and times made easy with lubridate. Journal of Statistical Software, 40: 1–25. http://www.jstatsoft.org/v40/i03/.

Hartill, B. W., Watson, T. G., and Bian, R. 2011. Refining and applying a maximum-count aerial-access survey design to estimate the harvest taken from New Zealand's largest recreational fishery. North American Journal of Fisheries Management, 31: 1197–1210.

Hartill, B. W., Edwards, C. T. T., and Jacobson, L. 2015. Comparison of recreational harvest estimates provided by onsite and offsite surveys: detecting bias and corroborating estimates. Canadian Journal of Fisheries and Aquatic Sciences, 72: 1379–1389. http://www.nrcresearchpress.com/doi/10.1139/cjfas-2014-0451.

Hoenig, J. M., Jones, C. M., Pollock, K. H., Robson, D. S., and Wade, D. L. 1997. Calculation of catch rate and total catch in roving surveys of anglers. Biometrics, 53: 306–317.

Jackson, G., and Moran, M. 2012. Recovery of inner Shark Bay snapper (*Pagrus auratus*) stocks : relevant research and adaptive recreational fisheries management in a World Heritage Property. Marine and Freshwater Research, 63: 1180–1190.

Jackson, G., Ryan, K. L., Green, T. J., Pollock, K. H., and Lyle, J. M. 2016. Assessing the effectiveness of harvest tags in the management of a small-scale, iconic marine recreational fishery in Western Australia. ICES Journal of Marine Science, 73: 2666–2676.

Jackson, G., Zilles, H., Brown, J., and Turner, S. 2017. Gascoyne Inner Shark Bay Scalefish Resource Status Report 2016. *In* Status Reports of the Fisheries and Aquatic Resources of Western Australia 2015/16: The State of the Fisheries, pp. 115–120. Ed. by W. Fletcher, M. Mumme, and F. Webster. Department of Fisheries; Western Australia.

Jackson, G., Cavalii, P., and Smith, S. 2018. Gascoyne Inner Shark Bay Scalefish Resource Status Report 2018. In Status Reports of the Fisheries and Aquatic Resources of Western Australia 2017/18. 99-104 pp.

Jones, C. M., and Pollock, K. H. 2012. Chapter 19 Recreational angler survey methods:

Estimation of effort, harvest, and released catch. *In* Fisheries Techniques. Third edition, pp. 883–916. Ed. by A. V. Zale, D. L. Parrish, and T. M. Sutton. American Fisheries Society.

Lai, E. K. M., Mueller, U., Hyndes, G. A., and Ryan, K. L. 2019. Comparing estimates of catch and effort for boat-based recreational fishing from aperiodic access-point surveys. Fisheries Research, 219: 105305. Elsevier. https://doi.org/10.1016/j.fishres.2019.06.003.

Pollock, K. H., Jones, C. M., and Brown, T. L. 1994. Angler survey methods and their application in fisheries management. American Fisheries Society, Special Publication 25. 371 pp.

R Core Team. 2018. R: A language and environment for statistical computing. https://www.r-project.org/.

Rees, A., Yearsley, G., Gowlett-Holmes, K., and Pogonoski, J. 2012. Codes for Australian Aquatic Biota (on-line version).

Ryan, K., Wise, B., Hall, N., Pollock, K., Sulin, E., and Gaughan, D. 2013. An integrated system to survey boat-based recreational fishing in Western Australia 2011/12. Fisheries Research Report No. 249. Department of Fisheries, Western Australia. 168 pp.

Ryan, K. L., Hall, N. G., Lai, E. K., Smallwood, C. B., Taylor, S. M., and Wise, B. S. 2015. State-wide survey of boat-based recreational fishing in Western Australia 2013/14. Fisheries Research Report No. 268. Government of Western Australia Department of Fisheries. 208 pp.

Ryan, K. L., Hall, N. G., Lai, E. K., Smallwood, C. B., Taylor, S. M., and Wise, B. S. 2017. State-wide survey of boat-based recreational fishing in Western Australia 2015/16. Fisheries Research Report No. 287. Department of Primary Industries and Regional Development, Government of Western Australia. 205 pp.

Ryan, K. L., Hall, N. G., Lai, E. K., Smallwood, C. B., Tate, A., Taylor, S. M., and Wise, B. S. 2019. Statewide survey of boat-based recreational fishing in Western Australia 2017/18. Fisheries Research Report No. 297. Department of Primary Industries and Regional Development, Government of Western Australia. 195 pp.

Smallwood, C. B., Pollock, K. H., Wise, B. S., Hall, N. G., and Gaughan, D. J. 2012. Expanding aerial–roving surveys to include counts of shore-based recreational fishers from remotely operated cameras: Benefits, limitations, and cost effectiveness. North American Journal of Fisheries Management, 32: 1265–1276.

Steffe, A. S., and Chapman, D. J. 2003. A survey of daytime recreational fishing during the annual period, March 1999 to February 2000, in Lake Macquarie, New South Wales. NSW fisheries final report series, No. 52: 124 p.

Steffe, A. S., Murphy, J. J., and Reid, D. D. 2008. Supplemented access point sampling designs: A cost-effective way of improving the accuracy and precision of fishing effort and harvest estimates derived from recreational fishing surveys. North American Journal of Fisheries Management, 28: 1001–1008.

Steffe, A. S., Taylor, S. M., Blight, S. J., Ryan, K. L., Desfosses, C. L., Tate, A. S., Smallwood, C. B., *et al.* 2017. Framework for integration of data from remotely operated cameras into

recreational fishery assessments in Western Australia. Fisheries Research Report No. 286, Government of Western Australia. Department of Fisheries. 32 pp.

Stuart, A., and Ord, K. 1998. Kendall's Advanced Theory of Statistics. Arnold, London. 351 pp.

Taylor, S. M., Steffe, A. S., Lai, E. K. M., Ryan, K. L., and Jackson, G. 2018. A survey of boat-based recreational fishing in inner Shark Bay 2016/17. 87 pp.

Wickham, H., and Francois, R. 2016. dplyr: A grammar of data manipulation. R package version 0.5.0. https://cran.r-project.org/package=dplyr (Accessed 1 March 2016).

Wise, B. S., Telfer, C. F., Lai, E. K. M., Hall, N. G., and Jackson, G. 2012. Long-term monitoring of boat-based recreational fishing in Shark Bay, Western Australia: Providing scientific advice for sustainable management in a World Heritage Area. Marine and Freshwater Research, 63: 1129–1141.

Appendix 1. Chronology of the management of Pink Snapper in Shark Bay (adapted from Wise *et al*., 2012)

Year/Time period	Management action
1950s–1970s	Minimum size limit of 380mm; no daily bag limits.
1977	Daily bag limit of 10 'reef fish' (includes Pink Snapper) per person state-wide.
1986	Minimum size limit increased to 410mm.
1990	Hamelin Pool Marine Nature Reserve gazetted. Shark Bay Marine Park gazetted.
1991	Daily bag limit reduced to eight 'reef fish' per person state-wide. Shark Bay inscribed on the World Heritage List.
1992	Shark Bay beach-seine and mesh-net fishery legislated.
1996	Commercial fishing for Pink Snapper in Shark Bay prohibited, except beach-seine and mesh-net fishery. Eastern Gulf: daily bag limit of four Pink Snapper per person introduced; minimum size limit increased to 450mm.
1997	Western Gulf: minimum size limit increased to 450mm; daily bag limit reduced to four Pink Snapper, with only two individuals >700mm. Eastern Gulf: Pink Snapper fishery (rec. and comm.) closed in May, then reopened July; daily bag limit reduced to two Pink Snapper individuals per person; slot size limit 500–700mm.
1998	Eastern Gulf: moratorium, Pink Snapper fishery closed in June.
2000	Denham Sound: daily bag limit reduced to two fish per person; size limit increased to 500mm, with only one Pink Snapper >700mm. Freycinet Estuary: same as Denham Sound plus 6-week spawning-season closure (15 August–30 September). Eastern Gulf: Pink Snapper fishery remains closed.
2002	Ministerial Working Group reviewed Pink Snapper research and management and considered management options for 2003–2005.
2003	All areas: daily bag limit one Pink Snapper per person with slot limit size 500–700mm. Denham Sound: TAC 10t (8t rec., 2t comm.). Freycinet Estuary: TAC 5t (3.8t via 900 rec. lottery quota tags, up to two tags per successful applicant each year; 1.2 comm. via 300 quota tags); spawning season closure (15 August–30 September). Eastern Gulf: moratorium lifted in March; TAC 15t (12t rec.; 3t comm.); spawning-season closure (1 April–31 July).
2005	Research and management reviewed and regulations updated for 2006–2008.
2006	Denham Sound: TAC increased to 15t (12t rec; 3t comm.). Freycinet Estuary: rec. lottery quota tags increased to 1050 and comm. quota tags increased to 350. Eastern Gulf: spawning-season closure reduced (1 May–31 July).
2012	Review of the research and management resulted in updated regulations for 2013–2015, including an increase in the recreational Pink Snapper bag limit from 1 to 2 in 2013.
2008	Research and management reviewed and regulations unchanged for 2009–2011.
2015	A review of management arrangements was undertaken following stock assessments that indicated the recovery of Pink Snapper stocks in Denham Sound, the Eastern Gulf and Freycinet Estuary.
2016	700mm maximum size limit for inner gulf Pink Snapper and the requirement to land Pink Snapper in whole form no longer applies. Freycinet Estuary: lottery quota tag system replaced with the Freycinet Estuary management zone in which a new possession limit of 5kg of finfish fillets or one day's bag limit of whole fish or fish trunks applied.

Appendix 2. Boat ramp survey header form.

Interviewer name		Date (dd/mm/yyyy)		Ramp	

Start Time (24-hr)		Finish Time (24-hr)	

Boat launches			
Time	Type	Time	Type

Boat retrievals			
Time	Type	Time	Type

Total number of trailers	
Start	Finish

Boat types
P: Powerboats
Y: Yachts
J: Jetskis
C: Commercial
O: Other

Comments

Appendix 3. Boat ramp survey interview form.

Date		Ramp		Boat Rego		Interview Time	

Retrieval Time (24-hr)		Launch Time (include date if different to today) (24-hr)		Boat type	☐ Power ☐ Yacht ☐ Jetski ☐ Other	Recreational Fishing?	☐ Yes ☐ No ☐ Other

FISHERS ONLY

Number People on the Boat	
Number of People Fishing	
Number of Licences	
Block Number Primarily Fished (in terms of time)	

Gear types and number used		
Lines, Gill/ cAst / Scoop /RL Pot / Snare / Drop net / SpEargun / Hand / Traps / GidgIe / Jig / Shepherds HooK / Other		
Total fishing time (hrs)		

Species Targeted 1	
Species Targeted 2	

Species (Sex for crabs and lobsters)	Block number (if diff to above)	Number Kept	Number Released	CFL (mm)	TL (mm)	Weight (grams)	CFL (mm)	TL (mm)	Weight (grams)

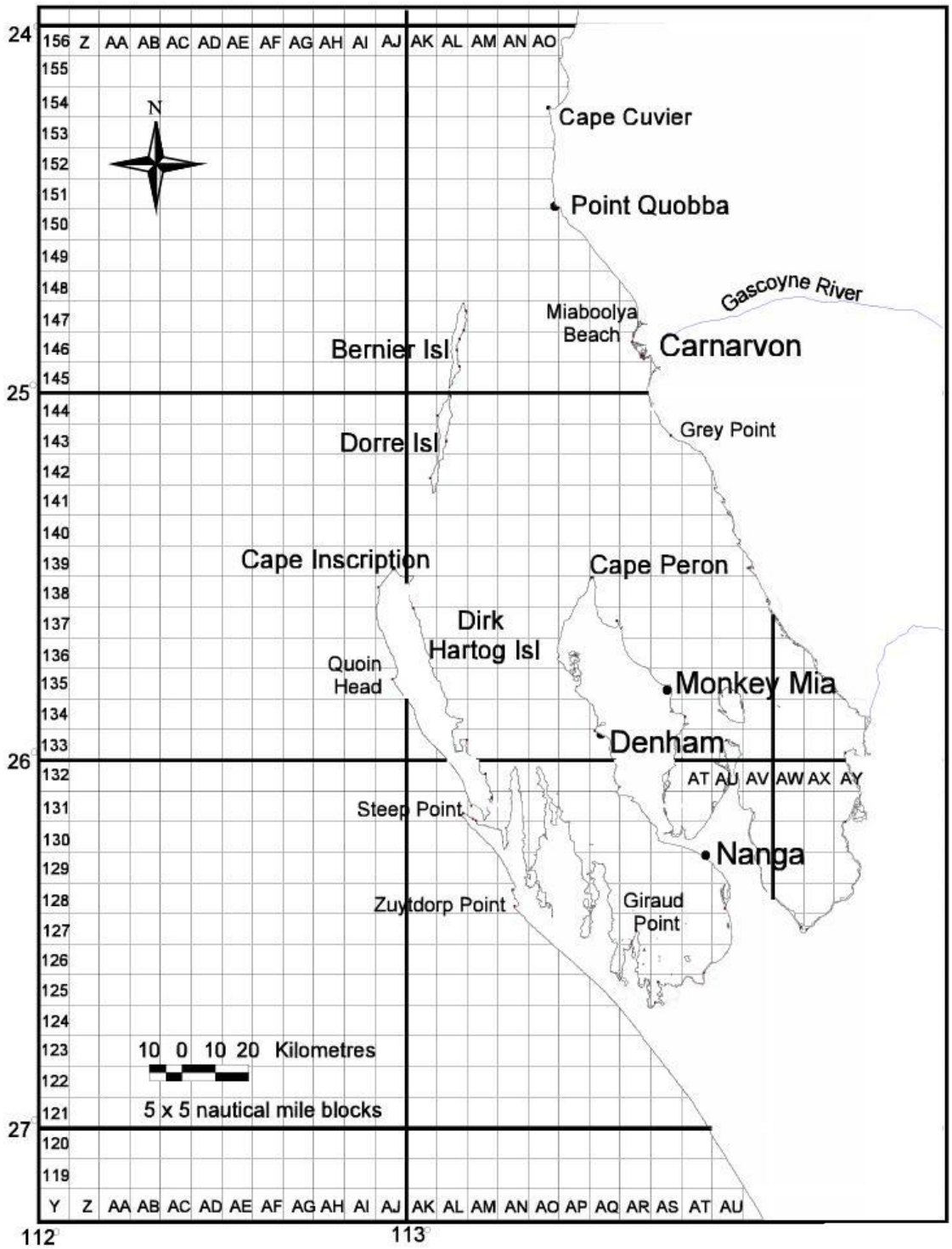
REFUSALS

Refused interview *(tick)*	☐ Yes ☐ No

Why? *(tick)*	☐ No time (fisher)	☐ Not interested	☐ Not fishing	☐ Information will be used against recreational fishers
	☐ Interviewer	☐ Other *(reason)*		

Species (Sex for crabs and lobsters)	Block number (if diff to above)	Number kept	Number released	CFL (mm)	TL (mm)	Weight (grams)	CFL (mm)	TL (mm)	Weight (grams)

Appendix 4. Map of Shark Bay aggregated in 5x5 nautical mile blocks. Each interviewed boat party reporting a fishing trip was asked in which block the majority of their recreational fishing occurred.



Shark Bay - Western Australia

Appendix 5. Boat ramp survey awareness/attitudinal form.

Date (dd/mm/yyyy)		Ramp		Boat Rego		Interview Time	
Interviewed before? If Y, select other fisher	☐ Yes ☐ No	Gender	☐ M ☐ F	Age	☐ 15-29 ☐ 30-44 ☐ 45-59 ☐ 60-74 ☐ > 74	Avidity	☐ <10 ☐ 10-19 ☐ 20-29 ☐ 30+	Postcode	

(a) The next few questions are about fishing regulations relating to *pink snapper* which may or may not apply to the kinds of fishing you do. **Can you recall the *minimum size limit* for *pink snapper* in Shark Bay?** (IF KNOWN EXACTLY CODE AWARE (UNAIDED), OTHERWISE ASK), **Actually it's 500 mm. can you recall hearing anything about this … or not.,**	☐ Aware (unaided) ☐ Aware (aided) ☐ Unaware
(b) **(And) do you agree with this *minimum size limit*., or do you think it should be higher, or lower.. or should there be no size limit at all for pink snapper?**	☐ Agree ☐ Higher ☐ Lower ☐ No minim. size ☐ Unsure

(c) **Can you recall the daily bag limit for pink snapper in Shark Bay?** (IF KNOWN EXACTLY CODE AWARE (UNAIDED), OTHERWISE ASK), **Actually it's 2 snapper (5 mixed). Can you recall hearing anything about this … or not?**	☐ Aware (unaided) ☐ Aware (aided) ☐ Unaware
(d) **(And) do you agree with this daily bag limit., or do you think it should be higher, or lower..or should there be no daily bag limit at all for pink snapper?**	☐ Agree ☐ Higher ☐ Lower ☐ No minim size ☐ Unsure

(e) In addition, on Jan 1st 2016 the harvest tag system for pink snapper in Freycinet Estuary was *removed*. **Do you strongly agree, agree, neither agree or disagree, mildly disagree or strongly disagree with this change?**	☐ Strongly agree ☐ Agree ☐ Neither agree or disagree ☐ Mildly disagree ☐ Strongly disagree ☐ Unsure

(f) **Are you aware of any *other current regulations* for *pink snapper* in Shark Bay?**	☐ Area/spawning closures ☐ In possession limits ☐ Marine Park ☐ Previous regulation ☐ Incorrect ☐ Unaware

REFUSALS

Refused interview *(tick)*		Why? *(tick)*	☐ No time (fisher)	☐ Not interested	☐ Not fishing	☐ Information will be used against recreational fishers
			☐ Interviewer	☐ Other *(reason)*		

Appendix 6. Information collected during the aerial survey.

Observation type was the first level of information to be collected and the four types are outlined below:

Observation type	Description
Boat	Vessel on the water currently participating in a recreational activity (e.g. fishing, swimming, diving, snorkelling). Additional attributes will be collected relating to this observation - see following sections. Note: If a commercial vessel is sighted, then record as a boat and then select 'Commercial as activity type'.
Shore	People on the beach participating in a recreational activity. Additional attributes will be collected relating to this observation – see following sections.
Unattended vessel	Vessel moored/anchored or on the beach which is not currently participating in a recreational activity (i.e. no people on board). No additional attributes will be collected relating to this observation. Motorised vessels only i.e. not kayaks left on the beach.
Camp	Camps (i.e. caravans, tents, campervans). A single camp can comprise multiple dwellings if they are grouped around a focus point such as fire pit or communal area. Generally, a caravan or 'pop-out' camper are considered a single camp as they can be expected to comprise a single family group. No additional attributes will be collected relating to this observation. Counts of camps were not conducted at the Nanga Bay Resort.

Activity type was the second level of information to be collected and the different activity types are described below for shore- and boat-based recreational fishing.

Observation type	Activity type	Description
Boat	Line fishing	Vessel participating in recreational line fishing (i.e. lines in the water, handling catch, baiting a line). Includes trolling.
	Other recreational fishing	Vessel participating in other extractive activity (i.e. netting, spearfishing, pots)
	Transiting*	Moving at high speed from one location to another (i.e., not currently undertaking any recreational activity)
	Non-extractive	Vessel participating in a non-extractive recreational activity (i.e. diving, snorkelling, swimming)
	Commercial	Vessel participating in commercial fishing (e.g. prawn trawling)
	Other	Any other activities (i.e. launching or retrieving, activities undertaken from charter or research vessels)
	Unknown	The activity being undertaken by the vessel cannot be ascertained
Shore	Recreational line fishing	Person/s participating in recreational line fishing
	Other recreational fishing	Person/s participating in other extractive activities (i.e. netting, spearfishing, scoop nets)
	Non-extractive	Person/s participating in a non-extractive recreational activity (i.e. walking, swimming, snorkelling, relaxing on beach). Do not count people who are located within the boundary of their campsite, or located at Nanga Caravan Park.
	Commercial	Person/s participating in commercial activities (i.e. commercial fishing – netting)
	Other	Any other activities
	Unknown	If the activity being undertaken by the person cannot be ascertained.

* Note: if a vessel is initially seen (and recorded) transiting but later observed undertaking a recreational activity, then this first entry should be removed and a new one created which collects this additional information.

Appendix 7. Formulae used for the expansion of the Supplementary Access Point Survey data.

7.1 Method

The Supplemented Access Point Survey design used a double sampling approach to adjust counts of powerboat retrievals for non-fishing trips by using party-based interview information collected during the randomly scheduled survey days at those ramps. Remote camera footage from all 365 days (24-hours) was examined for the 12-month period between March 2018 and February 2019. Boat parties that returned to each of these ramps were interviewed as part of the Traditional Access Point Survey (between 10:00–18:00), providing information on the proportion of boat parties that had been recreational fishing and harvest- and catch rates.

7.2 Analysis

7.2.1 Basic notation

j Denotes the stratum being considered ($j = 1, \dots, J$)

J Denotes the total number of strata

i Denotes the primary sampling unit (PSU, day) within the stratum ($i = 1, \dots, N_j$)

N_j Denotes the total population size (all possible sampling days) in stratum j

n_j Denotes the sample size in stratum j

z_{ij} Denotes the value of the ith unit of stratum j

$\overline{z}_j$ Denotes the sample mean for stratum j

$$s_j^2 = \left[\frac{\sum_{i=1}^{n_j}(z_{ij} - \bar{z}_j)^2}{(n_j - 1)}\right]$$

is the sample variance for stratum j

7.2.2 Single survey day

7.2.2.1 Number of powerboat retrievals

The number of powerboat retrievals ($\hat{P}_{kj}$) for the kth survey day in the jth day type (2 levels; weekdays (WD), weekend days and public holidays (WE/PH)) in a season (4 levels; Autumn = March–May; Winter = June–August; Spring = September–November; Summer = December–February) at each ramp was estimated for the period between nautical sunrise and nautical sunset as:

$$\hat{P}_{kj} = \sum_{i=1}^{n} x_i$$ Equation 1

where:

x_i is the number of powerboats that retrieved at the ramp between nautical sunrise and nautical sunset in the ith minute ($\mathrm{i} = 1, 2, 3, \ldots \mathrm{n}$ minutes).

If any 2-hr period (04:00–05:59, 06:00–07:59,…) in the kth survey day between nautical sunrise and nautical sunset had a proportion of missing footage <0.5, the missing period was scaled up to the total number of minutes in the period. If the proportion of missing footage was ≥ 0.5, the day was treated as missing at random.

7.2.2.2 Proportion of boat parties that had been recreational fishing

The proportion of boat parties that had been recreational fishing within inner Shark Bay ($\overline{Prop}_{kj}$) between nautical sunrise and nautical sunset was estimated for the kth survey day in the jth day type in a season at each ramp.

$$\overline{Prop}_{kj} = \frac{\sum_{i=1}^{n} P_k}{\sum_{i=1}^{n} T_k}$$ Equation 2

where:

P_k Denotes the number of interviewed boat parties that had been recreational fishing within inner Shark Bay for the kth survey day

T_k Denotes the total number of interviewed boat parties for the kth survey day

The above proportion was also calculated for those boat parties that had been recreational fishing inside and outside of inner Shark Bay (incl. the oceanic stock of Pink Snapper).

7.2.2.3 Harvest and catch rate

The "ratio of means" estimator was used to estimate the daily harvest rate and the daily catch rate ($\overline{\mathrm{R}}_{\mathrm{kj}}$;Hoenig *et al.*, 1997; Pollock *et al.*, 1994) between nautical sunrise and nautical sunset for those interviewed boat parties that had been recreational fishing in inner Shark Bay, in units of fish per boat party. These daily harvest rates and catch rates were also estimated for those boat parties that had been recreational fishing inside and outside of inner Shark Bay (incl. the oceanic stock of Pink Snapper).

$$\bar{R}_{kj} = \frac{\sum_{i=1}^{n} C_i}{\sum_{i=1}^{n} L_i}$$ Equation 3

where:

C_i Denotes the catch for the ith boat party

L_i Denotes the ith boat party

7.2.3 Expansion to stratum totals

7.2.3.1 Powerboat retrievals

The number of powerboat retrievals $(\hat{P}_j)$ between nautical sunrise and nautical sunset was calculated for each day type stratum in each season.

$$\hat{P}_j = \frac{\sum \hat{P}_{kj}}{n_j} N_j \qquad \text{Equation 4}$$

7.2.3.2 Proportion of boat parties that had been recreational fishing

The mean proportion of boat parties that had been recreational fishing within inner Shark Bay $(\overline{Prop}_j)$ between nautical sunrise and nautical sunset was calculated for each day type in each season.

$$\overline{Prop}_j = \frac{\sum \overline{Prop}_{kj}}{n_j} \qquad \text{Equation 5}$$

The calculation of the seasonal proportion of boat parties that had been recreational fishing was done by combining the mean daily proportions obtained from each day type within a season. The contribution of each day type stratum to the estimated seasonal harvest rate was weighted by the relative size of each day type stratum within the season (Pollock *et al.*, 1994; Steffe and Chapman, 2003). This approach gave a greater weighting to the weekday stratum because there are more weekdays than weekend days within a season.

$$\overline{Prop}_{Season} = \left(\frac{N_{wd}}{N_{Season}} \overline{Prop}_{wd}\right) + \left(\frac{N_{we}}{N_{Season}} \overline{Prop}_{we}\right) \qquad \text{Equation 6}$$

where:

N_{wd} is the number of weekdays in the season.

N_{we} is the number of weekend days and public holidays in the season.

N_{Season} is the total number of days in the season $(N_{wd} + N_{we})$

$\overline{Prop}_{wd}$ is the mean daily proportion of boat parties that had been recreational fishing for weekdays in a season.

$\overline{Prop}_{we}$ is the mean daily proportion of boat parties that had been recreational fishing for weekend days and public holidays in a season.

$\overline{Prop}_{Season}$ is the mean daily proportion of boat parties that had been recreational fishing for a season.

7.2.3.3 Fishing effort (boat trips)

Recreational fishing effort in boat days ($\widehat{E}_{\mathrm{j}}$) between nautical sunrise and nautical sunset was then calculated.

$$\widehat{E}_{\mathrm{j}} = \hat{P}_j \, \overline{Prop}_{\mathrm{j}} \qquad \text{Equation 7}$$

7.2.3.4 Harvest rate and catch rate

The mean daily harvest rate $\left(\bar{R}_{\mathrm{j}}\right)$ between nautical sunrise and nautical sunset was calculated for each day type stratum in each season.

$$\bar{R}_{\mathrm{j}} = \frac{\sum \bar{R}_{k\mathrm{j}}}{n_j} \qquad \text{Equation 8}$$

As per the seasonal proportion of boats that had been recreationally fishing, the calculation of seasonal harvest rates and catch rates was done by combining the mean values for each day type within a season. The contribution of each day type stratum to the estimated seasonal harvest rate and catch rate was weighted by the relative size of each day type stratum in a season.

$$\bar{R}_{Season} = \left(\frac{N_{wd}}{N_{Season}} \; \bar{R}_{wd}\right) + \left(\frac{N_{we}}{N_{Season}} \; \bar{R}_{we}\right) \qquad \text{Equation 9}$$

where:

$\bar{R}_{wd}$ is the mean daily harvest rate or catch rate for weekdays in a season.

$\bar{R}_{we}$ is the mean daily harvest rate or catch rate for weekend days and public holidays in a season.

$\bar{R}_{Season}$ is the mean daily harvest rate or catch rate for a season.

7.2.3.5 Harvest and catch

The estimated harvest and catch between nautical sunrise and nautical sunset was then calculated for each day type stratum in each season.

$$\widehat{C}_{\mathrm{j}} = \widehat{E}_j \, \bar{R}_{\mathrm{j}} \qquad \text{Equation 10}$$

7.2.4 Calculate annual totals from stratum totals

7.2.4.1 Effort

This was done by adding the fishing effort estimates of the day type strata together to obtain season totals, then by adding season totals to obtain annual totals for each ramp.

$$\hat{E}_{Tot} = \sum_{j=1}^{J} \hat{E}_{\mathrm{j}}$$ Equation 11

where $\hat{E}_{Tot}$ is total fishing effort (in boat trips) calculated by combining the estimates of each stratum. The term $\hat{E}_{Tot}$ refers to season effort totals when adding day type strata and to the annual effort total when season totals are combined.

7.2.4.2 Harvest and catch

This was done by adding the harvest and catch estimates of the day type strata together to obtain season totals, then by adding season totals to obtain annual totals, and then by adding the annual totals for each ramp to obtain a total for all three ramps combined.

$$\hat{C}_{Tot} = \sum_{j=1}^{J} \hat{C}_{\mathrm{j}}$$ Equation 12

where $\hat{C}_{Tot}$ is the total harvest or total catch calculated by combined the estimates of each stratum. The term $\hat{C}_{Tot}$ refers to season totals when adding day type strata, to the annual total when monthly totals are combined, and to the annual total from all three ramps when adding the three ramp totals together.

7.2.4.3 Catch by weight for Pink Snapper

This was done using the expanded estimate of the annual harvest in numbers and the average weight ($\overline{w}$) based on average weight data collected during the onsite survey. Because of the small sample size for the average weight in most strata, the conversion was applied to the annual catch total.

$$\hat{W}_{Tot} = \hat{C}_{Tot}\,\overline{w}$$ Equation 13

7.2.5 Calculate the precision of the estimates

7.2.5.1 Powerboat retrievals

$$Var(\bar{P}_j) = \frac{s_j^2}{n_j}\left(\frac{N_j - n_j}{N_j}\right)$$ Equation 14

$Var\left(\bar{P}_j\right)$ is the estimated variance of the mean daily number of powerboat retrievals between nautical sunrise and nautical sunset for the jth day type stratum within a season. The finite population correction factor was applied to the variance and standard error of the estimated number of powerboat retrievals for a stratum because >20% full PSU coverage was achieved for each stratum (refer to Steffe *et al.*, 2017).

$$SE\ (\bar{P}_j) = \sqrt{var(\bar{P}_j)}$$ Equation 15

where:

$SE\ (\bar{P}_j)$ is the estimated standard error of the mean daily number of powerboat retrievals.

$$Var(\hat{P}_j) = N_j^2\ Var\ (\bar{P}_j)$$ Equation 16

where:

$Var(\hat{P}_j)$ is the estimated variance of the total number of powerboat retrievals between nautical sunrise and nautical sunset for a stratum, calculated separately for each day type within each season.

$$SE(\hat{P}_j) = \sqrt{var\ (\hat{P}_j)}$$ Equation 17

where:

$SE(\hat{P}_j)$ is the estimated standard error of the total number of powerboat retrievals for a stratum.

$$Var(\hat{P}_{Tot}) = \sum_{j=1}^{J} var\ (\hat{P}_j)$$ Equation 18

where:

$Var(\hat{P}_{Tot})$ is the estimated total variance calculated by combining the estimated variances for each stratum. The term $Var(\hat{P}_{Tot})$ refers to season variance totals when adding variances from day type strata and the annual variance when season variances are combined for each ramp.

$$SE(\hat{P}_{Tot}) = \sqrt{var\ (\hat{P}_{Tot})}$$ Equation 19

7.2.5.2 Seasonal proportion of boat parties that had been recreational fishing

The estimates of variance for the stratified mean daily proportions of boat parties that had been recreational fishing between nautical sunrise and nautical sunset were calculated using the following equation:

$$Var\ (\overline{Prop}_{Season}) = \left[\left(\frac{N_{wd}}{N_{Season}}\right)^2 Var\ (\overline{Prop}_{wd})\right] + \left[\left(\frac{N_{we}}{N_{Season}}\right)^2 Var\ (\overline{Prop}_{we})\right]$$

Equation 20

where:

$Var\ (\overline{Prop}_{Season})$ is the estimated variance for the stratified mean daily proportion of boat parties that had been recreational fishing for a season.

$Var\ (\overline{Prop}_{wd})$ is the estimated variance for the mean daily harvest rates for the weekday stratum in a season.

$Var\ (\overline{Prop}_{we})$ is the estimated variance for the mean daily harvest rates for the weekend days and public holidays stratum in a season.

The estimates of standard errors for the stratified mean daily harvest rates for each season were calculated using the following equation:

$$SE(\overline{Prop}_{Season}) = \sqrt{var\ (\overline{Prop}_{Season})} \quad \text{Equation 21}$$

where $SE(\overline{Prop}_{Season})$ is the standard error of the stratified mean daily proportion of boat parties that had been recreationally fishing.

7.2.5.3 Effort (boat days)

The variance of recreational fishing effort, $Var(\hat{E})$, was derived from the variance of a product (Goodman, 1960) based on the expanded estimate of the number of powerboat retrievals for a stratum $(\hat{P}_j)$ and the mean proportion of boat parties that had been recreational fishing $\overline{(Prop}_j)$.

$$Var(\hat{E}) = \left[\hat{P}_j^{\,2} \times Var\ (\overline{Prop}_j)\right] + \left[\overline{Prop}_j^{\,2} \times Var\ (\hat{P}_j)\right] - \left[Var(\hat{P}_j) \times Var\ (\overline{Prop}_j)\right] \quad \text{Equation 22}$$

where the variance component for $\overline{Prop}_j$ was estimated from

$$Var(\overline{Prop}_j) = \frac{s_j^2}{n_j} \quad \text{Equation 23}$$

The standard error for recreational fishing effort in a stratum was calculated using the following equation:

$$SE = (\hat{E})\sqrt{Var(\hat{E})}) \quad \text{Equation 24}$$

where $SE(\hat{E})$ is the standard error of recreational fishing effort in a stratum.

7.2.5.4 Seasonal harvest rate and catch rate

The estimates of variance for the stratified mean harvest rate or catch rate were calculated using the following equation:

$$Var\ (\bar{R}_{Season}) = \left[\left(\frac{N_{wd}}{N_{Season}}\right)^2 Var\ (\bar{R}_{wd})\right] + \left[\left(\frac{N_{we}}{N_{Season}}\right)^2 Var\ (\bar{R}_{we})\right] \quad \text{Equation 25}$$

where:

$Var\ (\bar{R}_{Season})$ is the estimated variance for the mean daily harvest rate for a season.

$Var\ (\bar{R}_{wd})$ is the estimated variance for the mean daily harvest rate for the weekday stratum in a season.

$Var\ (\bar{R}_{we})$ is the estimated variance for the mean daily harvest rate for the weekend stratum in a season.

The estimates of standard errors for the stratified mean daily harvest rates for each season were calculated using the following equation:

$$SE(\bar{R}_{Season}) = \sqrt{var\ (\bar{R}_{Season})} \quad \text{Equation 26}$$

where $SE(\bar{R}_{Season})$ is the standard error of the stratified mean daily harvest rates in a season.

7.2.5.5 Harvest and catch (in numbers, for each ramp)

The variance of the harvest and catch (numbers of fish; $Var(\hat{C})$) was derived from the variance of a product (Goodman, 1960) based on the expanded estimate of fishing effort and the harvest or catch rate.

$$Var(\hat{C}) = \left[\hat{E}^2 \times Var\ (\bar{R}_j)\right] + \left[\bar{R}_j{}^2 \times Var\ (\hat{E})\right] - \left[Var(\hat{E}) \times Var\ (\bar{R}_j)\right] \quad \text{Equation 27}$$

where the variance component for $\bar{R}_j$ was estimated from

$$Var(\bar{R}_j) = \frac{s_j^2}{n_j} \quad \text{Equation 28}$$

7.2.5.6 Harvest and catch (by weight, for each ramp)

This was done using the variance of a product (Goodman, 1960).

$$Var(\hat{W}) = \left[\hat{C}^2 \times Var\ (\bar{w})\right] + \left[\bar{w}^2 \times Var\ (\hat{C})\right] - \left[Var(\bar{w}) \times Var\ (\hat{C})\right] \quad \text{Equation 29}$$

where the variance component for $\bar{w}$ was estimated from

$$Var(\bar{w}) = \frac{s_j^2}{n_j} \quad \text{Equation 30}$$

7.2.5.7 Harvest and catch (in numbers, all three ramps combined)

The variance of the harvest and catch for all three ramps combined $Var(\hat{C}_{Tot})$ was calculated by combining the estimated variances for each ramp.

$$Var(\hat{C}_{Tot}) = \sum_{j=1}^{J} var\ (\hat{C}) \quad \text{Equation 31}$$

Appendix 8. Formulae used for the expansion of the Aerial Survey data.

8.1 Method

An aerial survey of Freycinet Estuary was conducted between March and August 2018. Flights were completed on a random sample of days during which boat ramp surveys were conducted at Nanga. Within each season, days were stratified into weekdays and weekend days and public holidays. On each day, a flight period (secondary sampling unit) was chosen with unequal probability and with replacement (refer to Aerial Survey of Freycinet Estuary).

8.2 Analysis

8.2.1 Basic notation

j Denotes the stratum being considered ($j = 1, \dots, J$)

J Denotes the total number of strata

i Denotes the primary sampling unit (PSU, day) within the stratum ($i = 1, \dots, N_j$)

N_j Denotes the total population size (all possible sampling days) in stratum j

n_j Denotes the sample size in stratum j

z_{ij} Denotes the value of the ith unit of stratum j

$\overline{z}_j$ Denotes the sample mean for stratum j

$$s_j^2 = \left[\frac{\sum_{i=1}^{n_j}(z_{ij} - \bar{z}_j)^2}{(n_j - 1)}\right]$$

is the sample variance for stratum j

8.2.2 Single survey day

Fishing effort (in boat party hours) during flight period t for day k in the jth daytype (2 levels; weekdays (WD), weekend days and public holidays (WE/PH)) in a season (2 levels; Autumn = March–May; Winter = June–August) was estimated by:

$$\hat{e}_{tkj} = \frac{I_{tkj}}{T_{tkj}/T^*_{tkj}} = \frac{I_{tkj}T^*_{tkj}}{T_{tkj}} \qquad \text{Equation 1}$$

which is the instantaneous count (I_{tkj}) of boats identified during the flight divided by the relative length of the flight time (T_{tkj}) to the scheduled duration of the flight period (T^*_{tkj}).

Thus, on those days where the actual flight time was not 120 minutes, the instantaneous count was adjusted (refer to 7.1).

Total recreational fishing effort for day k in the jth day type between 07:00 and 17:00 was obtained by expansion:

$$\hat{E}_{kj} = \sum_{i=1}^{n} \frac{\hat{e}_{tkj}}{\pi_{tkj}}$$ Equation 2

where π_{tkj} is the probability that flight period t was included in the sample for day k in the jth day type based on the following selection probabilities (07:00–08:59=0.2; 09:00–10:59=0.3; 11:00–12:59=0.2; 13:00–14:59=0.2; 15:00–16:59=0.1).

8.2.3 Expansion to stratum totals

8.2.3.1 Fishing effort

Daily effort values for the 10-hour survey day (between 07:00 and 17:00) were expanded for each day type stratum in autumn and winter. This was done by multiplying the number of possible sample days in each stratum by the mean of the daily fishing effort.

$$\bar{E}_{\mathrm{j}} = \frac{\sum \hat{E}_{\mathrm{kj}}}{n_j}$$ Equation 3

where $\bar{E}_{\mathrm{j}}$ is the estimate of mean daily fishing effort for the jth day type, in units of boat party hours.

$$\hat{E}_{\mathrm{j}} = N_j \, \bar{E}_{\mathrm{j}}$$ Equation 4

where $\hat{E}_{\mathrm{j}}$ is the estimate of total fishing effort for the jth day type, in units of boat hours.

8.2.4 Calculate annual totals from stratum totals

8.2.4.1 Fishing effort

This was done by adding the fishing effort estimates of the day type strata together to obtain season totals, then by adding the autumn and winter totals to obtain a 6-month total.

$$\hat{E}_{Tot} = \sum_{j=1}^{J} \hat{E}_{\mathrm{j}}$$ Equation 5

where $\hat{E}_{Tot}$ is total fishing effort calculated by combining the estimates of each stratum. The term $\hat{E}_{Tot}$ refers to season effort totals when adding day type strata, and to the 6-month total when the totals for autumn and winter are combined.

8.2.5 Calculate the precision of the estimates

8.2.5.1 Fishing effort

$$Var(\bar{E}_j) = \frac{s_j^2}{n_j}$$ Equation 6

where $Var\left(\bar{E}_j\right)$ is the estimated variance of mean daily fishing effort for the jth day type in a season

$$SE\ (\bar{E}_j) = \sqrt{Var\left(\bar{E}_j\right)}$$ Equation 7

where $SE\ (\bar{E}_j)$ is the estimated standard error of mean daily fishing effort.

$$Var(\hat{E}_j) = N_j^2\ Var\ (\bar{E}_j)$$ Equation 8

where $Var(\hat{E}_j)$ is the estimated variance of total effort for a stratum, calculated separately for each day type within each season.

$$SE\left(\hat{E}_{\mathrm{j}}\right)\ = \sqrt{Var(\hat{E}_j)}$$ Equation 9

where $SE\left(\hat{E}_{\mathrm{j}}\right)$ is the estimated standard error of total effort for a stratum.

$$Var(\hat{E}_{Tot})\ =\ \sum_{j=1}^{J} Var\left(\hat{E}_{\mathrm{j}}\right)$$ Equation 10

where $Var(\hat{E}_{Tot})$ is the estimated total variance calculated by combining the estimated effort variances for each stratum. The term $Var(\hat{E}_{Tot})$ refers to season variance totals when adding variances from day type strata and to the 6 month variance when autumn and winter variances are combined.

$$SE(\hat{E}_{Tot})\ = \sqrt{Var(\hat{E}_{Tot})}$$ Equation 11

where $SE\left(\widehat{E_{\mathrm{Tot}}}\right)$ is the estimated standard error of total effort for a stratum.

Appendix 9. Formulae used for the integration of the Freycinet Estuary Survey data.

9.1 Method

The estimation of the kept catch of Pink Snapper for Freycinet Estuary required the integration of data collected from the Supplementary Access Point Survey and the Aerial Survey. The fishing effort data obtained from the Aerial Survey was used to upscale the ramp-based estimated kept catch of Pink Snapper at Nanga according to the steps outlined below. Because the aerial survey was conducted between March 2018 and August 2018, the estimated kept catch of Pink Snapper for Freycinet Estuary was restricted to this 6-month period.

9.2 Analysis

9.2.1 Basic notation

j Denotes the stratum being considered ($j = 1, \dots, J$)

J Denotes the total number of strata

i Denotes the primary sampling unit (PSU, day) within the stratum ($i = 1, \dots, N_j$)

N_j Denotes the total population size (all possible sampling days) in stratum j

n_j Denotes the sample size in stratum j

z_{ij} Denotes the value of the ith unit of stratum j

$\overline{z}_j$ Denotes the sample mean for stratum j

$$s_j^2 = \left[\frac{\sum_{i=1}^{n_j}(z_{ij} - \bar{z}_j)^2}{(n_j - 1)}\right]$$

is the sample variance for stratum j

9.2.2 Adjusting for fishing activity occurring outside of the aerial survey

The scheduling of flights was restricted to a 10-h period between 07:00 and 17:00. However, remote camera data and interviews with boat parties at Nanga revealed fishing activity outside of this period. As such, the number of powerboat retrievals at Nanga was used to adjust the estimates of fishing effort from the aerial survey to account for activity that occurred outside of the scheduling of the aerial survey.

This adjustment was based on the mean proportion of daily powerboat retrievals that occurred during the timing of the 10-hr aerial survey. Based on interviewing fishing parties at Nanga, the mean travel time from the ramp to the fishing location (in mins) was estimated for each

stratum and this was added to the 10-hr period, assuming an equal travel time to and from the fishing location. This additional step was necessary because the aerial survey provided counts of boats that were fishing at the time of the flight and boats that were transiting from the fishing location and returning to the ramp at Nanga were not included in the estimation of fishing effort. The total fishing day was defined as the period between nautical sunrise and nautical sunset.

Adjusted fishing effort was thus:

$$\hat{E}_{jadj} = \frac{\hat{E}_{\mathrm{j}}}{\bar{d}_j} \qquad \text{Equation 1}$$

where $\hat{E}_{\mathrm{j}}$ is an estimate of total fishing effort for the jth day type (2 levels; weekdays (WD), weekend days and public holidays (WE/PH)) in a season (2 levels; Autumn = March–May; Winter = June–August), in units of boat party hours (refer to Appendix 8) and $\bar{d}_j$ is an estimate of the mean proportion of daily powerboat retrievals (between nautical sunrise and sunset) that occurred during the scheduling of the aerial survey for the jth day type stratum in autumn and winter.

9.2.3 Converting unit of measurement from boat party hours to boat trips

The unit of measurement for adjusted fishing effort was converted from boat party hours to boat trips using the interview data collected at Nanga. This conversion was done at the stratum level using the mean daily fishing time (in mins).

Adjusted fishing effort expressed in the number of trips was thus:

$$\hat{E}_{jadjnew} = \frac{\hat{E}_{jadj}}{\bar{t}_{jboat}} \qquad \text{Equation 2}$$

where $\bar{t}_{jboat}$ is the mean daily fishing time per boat party (in mins) for the jth day type in autumn and winter.

9.2.4 Estimating total kept catch of Pink Snapper for Freycinet Estuary

The estimated total kept catch of Pink Snapper for Freycinet Estuary was then calculated for each day type stratum in autumn and winter

$$\hat{C}_{\mathrm{j}} = \hat{E}_{jadjnew}\,\bar{R}_{\mathrm{j}} \qquad \text{Equation 3}$$

where $\hat{C}_{\mathrm{j}}$ is the estimated kept catch of Pink Snapper in Freycinet Estuary within each stratum and $\bar{R}_{\mathrm{j}}$ is the mean daily harvest rate of Pink Snapper (refer to Appendix 7).

9.2.5 Calculate 6-month total from stratum totals

9.2.5.1 Fishing effort

This was done by adding the adjusted fishing effort estimates of the day type strata together to obtain season totals, then by adding the autumn and winter totals to obtain a 6-month total.

$$\hat{E}_{Totadj} = \sum_{j=1}^{J} \hat{E}_{jadjnew}$$ Equation 4

where $\hat{E}_{Totadj}$ is total fishing effort calculated by combining the estimates of each stratum. The term $\hat{E}_{Totadj}$ refers to season effort totals when adding day type strata, and to the 6-month total when the totals for autumn and winter are combined.

9.2.5.2 Harvest and catch

This was done by adding the harvest and catch estimates of the day type strata together to obtain season totals, then by adding season totals to obtain annual totals.

$$\hat{C}_{Tot} = \sum_{j=1}^{J} \hat{C}_{\mathrm{j}}$$ Equation 5

where $\hat{C}_{Tot}$ is the total harvest or total catch calculated by combined the estimates of each stratum. The term $\hat{C}_{Tot}$ refers to season totals when adding day type strata, and to the annual total when seasonal totals are combined.

9.2.5.3. Converting total catch for catch in numbers to catch by weight

This was done using the expanded estimate of the annual harvest in numbers for Freycinet Estuary and the average weight ($\overline{w}$) based on average weight data collected during the onsite survey at Nanga. Because of the relatively small number of fish weighed in some strata, the average weight data were pooled at the individual boat party level.

$$\hat{W}_{Tot} = \hat{C}_{Tot}\,\overline{w}$$ Equation 6

9.2.6 Calculate the precision of the estimates

9.2.6.1 Fishing effort

The variance of adjusted fishing effort was approximated using Taylor expansion for the variance of a ratio (Stuart and Ord, 1998):

$$Var(\hat{E}_{jadj}) \left(\frac{(\widehat{E_{\mathrm{j}}})^2}{(\bar{d}_j)^2}\left[\frac{Var(\hat{E}_{\mathrm{j}})}{(\hat{E}_{\mathrm{j}})^2} + \frac{Var(\bar{d}_j)}{(\bar{d}_j)^2}\right]\right)$$ Equation 7

where the variance components for $\hat{E}_{\mathrm{j}}$ is presented in equation 8 of Appendix 8 and the variance component for $\bar{d}_j$ was estimated from:

$$Var(\bar{d}_j) = \frac{s_j^2}{n_j}\left(\frac{N_{j-}n_j}{N_j}\right)$$ Equation 8

The finite population correction factor was applied to the variance of $\bar{d}_j$ because this proportion was based on those counts of powerboat retrievals obtained from the remote camera data and >20% full PSU coverage was achieved for each stratum (refer to Steffe *et al.*, 2017). A covariance term for $\widehat{E}_j$ and $\bar{d}_j$ was not included because these two estimates were derived from separate, independent methods; i.e. $\widehat{E}_j$ was obtained from the Aerial Survey and $\bar{d}_j$ from the Supplementary Access Point Survey. It was thus assumed that fishing effort was not correlated with the mean proportion of daily fishing effort that occurred within the scheduling of the Aerial Survey.

The variance of adjusted fishing effort (number of boat trips) was also approximated using Taylor expansion for the variance of a ratio (Stuart and Ord, 1998).

$$Var\left(\hat{E}_{jadjnew}\right) = \left(\frac{\left(\hat{E}_{jadj}\right)^2}{\left(\bar{t}_{jboat}\right)^2}\left[\frac{Var\left(\hat{E}_{jadj}\right)}{\left(\hat{E}_{jadj}\right)^2} + \frac{Var\left(\bar{t}_{jboat}\right)}{\left(\bar{t}_{jboat}\right)^2}\right]\right) \quad \text{Equation 9}$$

A covariance term for $\widehat{E}_j adj$ and $\bar{t}_{jboat}$ was not included and it was assumed that the number of boat trips in a stratum was not correlated with the mean daily fishing time per boat party.

The standard error of the estimated variance of recreational fishing effort in Freycinet Estuary for a stratum was calculated separately for each day type within each season.

$$SE\left(\hat{E}_{jadjnew}\right) = \sqrt{Var(\hat{E}_{jadjnew})} \quad \text{Equation 10}$$

where $SE\left(\widehat{E}_j\right)$ is the estimated standard error of total effort for a stratum.

$$Var(\hat{E}_{Totadj}) = \sum_{j=1}^{J} Var\left(\hat{E}_{jadjnew}\right) \quad \text{Equation 11}$$

Where $Var(\hat{E}_{Totadj})$ is the estimated total variance calculated by combining the estimated effort variances for each stratum. The term $Var(\hat{E}_{Totadj})$ refers to season variance totals when adding variances from day type strata and to the 6 month variance when autumn and winter variances are combined.

$$SE(\hat{E}_{Totadj}) = \sqrt{Var(\hat{E}_{Totadj})} \quad \text{Equation 12}$$

where $SE\left(\hat{E}_{Totadj}\right)$ is the estimated standard error of total effort for a stratum.

9.2.6.2 Kept catch (numbers of fish)

The variance of the estimated kept catch (numbers of fish; $Var\left(\hat{C}_{Tot}\right)$) was estimated using the variance of the product of two independent random variables (Goodman, 1960):

$$Var\left(\hat{C}_{Tot}\right) = \left[\left(\hat{E}_{jadjnew}\right)^2 Var\left(\bar{R}_j\right)\right] + \left[\left(\bar{R}_j\right)^2 Var\left(\hat{E}_{adjnew}\right)\right] - \left[Var\left(\hat{E}_{adjnew}\right) Var\left(\bar{R}_j\right)\right] \quad \text{Equation 13}$$

where the variance components for $\bar{R}_j$ is presented in equation 22 of Appendix 7.

9.2.6.3 Harvest and Catch (weight)

This was done using the variance of a product (Goodman, 1960).

$$Var(\widehat{W}_{Tot}) = \left[\hat{C}_{Tot}{}^2\, Var\,(\overline{w})\right] + \left[\overline{w}^2\; Var\left(\hat{C}_{Tot}\right)\right] - \left[Var\left(\hat{C}_{Tot}\right) Var\,(\overline{w})\right]$$

Equation 14

where the variance components for $\overline{w}$ is presented in equation 30 of Appendix 7.

Appendix 10. Camera outages at Denham between March 2018 and February 2019.

White cells indicate no or minor outages (proportion missing < 0.5 in each 2-hr period), grey cells indicate major outages (proportion missing ≥ 0.5 in each 2-hr period). No major outages occurred during the survey.

	Date																														
Month	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**
M																															
A																															
M																															
J																															
J																															
A																															
S																															
O																															
N																															
D																															
J																															
F																															

Appendix 11. Camera outages at Monkey Mia between March 2018 and February 2019.

White cells indicate no or minor outages (proportion missing < 0.5 in each 2-hr period), grey cells indicate major outages (proportion missing ≥ 0.5 in each 2-hr period).

	Date																													
Month	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**
M																															
A																															
M																															
J																															
J																															
A																															
S																															
O																															
N																															
D																															
J																															
F																															

Appendix 12. Camera outages at Nanga between March 2018 and February 2019.

White cells indicate no or minor outages (proportion missing < 0.5 in each 2-hr period), grey cells indicate major outages (proportion missing ≥ 0.5 in each 2-hr period), black cells indicate the period in which the Nanga Bay Resort was closed and access to the boat ramp was cut off.

	Date																													
Month	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**
M																															
A																															
M																															
J																															
J																															
A																															
S																															
O																															
N																															
D																															
J																															
F																															

Appendix 13. Blue Swimmer Crab mean daily harvest rates (HPUE, number kept per boat) and catch rates (CPUE, number kept and released) for inner Shark Bay by ramp for each season and day type.

		Denham				Monkey Mia				Nanga			
Season	**Day Type**	**HPUE**	**se**	**CPUE**	**se**	**HPUE**	**se**	**CPUE**	**se**	**HPUE**	**se**	**CPUE**	**se**
Aut 18	WD	0.00	0.00	0.00	0.00	6.56	2.60	8.02	3.12	0.00	0.00	0.00	0.00
	WE/PH	0.00	0.00	0.00	0.00	3.55	1.22	4.96	1.60	0.00	0.00	0.00	0.00
	Total	0.00	0.00	0.00	0.00	5.58	1.79	7.02	2.17	0.00	0.00	0.00	0.00
Win 18	WD	0.00	0.00	0.00	0.00	10.32	2.58	18.30	3.50	0.00	0.00	0.00	0.00
	WE/PH	0.07	0.05	0.07	0.05	9.86	1.87	16.92	3.16	0.00	0.00	0.00	0.00
	Total	0.02	0.01	0.02	0.01	10.19	1.90	17.90	2.64	0.00	0.00	0.00	0.00
Spr 18	WD	0.00	0.00	0.00	0.00	8.75	2.42	11.76	3.06	0.00	0.00	0.00	0.00
	WE/PH	0.00	0.00	0.00	0.00	7.68	1.31	18.21	5.57	0.00	0.00	0.00	0.00
	Total	0.00	0.00	0.00	0.00	8.43	1.74	13.67	2.71	0.00	0.00	0.00	0.00
Sum 18/19	WD	0.00	0.00	0.00	0.00	3.15	1.69	3.98	2.20	0.00	0.00	0.00	0.00
	WE/PH	0.00	0.00	0.00	0.00	8.99	3.26	16.96	8.20	0.00	0.00	0.00	0.00
	Total	0.00	0.00	0.00	0.00	5.02	1.56	8.17	3.03	0.00	0.00	0.00	0.00
Total	WD	0.00	0.00	0.00	0.00	7.26	1.18	10.65	1.51	0.00	0.00	0.00	0.00
	WE	0.02	0.01	0.02	0.01	7.44	1.04	14.06	2.64	0.00	0.00	0.00	0.00
	Total	0.01	0.00	0.01	0.00	7.32	0.88	11.70	1.33	0.00	0.00	0.00	0.00

Appendix 14. Pink Snapper mean daily harvest rates (HPUE, number kept per boat) and catch rates (CPUE, number kept and released) for inner Shark Bay by ramp for each season and day type.

		Denham				Monkey Mia				Nanga			
Season	**Day Type**	**HPUE**	**se**	**CPUE**	**se**	**HPUE**	**se**	**CPUE**	**se**	**HPUE**	**se**	**CPUE**	**se**
Aut 18	WD	0.34	0.08	6.30	1.08	0.04	0.02	3.86	0.93	0.94	0.35	10.26	2.93
	WE/PH	0.33	0.13	10.53	2.40	0.04	0.04	3.58	1.00	0.72	0.38	8.59	4.95
	Total	0.34	0.07	7.68	1.07	0.04	0.02	3.77	0.71	0.86	0.26	9.71	2.55
Win 18	WD	0.66	0.13	5.94	1.05	0.05	0.05	3.75	1.48	1.45	0.27	19.00	2.22
	WE/PH	0.38	0.10	3.94	1.12	0.40	0.40	4.39	1.95	0.79	0.34	9.00	5.54
	Total	0.58	0.10	5.35	0.81	0.15	0.12	3.94	1.19	1.25	0.21	11.67	2.26
Spr 18	WD	0.41	0.15	6.48	2.42	0.24	0.10	2.85	0.79	0.43	0.43	6.64	3.85
	WE/PH	0.23	0.23	7.60	4.43	0.16	0.08	3.81	1.77	0.30	0.30	0.30	0.30
	Total	0.36	0.13	6.81	2.15	0.21	0.07	3.13	0.77	0.39	0.31	4.76	2.71
Sum 18/19	WD	0	0	0.69	0.50	0.04	0.04	3.11	1.31	-	-	-	-
	WE/PH	0	0	0.00	0.00	0.34	0.22	6.94	3.74	0	0	0	0
	Total	0	0	0.47	0.34	0.14	0.08	4.34	1.50	0	0	0	0
Total	WD	0.36	0.06	4.90	0.73	0.09	0.03	3.39	0.58	0.71	0.15	7.08	1.34
	WE	0.24	0.07	5.55	1.27	0.23	0.11	4.69	1.18	0.45	0.15	5.46	1.87
	Total	0.32	0.04	5.10	0.64	0.14	0.04	3.79	0.54	0.63	0.12	6.58	1.09

Appendix 15. Grass Emperor mean daily harvest rates (HPUE, number kept per boat) and catch rates (CPUE, number kept and released) for inner Shark Bay by ramp for each season and day type.

		Denham				Monkey Mia				Nanga			
Season	**Day Type**	**HPUE**	**se**	**CPUE**	**se**	**HPUE**	**se**	**CPUE**	**se**	**HPUE**	**se**	**CPUE**	**se**
Aut 18	WD	1.46	0.33	5.82	1.04	0.56	0.13	2.22	0.56	0.38	0.19	1.02	0.33
	WE/PH	1.67	0.72	4.35	1.25	1.28	0.74	3.04	1.67	0.23	0.15	0.36	0.20
	Total	1.52	0.33	5.34	0.81	0.80	0.26	2.49	0.66	0.33	0.13	0.80	0.23
Win 18	WD	0.58	0.14	1.70	0.43	0.13	0.10	0.31	0.21	0.21	0.06	0.60	0.22
	WE/PH	0.61	0.27	3.27	1.63	0.25	0.13	0.42	0.24	0.03	0.03	0.11	0.05
	Total	0.59	0.13	2.16	0.57	0.17	0.08	0.34	0.17	0.16	0.05	0.46	0.16
Spr 18	WD	0.37	0.11	1.00	0.37	0.04	0.03	0.20	0.11	0.29	0.18	1.00	0.85
	WE/PH	3.50	2.32	13.10	5.33	0.06	0.04	0.31	0.17	0.00	0.00	0.00	0.00
	Total	1.30	0.69	4.59	1.60	0.04	0.02	0.23	0.09	0.20	0.13	0.70	0.59
Sum 18/19	WD	0.09	0.09	0.27	0.19	0.55	0.26	1.65	1.14	-	-	-	-
	WE/PH	0.00	0.00	0.00	0.00	0.59	0.34	3.15	2.00	0.00	0.00	0.00	0.00
	Total	0.06	0.06	0.18	0.13	0.56	0.21	2.14	1.01	0.00	0.00	0.00	0.00
Total	WD	0.62	0.10	2.19	0.30	0.31	0.08	1.08	0.31	0.22	0.07	0.66	0.24
	WE	1.42	0.59	5.07	1.37	0.56	0.22	1.79	0.68	0.07	0.04	0.12	0.05
	Total	0.87	0.19	3.08	0.47	0.39	0.09	1.30	0.30	0.17	0.05	0.49	0.16

Appendix 16. Estimated annual catch (kept, released and total numbers) and percentage released by boat-based recreational fishers at Denham for inner Shark Bay and oceanic fishing trips between March 2018 and February 2019. Values in bold indicate a relative standard error >40% (i.e. se >40% of the estimate).

Reporting Group	Common Name	Scientific Name	Kept	se	Rel	se	Total	se	% Rel
Billfish	Black Marlin	*Makaira indica*	0	0	**1**	**1**	**1**	**1**	100
Bream	Frypan Bream	*Argyrops spinifer*	**49**	**49**	**39**	**39**	**88**	**88**	44
Bream	Pink Snapper	*Chrysophrys auratus*	2,051	231	22,878	2,464	24,930	2,566	92
Bream	Tarwhine	*Rhabdosargus sarba*	**15**	**12**	**28**	**23**	**42**	**34**	65
Bream	Western Yellowfin Bream	*Acanthopagrus morrisoni*	**220**	**184**	**387**	**363**	**607**	**545**	64
Catfish	Forktail Catfishes	*Ariidae - undifferentiated*	0	0	**2**	**2**	**2**	**2**	100
Cephalopod	Cuttlefish	*Sepia spp.*	**107**	**48**	**22**	**20**	**128**	**55**	17
Cephalopod	Octopuses	*Octopodidae - undifferentiated*	**7**	**6**	**6**	**5**	**13**	**7**	46
Cephalopod	Squid	*Order Teuthoidea - undifferentiated*	**2,504**	**1,509**	**917**	**884**	**3,421**	**2,374**	27
Cobia	Cobia	*Rachycentron canadum*	65	19	**19**	**11**	84	26	22
Cod	Birdwire Rockcod	*Epinephelus merra*	**97**	**44**	**93**	**75**	**189**	**89**	49
Cod	Blackspotted Rockcod	*Epinephelus malabaricus*	**30**	**14**	**18**	**17**	**48**	**22**	37
Cod	Chinaman Rockcod	*Epinephelus rivulatus*	**234**	**100**	799	290	1,033	306	77
Cod	Coral Rockcod	*Cephalopholis miniata*	**3**	**2**	0	0	**3**	**2**	0
Cod	Frostback Rockcod	*Epinephelus bilobatus*	**2**	**2**	**22**	**22**	**24**	**24**	92
Cod	Goldspotted Rockcod	*Epinephelus coioides*	**314**	**90**	**111**	**42**	**425**	**101**	26
Cod	Harlequin Fish	*Othos dentex*	0	0	**1**	**1**	**1**	**1**	100
Cod	Potato Rockcod	*Epinephelus tukula*	0	0	**3**	**3**	**3**	**3**	100
Cod	Rankin Cod	*Epinephelus multinotatus*	621	126	419	117	1,040	199	40
Cod	Temperate Basses & Rockcods	*Percichthyidae, Serranidae - undifferentiated*	**27**	**25**	**25**	**20**	**52**	**32**	48
Cod	Tomato Rockcod	*Cephalopholis sonnerati*	**7**	**3**	0	0	**7**	**3**	0

Reporting Group	Common Name	Scientific Name	Kept	se	Rel	se	Total	se	% Rel
Cod	Yellowspotted Rockcod	*Epinephelus areolatus*	**24**	**18**	**11**	**6**	**35**	**19**	31
Coral Trout	Barcheek Coral Trout	*Plectropomus maculatus*	**294**	**151**	**132**	**99**	**425**	**246**	31
Coral Trout	Common Coral Trout	*Plectropomus leopardus*	127	41	**39**	**21**	165	46	23
Coral Trout	Coral Trout	*Plectropomus spp. & Variola spp.*	0	0	**2**	**2**	**2**	**2**	100
Coral Trout	Yellowedge Coronation Trout	*Variola louti*	**19**	**10**	0	0	**19**	**10**	0
Crab	Blue Swimmer Crab	*Portunus armatus*	**25**	**17**	0	0	**25**	**17**	0
Eels	Eels	*Order Anguilliformes - undifferentiated*	0	0	**10**	**7**	**10**	**7**	100
Emperor	Bluespotted Emperor	*Lethrinus punctulatus*	**4**	**4**	**21**	**19**	**25**	**23**	85
Emperor	Grass Emperor	*Lethrinus laticaudis*	4,163	649	10,251	1,763	14,414	1,985	71
Emperor	Redthroat Emperor	*Lethrinus miniatus*	1,037	238	1,251	328	2,288	474	55
Emperor	Robinson's Seabream	*Gymnocranius grandoculis*	**8**	**8**	**5**	**5**	**13**	**10**	37
Emperor	Spangled Emperor	*Lethrinus nebulosus*	165	48	473	131	638	146	74
Emperor	Yellowtail Emperor	*Lethrinus atkinsoni*	0	0	**24**	**24**	**24**	**24**	100
Flathead	Flatheads	*Platycephalidae - undifferentiated*	**14**	**7**	**33**	**25**	**48**	**26**	70
Flathead	Northern Sand Flathead	*Platycephalus endrachtensis*	**10**	**7**	0	0	**10**	**7**	0
Flathead	Yellowtail Flathead	*Platycephalus westraliae*	273	65	201	73	473	98	42
Flounders	Flounders	*Bothidae, Psettodidae & Pleuronectidae*	**15**	**10**	**28**	**25**	**43**	**26**	66
Flounders	Smalltooth Flounder	*Pseudorhombus jenynsii*	**18**	**18**	0	0	**18**	**18**	0
Garfish	Garfishes	*Hemiramphidae - undifferentiated*	**39**	**31**	**47**	**36**	**85**	**55**	55
Garfish	Three-By-Two Garfish	*Hemiramphus robustus*	0	0	**11**	**7**	**11**	**7**	100
Giant Perch	Sand Bass	*Psammoperca waigiensis*	0	0	**16**	**12**	**16**	**12**	100
Goatfish	Bluespotted Goatfish	*Upeneichthys vlamingii*	**3**	**3**	0	0	**3**	**3**	0
Goatfish	Goatfishes	*Mullidae - undifferentiated*	0	0	**4**	**4**	**4**	**4**	100
Grunter	Striped Grunters	*Terapontidae - undifferentiated*	0	0	**163**	**73**	**163**	**73**	100
Grunter	Western Striped Grunter	*Pelates octolineatus*	**12**	**12**	**5**	**4**	**17**	**15**	29
Grunter	Yellowtail Grunter	*Amniataba caudavittata*	0	0	**248**	**153**	**248**	**153**	100

Reporting Group	Common Name	Scientific Name	Kept	se	Rel	se	Total	se	% Rel
Grunter Bream	Goldspotted Sweetlips	*Plectorhinchus flavomaculatus*	**33**	**33**	**1**	**1**	**34**	**33**	3
Grunter Bream	Grunter Breams	*Haemulidae - undifferentiated*	**16**	**11**	**24**	**17**	**40**	**21**	60
Grunter Bream	Painted Sweetlips	*Diagramma labiosum*	**11**	**7**	**31**	**19**	**42**	**24**	74
Gurnard	Gurnard Perches	*Neosebastidae - undifferentiated*	0	0	**5**	**5**	**5**	**5**	100
Gurnard	Searobins & Armour Gurnards	*Triglidae & Peristediidae - undifferentiated*	0	0	**2**	**2**	**2**	**2**	100
Leatherjacket	Horseshoe Leatherjacket	*Meuschenia hippocrepis*	**6**	**4**	**15**	**9**	**20**	**12**	72
Leatherjacket	Triggerfishes & Leatherjackets	*Balistidae, Monacanthidae - undifferentiated*	**3**	**3**	**114**	**60**	**117**	**60**	98
Lizardfish	Common Saury	*Saurida tumbil*	**20**	**20**	**163**	**82**	**182**	**89**	89
Lizardfish	Lizardfishes & Deepsea Lizardfishes	*Bathysauridae, Synodontidae - undifferentiated*	**5**	**3**	145	50	150	50	97
Lobster	Tropical Rock Lobster	*Panulirus spp. except P. cygnus*	**7**	**7**	0	0	**7**	**7**	0
Lobster	Western Rock Lobster	*Panulirus cygnus*	**143**	**61**	**9**	**9**	**152**	**64**	6
Longtom	Longtoms	*Belonidae - undifferentiated*	0	0	**4**	**3**	**4**	**3**	100
Mackerel	Mackerels	*Scombridae - undifferentiated*	0	0	**5**	**5**	**5**	**5**	100
Mackerel	School Mackerel	*Scomberomorus queenslandicus*	494	118	460	136	954	182	48
Mackerel	Shark Mackerel	*Grammatorcynus bicarinatus*	**44**	**23**	50	19	94	33	53
Mackerel	Spanish Mackerel	*Scomberomorus commerson*	**170**	**73**	**57**	**24**	227	76	25
Mackerel	Spotted Mackerel	*Scomberomorus munroi*	**12**	**6**	0	0	**12**	**6**	0
Mackerel	Wahoo	*Acanthocybium solandri*	**1**	**1**	0	0	**1**	**1**	0
Mahi Mahi	Mahi Mahis	*Coryphaena spp.*	**8**	**6**	0	0	**8**	**6**	0
Morwong	Morwongs	*Cheilodactylidae - undifferentiated*	0	0	**4**	**4**	**4**	**4**	100
Mullet	Mullets	*Mugilidae - undifferentiated*	**27**	**27**	0	0	**27**	**27**	0
Mulloway	Mulloway	*Argyrosomus japonicus*	108	29	**183**	**86**	291	97	63
Pearl Perch	Northern Pearl Perch	*Glaucosoma buergeri*	**64**	**26**	0	0	**64**	**26**	0
Pike	Great Barracuda	*Sphyraena barracuda*	**1**	**1**	**16**	**16**	**18**	**16**	93

Reporting Group	Common Name	Scientific Name	Kept	se	Rel	se	Total	se	% Rel
Pike	Pikes	*Sphyraenidae - undifferentiated*	**106**	**75**	**32**	**15**	**138**	**77**	23
Pike	Snook	*Sphyraena novaehollandiae*	**65**	**38**	50	20	115	45	44
Pike	Yellowtail Barracuda	*Sphyraena obtusata*	**25**	**19**	**20**	**20**	**45**	**27**	44
Rays	Guitarfishes	*Rhinobatidae - undifferentiated*	0	0	**3**	**3**	**3**	**3**	100
Remora	Remora	*Remora remora*	0	0	**14**	**14**	**14**	**14**	100
Sea Mullet	Sea Mullet	*Mugil cephalus*	**281**	**278**	**4**	**4**	**285**	**278**	1
Sergeant Baker	Sergeant Baker	*Latropiscis purpurissatus*	0	0	**85**	**67**	**85**	**67**	100
Sharks	Blacktip Reef Shark	*Carcharhinus melanopterus*	0	0	**1**	**1**	**1**	**1**	100
Sharks	Blacktip Shark	*Carcharhinus, Loxodon & Rhizoprionodon spp.*	**2**	**2**	0	0	**2**	**2**	0
Sharks	Bronze Whaler	*Carcharhinus brachyurus*	**5**	**5**	**109**	**80**	**114**	**80**	96
Sharks	Dusky Whaler	*Carcharhinus obscurus*	0	0	**10**	**10**	**10**	**10**	100
Sharks	Hammerhead Sharks	*Sphyrnidae - undifferentiated*	0	0	**15**	**11**	**15**	**11**	100
Sharks	Lemon Shark	*Negaprion acutidens*	0	0	**20**	**12**	**20**	**12**	100
Sharks	Nervous Shark	*Carcharhinus cautus*	**6**	**6**	**6**	**6**	**12**	**12**	50
Sharks	Sandbar Shark	*Carcharhinus plumbeus*	**3**	**3**	**3**	**3**	**6**	**4**	50
Sharks	Spinner Shark	*Carcharhinus brevipinna*	0	0	**2**	**2**	**2**	**2**	100
Sharks	Tiger Shark	*Galeocerdo cuvier*	0	0	**12**	**9**	**12**	**9**	100
Sharks	Western Spotted Gummy Shark	*Mustelus stevensi*	0	0	**7**	**5**	**7**	**5**	100
Sharks	Whaler & Weasel Sharks	*Carcharhinidae, Hemigaleidae - undifferentiated*	**3**	**3**	261	85	264	85	99
Sharks	Whiskery Shark	*Furgaleus macki*	**3**	**3**	0	0	**3**	**3**	0
Sharks	Whitetip Reef Shark	*Triaenodon obesus*	0	0	**8**	**8**	**8**	**8**	100
Tailor	Tailor	*Pomatomus saltatrix*	**112**	**59**	**54**	**37**	**166**	**79**	33
Threadfin Bream	Western Butterfish	*Pentapodus vitta*	**544**	**316**	3,274	569	3,819	771	86
Toadfish	Silver Toadfish	*Lagocephalus sceleratus*	0	0	**434**	**80**	**434**	**80**	100
Toadfish	Toadfishes	*Tetraodontidae - undifferentiated*	0	0	**83**	**62**	**83**	**62**	100
Toadfish	Weeping Toadfish	*Torquigener pleurogramma*	0	0	**5**	**5**	**5**	**5**	100
Trevally	Bludger Trevally	*Carangoides gymnostethus*	**3**	**3**	**8**	**8**	**12**	**9**	70

Reporting Group	Common Name	Scientific Name	Kept	se	Rel	se	Total	se	% Rel
Trevally	Diamond Trevally	*Alectis indica*	0	0	**1**	**1**	**1**	**1**	100
Trevally	Giant Trevally	*Caranx ignobilis*	**1**	**1**	**4**	**3**	**5**	**3**	77
Trevally	Golden Trevally	*Gnathanodon speciosus*	**13**	**7**	**31**	**14**	45	16	70
Trevally	Samsonfish	*Seriola hippos*	**7**	**5**	0	0	**7**	**5**	0
Trevally	Silver Trevally	*Pseudocaranx georgianus spp. complex*	**5**	**5**	0	0	**5**	**5**	0
Trevally	Turrum	*Carangoides fulvoguttatus*	**4**	**3**	**34**	**25**	**37**	**25**	90
Tropical Snapper	Brownstripe Snapper	*Lutjanus vitta*	**2**	**2**	0	0	**2**	**2**	0
Tropical Snapper	Crimson Snapper	*Lutjanus erythropterus*	**3**	**3**	0	0	**3**	**3**	0
Tropical Snapper	Goldband Snapper	*Pristipomoides multidens*	**26**	**16**	0	0	**26**	**16**	0
Tropical Snapper	Golden Snapper	*Lutjanus johnii*	**3**	**3**	0	0	**3**	**3**	0
Tropical Snapper	Mangrove Jack	*Lutjanus argentimaculatus*	**3**	**2**	0	0	**3**	**2**	0
Tropical Snapper	Moses' Snapper	*Lutjanus russellii*	**30**	**18**	**24**	**16**	**53**	**25**	45
Tropical Snapper	Red Emperor	*Lutjanus sebae*	121	43	**38**	**20**	158	58	24
Tropical Snapper	Stripey Snapper	*Lutjanus carponotatus*	530	129	651	193	1,181	267	55
Tuna	Mackerel Tuna	*Euthynnus affinis*	0	0	**6**	**6**	**6**	**6**	100
Tuna	Skipjack Tuna	*Katsuwonus pelamis*	**4**	**4**	**25**	**23**	**29**	**24**	86
Tuna	Southern Bluefin Tuna	*Thunnus maccoyii*	0	0	**1**	**1**	**1**	**1**	100
Tuna	Yellowfin Tuna	*Thunnus albacares*	**8**	**5**	0	0	**8**	**5**	0
Tuskfish & Wrasse	Baldchin Groper	*Choerodon rubescens*	**739**	**445**	**103**	**46**	**842**	**447**	12
Tuskfish & Wrasse	Blackspot Tuskfish	*Choerodon schoenleinii*	450	153	1,082	185	1,532	249	71
Tuskfish & Wrasse	Blue Tuskfish	*Choerodon cyanodus*	**5**	**3**	**22**	**11**	**27**	**12**	83
Tuskfish & Wrasse	Bluebarred Parrotfish	*Scarus ghobban spp. complex*	**4**	**3**	**3**	**3**	**7**	**5**	46
Tuskfish & Wrasse	Bluespotted Tuskfish	*Choerodon cauteroma*	**15**	**14**	**17**	**10**	**38**	**23**	45
Tuskfish & Wrasse	Foxfish	*Bodianus frenchii*	**18**	**10**	0	0	**18**	**10**	0
Tuskfish & Wrasse	Goldspot Pigfish	*Bodianus perditio*	**11**	**10**	0	0	**11**	**10**	0
Tuskfish & Wrasse	Parrotfishes	*Scaridae - undifferentiated*	**2**	**2**	**21**	**14**	**23**	**14**	93
Tuskfish & Wrasse	Pigfishes	*Bodianus spp.*	**1**	**1**	0	0	**1**	**1**	0
Tuskfish & Wrasse	Tuskfishes	*Choerodon spp.*	**5**	**5**	**40**	**28**	**45**	**28**	89

Reporting Group	Common Name	Scientific Name	Kept	se	Rel	se	Total	se	% Rel
Tuskfish & Wrasse	Western King Wrasse	*Coris auricularis*	0	0	**17**	**17**	**17**	**17**	100
Tuskfish & Wrasse	Wrasses	*Labridae - undifferentiated*	0	0	**125**	**57**	**125**	**57**	100
Unknown	*Unknown Species*		21	21	210	117	327	232	64
Whiting	Goldenline Whiting		0	0	**2**	**2**	**2**	**2**	100
Whiting	Western School Whiting	*Sillago vittata*	**257**	**257**	**9**	**9**	**267**	**257**	4
Whiting	Western Trumpeter Whiting	*Sillago burrus*	**48**	**38**	**196**	**100**	**245**	**107**	80
Whiting	Whitings	*Sillaginidae - undifferentiated*	**974**	**796**	**524**	**524**	**1,498**	**1,315**	35
Whiting	Yellowfin Whiting	*Sillago schomburgkii*	**113**	**113**	**62**	**44**	**174**	**151**	36

Appendix 17. Estimated annual catch (kept, released and total numbers) and percentage released by boat-based recreational fishers at Monkey Mia for inner Shark Bay and oceanic fishing trips between March 2018 and February 2019. Values in bold indicate a relative standard error >40% (i.e. se >40% of the estimate).

Reporting Group	Common Name	Scientific Name	Kept	se	Rel	se	Total	se	% Rel
Bonitos	Bonitos	*Sarda australis & Cybiosarda elegans*	0	0	**16**	**16**	**16**	**16**	100
Bream	Pink Snapper	*Chrysophrys auratus*	**601**	**192**	**15,861**	**2,310**	**16,462**	**2,376**	96
Bream	Western Yellowfin Bream	*Acanthopagrus morrisoni*	**48**	**32**	**306**	**177**	**354**	**180**	86
Catfish	Forktail Catfishes	*Ariidae - undifferentiated*	**54**	**27**	**725**	**298**	**778**	**304**	93
Catfish	Giant Sea Catfish	*Netuma thalassina*	**51**	**43**	**1,157**	**676**	**1,208**	**678**	96
Cephalopod	Squid	*Order Teuthoidea - undifferentiated*	**30**	**22**	0	0	**30**	**22**	0
Cobia	Cobia	*Rachycentron canadum*	0	0	**12**	**12**	**12**	**12**	100
Cod	Blackspotted Rockcod	*Epinephelus malabaricus*	**88**	**54**	**27**	**20**	**115**	**67**	23
Cod	Frostback Rockcod	*Epinephelus bilobatus*	**27**	**27**	**7**	**7**	**34**	**34**	20
Cod	Goldspotted Rockcod	*Epinephelus coioides*	498	101	441	119	939	203	47
Cod	Rankin Cod	*Epinephelus multinotatus*	**185**	**79**	313	113	498	158	63
Cod	Yellowspotted Rockcod	*Epinephelus areolatus*	**81**	**44**	**98**	**45**	**179**	**84**	55
Crab	Blue Swimmer Crab	*Portunus armatus*	33,200	3,902	21,112	3,291	54,312	5,946	39
Crab	Coral Crab	*Charybdis feriata*	0	0	**9**	**9**	**9**	**9**	100
Crab	Green Mud Crab	*Scylla serrata*	0	0	**4**	**4**	**4**	**4**	100
Emperor	Grass Emperor	*Lethrinus laticaudis*	1,629	375	3,676	858	5,306	1,155	69
Emperor	Spangled Emperor	*Lethrinus nebulosus*	**66**	**60**	**125**	**92**	**190**	**150**	65
Flathead	Flatheads	*Platycephalidae - undifferentiated*	**27**	**19**	**10**	**8**	**36**	**23**	27
Flathead	Yellowtail Flathead	*Platycephalus westraliae*	150	51	**167**	**70**	318	107	53
Grunter	Striped Grunters	*Terapontidae - undifferentiated*	0	0	**245**	**141**	**245**	**141**	100
Grunter	Yellowtail Grunter	*Amniataba caudavittata*	279	251	**347**	**144**	**626**	**288**	55
Grunter Bream	Painted Sweetlips	*Diagramma labiosum*	0	0	**4**	**4**	**4**	**4**	100

Reporting Group	Common Name	Scientific Name	Kept	se	Rel	se	Total	se	% Rel
Leatherjacket	Fanbelly Leatherjacket	*Monacanthus chinensis*	0	0	**14**	**14**	**14**	**14**	100
Leatherjacket	Horseshoe Leatherjacket	*Meuschenia hippocrepis*	0	0	**3**	**3**	**3**	**3**	100
Lizardfish	Common Saury	*Saurida tumbil*	0	0	**165**	**139**	**165**	**139**	100
Lizardfish	Lizardfishes & Deepsea Lizardfishes	*Bathysauridae, Synodontidae - undifferentiated*	**7**	**7**	**449**	**243**	**456**	**245**	98
Mackerel	School Mackerel	*Scomberomorus queenslandicus*	152	39	69	22	221	51	31
Mackerel	Spanish Mackerel	*Scomberomorus commerson*	**19**	**14**	**6**	**6**	**25**	**17**	25
Mackerel	Spotted Mackerel	*Scomberomorus munroi*	**6**	**4**	**45**	**25**	**50**	**28**	88
Mullet	Mullets	*Mugilidae - undifferentiated*	**1,394**	**927**	**503**	**503**	**1,898**	**1,403**	27
Mulloway	Mulloway	*Argyrosomus japonicus*	80	37	**167**	**102**	**247**	**132**	68
Pike	Pikes	*Sphyraenidae - undifferentiated*	0	0	**20**	**18**	**20**	**18**	100
Pike	Snook	*Sphyraena novaehollandiae*	0	0	**205**	**146**	**205**	**146**	100
Pike	Yellowtail Barracuda	*Sphyraena obtusata*	0	0	**3**	**3**	**3**	**3**	100
Rays	Guitarfishes	*Rhinobatidae - undifferentiated*	4	4	86	35	**89**	**35**	96
Rays	Stingrays	*Dasyatidae - undifferentiated*	0	0	**4**	**4**	**4**	**4**	100
Sea Mullet	Sea Mullet	*Mugil cephalus*	**297**	**192**	0	0	**297**	**192**	0
Sea Turtle	Loggerhead Turtle	*Caretta caretta*	0	0	**8**	**8**	**8**	**8**	100
Sharks	Blacktip Reef Shark	*Carcharhinus melanopterus*	0	0	**353**	**217**	**353**	**217**	100
Sharks	Blacktip Shark	*Carcharhinus, Loxodon & Rhizoprionodon spp.*	**2**	**2**	**35**	**29**	**37**	**29**	94
Sharks	Bronze Whaler	*Carcharhinus brachyurus*	0	0	**17**	**15**	**17**	**15**	100
Sharks	Bull Shark	*Carcharhinus leucas*	0	0	**12**	**12**	**12**	**12**	100
Sharks	Lemon Shark	*Negaprion acutidens*	0	0	**17**	**15**	**17**	**15**	100
Sharks	Sandbar Shark	*Carcharhinus plumbeus*	0	0	**8**	**8**	**8**	**8**	100
Sharks	Spinner Shark	*Carcharhinus brevipinna*	0	0	**38**	**29**	**38**	**29**	100
Sharks	Whaler & Weasel Sharks	*Carcharhinidae, Hemigaleidae - undifferentiated*	**21**	**15**	125	40	146	42	86
Sharks	Wobbegong	*Orectolobidae - undifferentiated*	**3**	**3**	0	0	**3**	**3**	0
Tailor	Tailor	*Pomatomus saltatrix*	281	100	**150**	**96**	**431**	**176**	35

Reporting Group	Common Name	Scientific Name	Kept	se	Rel	se	Total	se	% Rel
Threadfin	King Threadfin	*Polydactylus macrochir*	**17**	**17**	**42**	**42**	**60**	**46**	71
Threadfin Bream	Western Butterfish	*Pentapodus vitta*	**240**	**126**	2,513	632	2,753	664	91
Toadfish	Silver Toadfish	*Lagocephalus sceleratus*	0	0	**16**	**10**	**16**	**10**	100
Toadfish	Toadfishes	*Tetraodontidae - undifferentiated*	0	0	**41**	**28**	**41**	**28**	100
Trevally	Giant Trevally	*Caranx ignobilis*	0	0	**34**	**24**	**34**	**24**	100
Trevally	Golden Trevally	*Gnathanodon speciosus*	**18**	**15**	**77**	**47**	**95**	**49**	81
Tropical Snapper	Moses' Snapper	*Lutjanus russellii*	0	0	**22**	**22**	**22**	**22**	100
Tropical Snapper	Stripey Snapper	*Lutjanus carponotatus*	**47**	**24**	**19**	**10**	66	25	29
Tuna	Longtail Tuna	*Thunnus tonggol*	**6**	**6**	**43**	**32**	**49**	**34**	87
Tuskfish & Wrasse	Blackspot Tuskfish	*Choerodon schoenleinii*	706	165	675	137	1,381	241	49
Tuskfish & Wrasse	Bluespotted Tuskfish	*Choerodon cauteroma*	**41**	**33**	**41**	**28**	**82**	**52**	50
Tuskfish & Wrasse	Goldspot Pigfish	*Bodianus perditio*	0	0	**2**	**2**	**2**	**2**	100
Tuskfish & Wrasse	Surf Parrotfish	*Scarus rivulatus*	**62**	**50**	0	0	**62**	**50**	0
Tuskfish & Wrasse	Tuskfishes	*Choerodon spp.*	0	0	**7**	**7**	**7**	**7**	100
Tuskfish & Wrasse	Wrasses	*Labridae - undifferentiated*	0	0	**42**	**28**	**42**	**28**	100
Unknown	*Unknown Species*		0	0	**113**	**86**	**113**	**113**	86
Whiting	Western School Whiting	*Sillago vittata*	**207**	**130**	**149**	**74**	**356**	**186**	42
Whiting	Western Trumpeter Whiting	*Sillago burrus*	**3**	**3**	**60**	**54**	**63**	**55**	95
Whiting	Whitings	*Sillaginidae - undifferentiated*	**1,065**	**532**	**327**	**152**	**1,392**	**668**	23
Whiting	Yellowfin Whiting	*Sillago schomburgkii*	2,393	853	**586**	**331**	2,979	1,106	20

Appendix 18. Estimated annual catch (kept, released and total numbers) and percentage released by boat-based recreational fishers at Nanga for inner Shark Bay and oceanic fishing trips between March 2018 and February 2019. Values in bold indicate a relative standard error >40% (i.e. se >40% of the estimate).

Reporting Group	Common Name	Scientific Name	Kept	se	Rel	se	Total	se	% Rel
Bream	Pink Snapper	*Chrysophrys auratus*	917	136	8,275	1,406	9,192	1,444	90
Bream	Western Yellowfin Bream	*Acanthopagrus morrisoni*	0	0	**4**	**4**	**4**	**4**	100
Cephalopod	Squid	*Order Teuthoidea - undifferentiated*	**63**	**38**	**5**	**5**	**69**	**39**	8
Cod	Goldspotted Rockcod	*Epinephelus coioides*	**1**	**1**	0	0	**1**	**1**	0
Eels	Eels	*Order Anguilliformes - undifferentiated*	0	0	**2**	**2**	**2**	**2**	100
Emperor	Grass Emperor	*Lethrinus laticaudis*	193	46	322	85	515	115	63
Emperor	Spangled Emperor	*Lethrinus nebulosus*	**3**	**3**	**258**	**258**	**261**	**261**	99
Flathead	Flatheads	*Platycephalidae - undifferentiated*	**5**	**5**	0	0	**5**	**5**	0
Flathead	Fringe-Eye Flathead	*Cymbacephalus nematophthalmus*	**1**	**1**	0	0	**1**	**1**	0
Flathead	Yellowtail Flathead	*Platycephalus westraliae*	**5**	**4**	**32**	**21**	**37**	**22**	86
Flounders	Smalltooth Flounder	*Pseudorhombus jenynsii*	0	0	**10**	**10**	**10**	**10**	100
Giant Perch	Sand Bass	*Psammoperca waigiensis*	**5**	**5**	**5**	**5**	**9**	**9**	50
Lizardfish	Lizardfishes & Deepsea Lizardfishes	*Bathysauridae, Synodontidae - undifferentiated*	0	0	**3**	**3**	**3**	**3**	100
Longtom	Longtoms	*Belonidae - undifferentiated*	0	0	**2**	**2**	**2**	**2**	100
Mackerel	School Mackerel	*Scomberomorus queenslandicus*	**8**	**4**	0	0	**8**	**4**	0
Mackerel	Shark Mackerel	*Grammatorcynus bicarinatus*	**2**	**2**	0	0	**2**	**2**	0
Mackerel	Spanish Mackerel	*Scomberomorus commerson*	0	0	**1**	**1**	**1**	**1**	100
Mulloway	Mulloway	*Argyrosomus japonicus*	**8**	**5**	**16**	**8**	**24**	**10**	66
Pike	Snook	*Sphyraena novaehollandiae*	**6**	**6**	**54**	**23**	**60**	**28**	89
Pike	Yellowtail Barracuda	*Sphyraena obtusata*	**7**	**7**	0	0	**7**	**7**	0
Rays	Guitarfishes	*Rhinobatidae - undifferentiated*	0	0	**12**	**10**	**12**	**10**	100
Sharks	Bronze Whaler	*Carcharhinus brachyurus*	**2**	**2**	0	0	**2**	**2**	0

Reporting Group	Common Name	Scientific Name	Kept	se	Rel	se	Total	se	% Rel
Sharks	Dusky Whaler	*Carcharhinus obscurus*	**5**	**5**	0	0	**5**	**5**	0
Sharks	Nervous Shark	*Carcharhinus cautus*	0	0	**1**	**1**	**1**	**1**	100
Sharks	Port Jackson Shark	*Heterodontus portusjacksoni*	0	0	**1**	**1**	**1**	**1**	100
Sharks	Sandbar Shark	*Carcharhinus plumbeus*	0	0	**10**	**10**	**10**	**10**	100
Sharks	Whaler & Weasel Sharks	*Carcharhinidae, Hemigaleidae - undifferentiated*	**1**	**1**	**74**	**55**	**75**	**55**	98
Sharks	Wobbegong	*Orectolobidae - undifferentiated*	0	0	**6**	**6**	**6**	**6**	100
Tailor	Tailor	*Pomatomus saltatrix*	**110**	**91**	**5**	**5**	**115**	**92**	4
Threadfin Bream	Western Butterfish	*Pentapodus vitta*	**6**	**4**	**223**	**125**	**229**	**125**	97
Toadfish	Silver Toadfish	*Lagocephalus sceleratus*	0	0	**2**	**2**	**2**	**2**	100
Trevally	Golden Trevally	*Gnathanodon speciosus*	**1**	**1**	0	0	**1**	**1**	0
Tuskfish & Wrasse	Blackspot Tuskfish	*Choerodon schoenleinii*	**48**	**35**	418	150	466	163	90
Tuskfish & Wrasse	Blue Tuskfish	*Choerodon cyanodus*	0	0	**2**	**2**	**2**	**2**	100
Tuskfish & Wrasse	Bluebarred Parrotfish	*Scarus ghobban spp. complex*	0	0	**40**	**28**	**40**	**28**	100
Tuskfish & Wrasse	Bluespotted Tuskfish	*Choerodon cauteroma*	0	0	**11**	**11**	**11**	**11**	100
Tuskfish & Wrasse	Wrasses	*Labridae - undifferentiated*	0	0	**2**	**2**	**2**	**2**	100
Unknown	*Unknown Species*		0	0	**5**	**4**	**5**	**5**	4
Whiting	Western Trumpeter Whiting	*Sillago burrus*	0	0	**13**	**13**	**13**	**13**	100

Appendix 19. Combined estimated annual catch (kept, released and total numbers) and percentage released by boat-based recreational fishers from Denham, Monkey Mia and Nanga for inner Shark Bay and oceanic fishing trips between March 2018 and February 2019. Values in bold indicate a relative standard error >40% (i.e. se >40% of the estimate).

Reporting Group	Common Name	Scientific Name	Kept	se	Rel	se	Total	se	% Rel
Billfish	Black Marlin	*Makaira indica*	0	0	**1**	**1**	**1**	**1**	100
Bonitos	Bonitos	*Sarda australis & Cybiosarda elegans*	0	0	**16**	**16**	**16**	**16**	100
Bream	Frypan Bream	*Argyrops spinifer*	**49**	**49**	**39**	**39**	**88**	**88**	44
Bream	Pink Snapper	*Chrysophrys auratus*	3,569	330	47,015	3,658	50,584	3,783	93
Bream	Tarwhine	*Rhabdosargus sarba*	**15**	**12**	**28**	**23**	**42**	**34**	65
Bream	Western Yellowfin Bream	*Acanthopagrus morrisoni*	**267**	**187**	**697**	**404**	**965**	**574**	72
Catfish	Forktail Catfishes	*Ariidae - undifferentiated*	**54**	**27**	**727**	**298**	780	304	93
Catfish	Giant Sea Catfish	*Netuma thalassina*	**51**	**43**	**1,157**	**676**	**1,208**	**678**	96
Cephalopod	Cuttlefish	*Sepia spp.*	**107**	**48**	**22**	**20**	**128**	**55**	17
Cephalopod	Octopuses	*Octopodidae - undifferentiated*	**7**	**6**	**6**	**5**	**13**	**7**	46
Cephalopod	Squid	*Order Teuthoidea - undifferentiated*	**2,597**	**1,509**	**922**	**884**	**3,520**	**2,375**	26
Cobia	Cobia	*Rachycentron canadum*	65	19	**31**	**17**	97	29	32
Cod	Birdwire Rockcod	*Epinephelus merra*	**97**	**44**	**93**	**75**	**189**	**89**	49
Cod	Blackspotted Rockcod	*Epinephelus malabaricus*	**119**	**56**	**44**	**26**	**163**	**71**	27
Cod	Chinaman Rockcod	*Epinephelus rivulatus*	**234**	**100**	799	290	1,033	306	77
Cod	Coral Rockcod	*Cephalopholis miniata*	**3**	**2**	0	0	**3**	**2**	0
Cod	Frostback Rockcod	*Epinephelus bilobatus*	**29**	**27**	**29**	**23**	**58**	**42**	50
Cod	Goldspotted Rockcod	*Epinephelus coioides*	813	135	552	127	1,364	226	40
Cod	Harlequin Fish	*Othos dentex*	0	0	**1**	**1**	**1**	**1**	100
Cod	Potato Rockcod	*Epinephelus tukula*	0	0	**3**	**3**	**3**	**3**	100
Cod	Rankin Cod	*Epinephelus multinotatus*	806	149	732	163	1,538	254	48
Cod	Temperate Basses & Rockcods	*Percichthyidae, Serranidae - undifferentiated*	**27**	**25**	**25**	**20**	**52**	**32**	48

Reporting Group	Common Name	Scientific Name	Kept	se	Rel	se	Total	se	% Rel
Cod	Tomato Rockcod	*Cephalopholis sonnerati*	**7**	**3**	0	0	**7**	**3**	0
Cod	Yellowspotted Rockcod	*Epinephelus areolatus*	**105**	**47**	**109**	**45**	214	86	51
Coral Trout	Barcheek Coral Trout	*Plectropomus maculatus*	**294**	**151**	**132**	**99**	**425**	**246**	31
Coral Trout	Common Coral Trout	*Plectropomus leopardus*	127	41	**39**	**21**	165	46	23
Coral Trout	Coral Trout	*Plectropomus spp. & Variola spp.*	0	0	**2**	**2**	**2**	**2**	100
Coral Trout	Yellowedge Coronation Trout	*Variola louti*	**19**	**10**	0	0	**19**	**10**	0
Crab	Blue Swimmer Crab	*Portunus armatus*	33,225	3,902	21,112	3,291	54,337	5,946	39
Crab	Coral Crab	*Charybdis feriata*	0	0	**9**	**9**	**9**	**9**	100
Crab	Green Mud Crab	*Scylla serrata*	0	0	**4**	**4**	**4**	**4**	100
Eels	Eels	*Order Anguilliformes - undifferentiated*	0	0	**13**	**7**	**13**	**7**	100
Emperor	Bluespotted Emperor	*Lethrinus punctulatus*	**4**	**4**	**21**	**19**	**25**	**23**	85
Emperor	Grass Emperor	*Lethrinus laticaudis*	5,985	751	14,250	1,962	20,235	2,300	70
Emperor	Redthroat Emperor	*Lethrinus miniatus*	1,037	238	1,251	328	2,288	474	55
Emperor	Robinson's Seabream	*Gymnocranius grandoculis*	**8**	**8**	**5**	**5**	**13**	**10**	37
Emperor	Spangled Emperor	*Lethrinus nebulosus*	234	77	856	303	1,090	335	79
Emperor	Yellowtail Emperor	*Lethrinus atkinsoni*	0	0	**24**	**24**	**24**	**24**	100
Flathead	Flatheads	*Platycephalidae - undifferentiated*	**45**	**21**	**43**	**27**	88	35	49
Flathead	Fringe-Eye Flathead	*Cymbacephalus nematophthalmus*	**1**	**1**	0	0	**1**	**1**	0
Flathead	Northern Sand Flathead	*Platycephalus endrachtensis*	**10**	**7**	0	0	**10**	**7**	0
Flathead	Yellowtail Flathead	*Platycephalus westraliae*	428	83	399	103	828	147	48
Flounders	Flounders	*Bothidae, Psettodidae & Pleuronectidae*	**15**	**10**	**28**	**25**	**43**	**26**	66
Flounders	Smalltooth Flounder	*Pseudorhombus jenynsii*	**18**	**18**	**10**	**10**	**28**	**21**	35
Garfish	Garfishes	*Hemiramphidae - undifferentiated*	**39**	**31**	**47**	**36**	**85**	**55**	55
Garfish	Three-By-Two Garfish	*Hemiramphus robustus*	0	0	**11**	**7**	**11**	**7**	100
Giant Perch	Sand Bass	*Psammoperca waigiensis*	**5**	**5**	**21**	**12**	**25**	**15**	81
Goatfish	Bluespotted Goatfish	*Upeneichthys vlamingii*	**3**	**3**	0	0	**3**	**3**	0
Goatfish	Goatfishes	*Mullidae - undifferentiated*	0	0	**4**	**4**	**4**	**4**	100
Grunter	Striped Grunters	*Terapontidae - undifferentiated*	0	0	409	159	409	159	100

Reporting Group	Common Name	Scientific Name	Kept	se	Rel	se	Total	se	% Rel
Grunter	Western Striped Grunter	*Pelates octolineatus*	**12**	**12**	**5**	**4**	**17**	**15**	29
Grunter	Yellowtail Grunter	*Amniataba caudavittata*	**279**	**251**	595	211	874	326	68
Grunter Bream	Goldspotted Sweetlips	*Plectorhinchus flavomaculatus*	**33**	**33**	**1**	**1**	**34**	**33**	3
Grunter Bream	Grunter Breams	*Haemulidae - undifferentiated*	**16**	**11**	**24**	**17**	**40**	**21**	60
Grunter Bream	Painted Sweetlips	*Diagramma labiosum*	**11**	**7**	**35**	**19**	**46**	**24**	76
Gurnard	Gurnard Perches	*Neosebastidae - undifferentiated*	0	0	**5**	**5**	**5**	**5**	100
Gurnard	Searobins & Armour Gurnards	*Triglidae & Peristediidae - undifferentiated*	0	0	**2**	**2**	**2**	**2**	100
Leatherjacket	Fanbelly Leatherjacket	*Monacanthus chinensis*	0	0	**14**	**14**	**14**	**14**	100
Leatherjacket	Horseshoe Leatherjacket	*Meuschenia hippocrepis*	**6**	**4**	**18**	**9**	**23**	**13**	76
Leatherjacket	Triggerfishes & Leatherjackets	*Balistidae, Monacanthidae - undifferentiated*	**3**	**3**	**114**	**60**	**117**	**60**	98
Lizardfish	Common Saury	*Saurida tumbil*	**20**	**20**	**328**	**162**	**347**	**165**	94
Lizardfish	Lizardfishes & Deepsea Lizardfishes	*Bathysauridae, Synodontidae - undifferentiated*	**12**	**8**	**598**	**248**	**610**	**250**	98
Lobster	Tropical Rock Lobster	*Panulirus spp. except P. cygnus*	**13**	**9**	0	0	**13**	**9**	0
Lobster	Western Rock Lobster	*Panulirus cygnus*	**143**	**61**	**9**	**9**	**152**	**64**	6
Longtom	Longtoms	*Belonidae - undifferentiated*	0	0	**6**	**4**	**6**	**4**	100
Mackerel	Mackerels	*Scombridae - undifferentiated*	0	0	**5**	**5**	**5**	**5**	100
Mackerel	School Mackerel	*Scomberomorus queenslandicus*	654	125	529	138	1,183	189	45
Mackerel	Shark Mackerel	*Grammatorcynus bicarinatus*	**46**	**23**	50	19	96	33	52
Mackerel	Spanish Mackerel	*Scomberomorus commerson*	189	75	65	25	253	78	25
Mackerel	Spotted Mackerel	*Scomberomorus munroi*	**18**	**8**	**45**	**25**	**62**	**29**	72
Mackerel	Wahoo	*Acanthocybium solandri*	**1**	**1**	0	0	**1**	**1**	0
Mahi Mahi	Mahi Mahis	*Coryphaena spp.*	**8**	**6**	0	0	**8**	**6**	0
Morwong	Morwongs	*Cheilodactylidae - undifferentiated*	0	0	**4**	**4**	**4**	**4**	100
Mullet	Mullets	*Mugilidae - undifferentiated*	**1,421**	**927**	**503**	**503**	**1,925**	**1,403**	26
Mulloway	Mulloway	*Argyrosomus japonicus*	196	47	366	133	562	164	65
Pearl Perch	Northern Pearl Perch	*Glaucosoma buergeri*	**64**	**26**	0	0	**64**	**26**	0

Reporting Group	Common Name	Scientific Name	Kept	se	Rel	se	Total	se	% Rel
Pike	Great Barracuda	*Sphyraena barracuda*	**1**	**1**	**16**	**16**	**18**	**16**	93
Pike	Pikes	*Sphyraenidae - undifferentiated*	**106**	**75**	**52**	**24**	**159**	**79**	33
Pike	Snook	*Sphyraena novaehollandiae*	**72**	**39**	**309**	**149**	**380**	**155**	81
Pike	Yellowtail Barracuda	*Sphyraena obtusata*	**32**	**20**	**22**	**20**	**54**	**28**	41
Rays	Guitarfishes	*Rhinobatidae - undifferentiated*	**4**	**4**	100	37	104	37	96
Rays	Stingrays	*Dasyatidae - undifferentiated*	0	0	**4**	**4**	**4**	**4**	100
Remora	Remora	*Remora remora*	0	0	**14**	**14**	**14**	**14**	100
Sea Mullet	Sea Mullet	*Mugil cephalus*	**577**	**338**	**4**	**4**	**581**	**338**	1
Sea Turtle	Loggerhead Turtle	*Caretta caretta*	0	0	**8**	**8**	**8**	**8**	100
Sergeant Baker	Sergeant Baker	*Latropiscis purpurissatus*	0	0	**85**	**67**	**85**	**67**	100
Sharks	Blacktip Reef Shark	*Carcharhinus melanopterus*	0	0	**354**	**217**	**354**	**217**	100
Sharks	Blacktip Shark	*Carcharhinus, Loxodon & Rhizoprionodon spp.*	**4**	**3**	**35**	**29**	**39**	**29**	90
Sharks	Bronze Whaler	*Carcharhinus brachyurus*	**7**	**5**	**126**	**81**	**133**	**81**	95
Sharks	Bull Shark	*Carcharhinus leucas*	0	0	**12**	**12**	**12**	**12**	100
Sharks	Dusky Whaler	*Carcharhinus obscurus*	**5**	**5**	**10**	**10**	**15**	**11**	68
Sharks	Hammerhead Sharks	*Sphyrnidae - undifferentiated*	0	0	**15**	**11**	**15**	**11**	100
Sharks	Lemon Shark	*Negaprion acutidens*	0	0	**36**	**19**	**36**	**19**	100
Sharks	Nervous Shark	*Carcharhinus cautus*	**6**	**6**	**7**	**6**	**14**	**13**	54
Sharks	Port Jackson Shark	*Heterodontus portusjacksoni*	0	0	**1**	**1**	**1**	**1**	100
Sharks	Sandbar Shark	*Carcharhinus plumbeus*	**3**	**3**	**21**	**13**	**24**	**13**	87
Sharks	Spinner Shark	*Carcharhinus brevipinna*	0	0	**41**	**29**	**41**	**29**	100
Sharks	Tiger Shark	*Galeocerdo cuvier*	0	0	**12**	**9**	**12**	**9**	100
Sharks	Western Spotted Gummy Shark	*Mustelus stevensi*	0	0	**7**	**5**	**7**	**5**	100
Sharks	Whaler & Weasel Sharks	*Carcharhinidae, Hemigaleidae - undifferentiated*	**24**	**15**	460	109	485	109	95
Sharks	Whiskery Shark	*Furgaleus macki*	**3**	**3**	0	0	**3**	**3**	0
Sharks	Whitetip Reef Shark	*Triaenodon obesus*	0	0	**8**	**8**	**8**	**8**	100

Reporting Group	Common Name	Scientific Name	Kept	se	Rel	se	Total	se	% Rel
Sharks	Wobbegong	*Orectolobidae - undifferentiated*	**3**	**3**	**6**	**6**	**9**	**7**	68
Tailor	Tailor	*Pomatomus saltatrix*	**503**	**147**	209	103	**712**	**214**	29
Threadfin	King Threadfin	*Polydactylus macrochir*	**17**	**17**	**42**	**42**	**60**	**46**	71
Threadfin Bream	Western Butterfish	*Pentapodus vitta*	**791**	**340**	6,010	860	6,801	1,025	88
Toadfish	Silver Toadfish	*Lagocephalus sceleratus*	0	0	**453**	**81**	**453**	**81**	100
Toadfish	Toadfishes	*Tetraodontidae - undifferentiated*	0	0	**125**	**69**	**125**	**69**	100
Toadfish	Weeping Toadfish	*Torquigener pleurogramma*	0	0	**5**	**5**	**5**	**5**	100
Trevally	Bludger Trevally	*Carangoides gymnostethus*	**3**	**3**	**8**	**8**	**12**	**9**	70
Trevally	Diamond Trevally	*Alectis indica*	0	0	**1**	**1**	**1**	**1**	100
Trevally	Giant Trevally	*Caranx ignobilis*	**1**	**1**	**39**	**24**	**40**	**24**	97
Trevally	Golden Trevally	*Gnathanodon speciosus*	**32**	**17**	**109**	**49**	141	51	77
Trevally	Samsonfish	*Seriola hippos*	**7**	**5**	0	0	**7**	**5**	0
Trevally	Silver Trevally	*Pseudocaranx georgianus spp. complex*	**5**	**5**	0	0	**5**	**5**	0
Trevally	Turrum	*Carangoides fulvoguttatus*	**4**	**3**	**34**	**25**	**37**	**25**	90
Tropical Snapper	Brownstripe Snapper	*Lutjanus vitta*	**2**	**2**	0	0	**2**	**2**	0
Tropical Snapper	Crimson Snapper	*Lutjanus erythropterus*	**3**	**3**	0	0	**3**	**3**	0
Tropical Snapper	Goldband Snapper	*Pristipomoides multidens*	**26**	**16**	0	0	**26**	**16**	0
Tropical Snapper	Golden Snapper	*Lutjanus johnii*	**3**	**3**	0	0	**3**	**3**	0
Tropical Snapper	Mangrove Jack	*Lutjanus argentimaculatus*	**3**	**2**	0	0	**3**	**2**	0
Tropical Snapper	Moses' Snapper	*Lutjanus russellii*	**30**	**18**	**46**	**28**	**75**	**33**	61
Tropical Snapper	Red Emperor	*Lutjanus sebae*	121	43	**38**	**20**	158	58	24
Tropical Snapper	Stripey Snapper	*Lutjanus carponotatus*	577	132	670	193	1,247	269	54
Tuna	Longtail Tuna	*Thunnus tonggol*	**6**	**6**	**43**	**32**	**49**	**34**	87
Tuna	Mackerel Tuna	*Euthynnus affinis*	0	0	**6**	**6**	**6**	**6**	100
Tuna	Skipjack Tuna	*Katsuwonus pelamis*	**4**	**4**	**25**	**23**	**29**	**24**	86
Tuna	Southern Bluefin Tuna	*Thunnus maccoyii*	0	0	**1**	**1**	**1**	**1**	100
Tuna	Yellowfin Tuna	*Thunnus albacares*	**8**	**5**	0	0	**8**	**5**	0
Tuskfish & Wrasse	Baldchin Groper	*Choerodon rubescens*	**739**	**445**	**103**	**46**	**842**	**447**	12

Reporting Group	Common Name	Scientific Name	Kept	se	Rel	se	Total	se	% Rel
Tuskfish & Wrasse	Blackspot Tuskfish	*Choerodon schoenleinii*	1,204	228	2,175	275	3,379	383	64
Tuskfish & Wrasse	Blue Tuskfish	*Choerodon cyanodus*	**5**	**3**	**24**	**11**	**29**	**12**	84
Tuskfish & Wrasse	Bluebarred Parrotfish	*Scarus ghobban spp. complex*	**4**	**3**	**43**	**29**	**46**	**29**	92
Tuskfish & Wrasse	Bluespotted Tuskfish	*Choerodon cauteroma*	**56**	**36**	**70**	**31**	**131**	**58**	53
Tuskfish & Wrasse	Foxfish	*Bodianus frenchii*	**18**	**10**	0	0	**18**	**10**	0
Tuskfish & Wrasse	Goldspot Pigfish	*Bodianus perditio*	**11**	**10**	**2**	**2**	**13**	**10**	17
Tuskfish & Wrasse	Parrotfishes	*Scaridae - undifferentiated*	**2**	**2**	**21**	**14**	**23**	**14**	93
Tuskfish & Wrasse	Pigfishes	*Bodianus spp.*	**1**	**1**	0	0	**1**	**1**	0
Tuskfish & Wrasse	Surf Parrotfish	*Scarus rivulatus*	**62**	**50**	0	0	**62**	**50**	0
Tuskfish & Wrasse	Tuskfishes	*Choerodon spp.*	**5**	**5**	**48**	**29**	**53**	**29**	91
Tuskfish & Wrasse	Western King Wrasse	*Coris auricularis*	0	0	**17**	**17**	**17**	**17**	100
Tuskfish & Wrasse	Wrasses	*Labridae - undifferentiated*	0	0	170	64	170	64	100
Unknown	*Unknown Species*		**21**	**21**	**329**	**145**	**446**	**350**	150
Whiting	Goldenline Whiting	*Sillago analis*	0	0	**2**	**2**	**2**	**2**	100
Whiting	Western School Whiting	*Sillago vittata*	**465**	**288**	**158**	**75**	**623**	**317**	25
Whiting	Western Trumpeter Whiting	*Sillago burrus*	**52**	**38**	**269**	**115**	321	121	84
Whiting	Whitings	*Sillaginidae - undifferentiated*	**2,040**	**957**	**851**	**546**	**2,891**	**1,475**	29
Whiting	Yellowfin Whiting	*Sillago schomburgkii*	2,506	861	**648**	**334**	3,154	1,116	21