



Department of
Primary Industries and
Regional Development

*We're working for
Western Australia.*

Fisheries Research Report No. 325

Recreational fishing for Western Rock Lobster: estimates of participation, effort and catch in 2021/22

Smallwood, C.B., Ryan, K.L., Tate, A.C. and Rudd, L.J.

October 2022

Correct citation:

Smallwood, C.B., Ryan, K.L., Tate, A.C. and Rudd, L.J. 2022. Recreational fishing for Western Rock Lobster: estimates of participation, effort and catch in 2021/22. Fisheries Research Report No. 325. Department of Primary Industries and Regional Development, Western Australia. 36 pp.

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: fish.wa.gov.au

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

Important disclaimer

The Chief Executive Officer of the Department of Primary Industries and Regional Development and the State of Western Australia accept no liability whatsoever by reason of negligence or otherwise arising from the use or release of this information or any part of it.

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: 978-1-921845-08-6 (Print)

ISSN: 2202-5758 (Online) ISBN: 978-1-921845-07-9 (Online)

Copyright © State of Western Australia (Department of Primary Industries and Regional Development) 2022

Table of Contents

Executive Summary	1
1.0 Introduction	2
1.1 Background	2
1.2 Need... ..	3
1.3 Objectives.....	3
2.0 Method	4
2.1 Phone-recall survey	4
2.1.1 Survey design and scope	4
2.1.2 Analysis.....	7
2.1.3 Response rate.....	8
2.2 Boat ramp survey	8
2.2.1 Survey design	8
2.2.2 Analysis.....	9
2.2.3 Response rate.....	10
2.3 Tour Operator Returns.....	10
2.3.1 Data collection.....	10
2.3.2 Analysis.....	10
2.3.3 Response rate.....	11
2.4 Recreational harvest.....	11
3.0 Results	12
3.1 Participation.....	12
3.1.1 Phone-recall survey	12
3.1.2 Tour operators.....	13
3.2 Gear type and loss	14
3.2.1 Phone-recall surveys.....	14
3.2.2 Tour operators.....	14
3.3 Effort... ..	14
3.3.1 Phone-recall surveys.....	14
3.3.2 Tour operators.....	15
3.4 Average weight.....	15
3.4.1 Boat ramp survey	15
3.4.2 Tour operators.....	15
3.5 Retained catch.....	15
3.5.1 Phone-recall survey	15

3.5.2 Tour operators.....	16
3.6 Recreational Harvest	17
3.6.1 Total Allowable Recreational Catch (TARC)	17
3.6.2 Allowable Harvest Level (AHL).....	17
4.0 Discussion.....	18
4.1 Participation.....	18
4.2 Fishing effort and retained catch	19
4.3 Management Implications.....	21
4.4 Future research	21
5.0 Acknowledgements	22
6.0 References	23
7.0 Appendices	25

Executive Summary

The Western Rock Lobster (WRL) (*Panulirus cygnus*) is the most commonly caught Rock Lobster (RL) species in Western Australia. Catches from the commercial and recreational sectors are required to determine and monitor Total Allowable Commercial Catch (TACC), Total Allowable Recreational Catch (TARC) and proportion of Allowable Harvest Level (AHL) achieved. The TARC is set at 5% of the AHL and evaluated in the harvest strategy based on a 5-year average.

Since 2018/19, data for the recreational sector have been collected using phone-recall surveys to provide estimates of participation, fishing effort and retained catch (by numbers) from recreational fishers who hold a RL licence. Average weight, obtained from boat ramp surveys, are used to convert estimates of retained catch from licensed fishers by number to weight. Tour Operator Returns (Charter Logbooks) provide a census of the annual participation, effort and retained catch (by numbers) from charter fishers. Random length samples of WRL are provided by tour operators and converted to weight using a length-weight equation which are then used to convert the retained catch from numbers to weight.

This report provides estimates of recreational rock lobster fishing participation, effort and catch for 2021/22 (1 February 2021–31 January 2022). Participation in the RL recreational fishery (all species) by licensed fishers (RL licence holders aged five years and older) in 2021/22 was 67.3% or 37,466 fishers (95% CI 35,980–38,952). This was steady (*i.e.*, the 95% CI overlapped between survey years) when compared to phone recall surveys conducted between 2018/19 and 2020/21 (66.6–67.7%).

The total fishing effort for RL fishing (all species) in 2021/22 by licensed fishers was 522,019 days fished (95% CI 468,799–575,240); of which 75.8% or 395,781 days (344,426–447,137) was by potting and 24.2% or 126,238 days (104,188–148,288) by diving. This was steady when compared to phone recall surveys conducted between 2018/19 and 2020/21. The majority of fishing effort in 2021/22 occurred in the Metro-West Coast region (70.1%).

The retained recreational catch of WRL by licensed fishers in 2021/22, based on an overall (*i.e.*, combined across potting and diving) average weight of 610.7 g, was 487 t (95% CI 434–541); of which 75.0% or 366 t (320–411) was harvested by potting and 25.0% or 122 t (88–156) by diving. This was steady when compared to phone recall surveys conducted between 2018/19–2020/21.

Retained catch of WRL from tour operators in 2021/22 was 17 t (based on an overall average weight of 505.6 g) and has increased annually from 9 t in 2018/19. The majority of this catch in 2021/22 was taken by potting (93.2%).

The 5-year average recreational catch (for licensed and tour operators combined) was 505 t in 2021/22, which represents 4.9% of the AHL.

1.0 Introduction

1.1 Background

The Western Rock Lobster (WRL) (*Panulirus cygnus*) is one of the four Rock Lobster (RL) species caught in Western Australia, and the commercial fishery for this species is the most highly valued in Western Australia. The fishery for this species was the first in the world to obtain Marine Stewardship Council certification and the first in Western Australia to be managed under a resource allocation process (Newman et al., 2021). Catches for the commercial (95% allocation) and recreational (5% allocation) sectors are therefore required to determine and monitor Total Allowable Commercial Catches (TACC), Total Allowable Recreational Catches (TARC) and proportion of Allowable Harvest Level (AHL) achieved (Crowe et al., 2013; Ryan et al., 2016).

The West Coast Rock Lobster Managed Fishery (WCRLF) is managed using Total Allowable Commercial Catch (TACC) limits across three zones, which stretch from Exmouth to Augusta (Figure 1). Data on commercial catches are obtained via mandatory logbook reporting and baited pots are the only allowable method of commercial capture (Bellchambers et al., 2017).

Fishing for RL species from tour operator vessels can occur using pots and by diving. Reporting via statutory Tour Operator Returns (Charter Logbooks) provides a census of retained catch of WRL from charter fishing (Ryan et al., 2016).

The recreational fishery is managed using a statewide TARC specifically for WRL (first introduced in 2010/11) and a recreational licence (first introduced in the 1970s) is required to target any RL species in Western Australia. When summarised by financial year, there were 56,362 RL licences issued in 2020/21 (DPIRD, 2021), exceeding the previous peak in numbers which occurred in 2016/17 (55,441) (DoF, 2017). The majority of recreational fishing activity for RL occurs between Perth and Geraldton.

Catches of RL from licensed recreational fishers and tour operators are managed using input controls (*i.e.*, pots-per-licence, bag limits, size limits, possession limits and closed seasons). There have been several changes to the temporal restrictions, most recently in July 2018, when the recreational fishery was opened for 12-months each year (Appendix 1). Prior to this, fishing for RL had been restricted to fishing from 15 October–30 June (Ryan et al., 2016).

Historically, estimates of catch (in numbers) for the recreational sector have been collected using mail surveys (1986/87–2017/18) which captured data for the shorter fishing seasons (7.5 or 8.5 months) permitted at the time (Melville-Smith and Anderton, 2000; Ryan et al., 2016; Thomson and Melville-Smith, 2005; Trinnie et al., 2021). These surveys were run after the closure of the fishing season at the end of June each year. Periodic phone-diary surveys were also conducted between 2000/01 and 2008/09 (Baharthah, 2007) and phone-recall surveys in 2001/02 (Baharthah, 2007) and from 2015/16 to 2017/18 (Trinnie et al., 2021).

1.2 Need

The historical mail surveys worked efficiently when the recreational fishery was open for short time periods, as it minimised biases associated with fishers having to recall data over a long time period (Pollock et al., 1994). However, declining response rates (26% in 2017/18) (Trinnie et al., 2021) and an easing of management restrictions to allow for a 12-month recreational fishing season (as of July 2018) necessitated a new approach to data collection. These changes also coincided with a realignment of the commercial fishing season (15 January–14 January). Therefore, a new sampling methodology was developed to address declining response rates, minimise recall bias and better align fishing seasons between the recreational and commercial sectors.

1.3 Objectives

The objective of this report is to provide estimates of participation, fishing effort and retained catch (by numbers) of RL (all species) from the recreational sector during the 2021/22 (1 February 2021–31 January 2022) fishing season. For the first time, information on gear type and loss is also reported. For WRL only, the average weight and retained catch (by weight) are also calculated. These estimates were calculated from phone-recall surveys of RL licensed fishers, boat ramp surveys of boat-based recreational fishers and data from statutory Tour Operator Returns.

These recreational catch estimates are used to compare against the TARC (5% of the AHL) and evaluated in the harvest strategy based on a 5-year average.

2.0 Method

2.1 Phone-recall survey

2.1.1 Survey design and scope

The phone-recall survey is a single-phase design, with all sampling completed in a single wave over a period of approximately four weeks. The survey commenced in the week following the completion of the 2021/22 fishing season on the 31 January 2022. The use of interviewer prompts for defined fishing regions and months were used to assist fishers with recalling information and minimise recall bias.

The phone-recall survey is a stratified random sampling design, with samples divided into homogeneous units to reduce sampling variance. These strata were related to groupings of Regional Development Commission (RDC) boundaries, similar to other statewide recreational fishing surveys (Ryan et al., 2022). However, some regional strata were combined to better represent the population of RL licensed fishers. The five residential strata are defined as Metropolitan, Mid-West (including the Mid-West and Wheatbelt RDCs), Peel, South-West and Country (including the Kimberley, Gascoyne, Goldfields-Esperance, Great Southern RDCs and Interstate).

The sampling frame for these phone-recall surveys was a list of fishers who had held or renewed a RL licence during the 12-months prior to the survey period. This licence is required to undertake fishing for any of the four RL species in Western Australia. A minimum age criterion of 5 years was applied to the phone-recall surveys, and parents were required to be a proxy for children aged 5–13 years. Parent permission was required for children aged 14–17 years to participate. A random sample of 2,150 RL licence holders who held a licence issued in the 12-months prior to the survey period were selected for the survey. Subject to their consent to participate in the survey, RL fishers were asked to recall their effort and catch within this fishery over the previous 12-months on a month-by-month basis (Table 1).

Activity from fishers collecting RL from the shore are included in the phone-recall survey. However, RL fishing by licensed fishers from charter-boats were excluded from the phone-recall survey as these catches are reported through mandatory Tour Operator Returns (Charter Logbooks) (Section 2.3).

Commercial management zones for the RL fishery are different to the bioregions and zones used for reporting recreational fishing activity in statewide surveys (Ryan et al., 2022). However, modification of the geographical boundaries used for recreational fishing surveys broadly aligned to reporting between the sectors. The phone-recall surveys therefore collected data from five marine 'regions': North Coast, Gascoyne Coast, Mid-West Coast (including the Kalbarri and Mid-West zones in the West Coast Bioregion), Metro-West Coast (including the Metropolitan and South zones in the West Coast Bioregion) and South Coast (Figure 1). The Gascoyne Coast and Mid-West Coast regions approximate the combination of Zone A and Zone B of the commercial WRL fishery. Separate estimates for Zone A and Zone B

cannot be provided. The Metro-West Coast region approximates Zone C of the commercial WRL fishery.

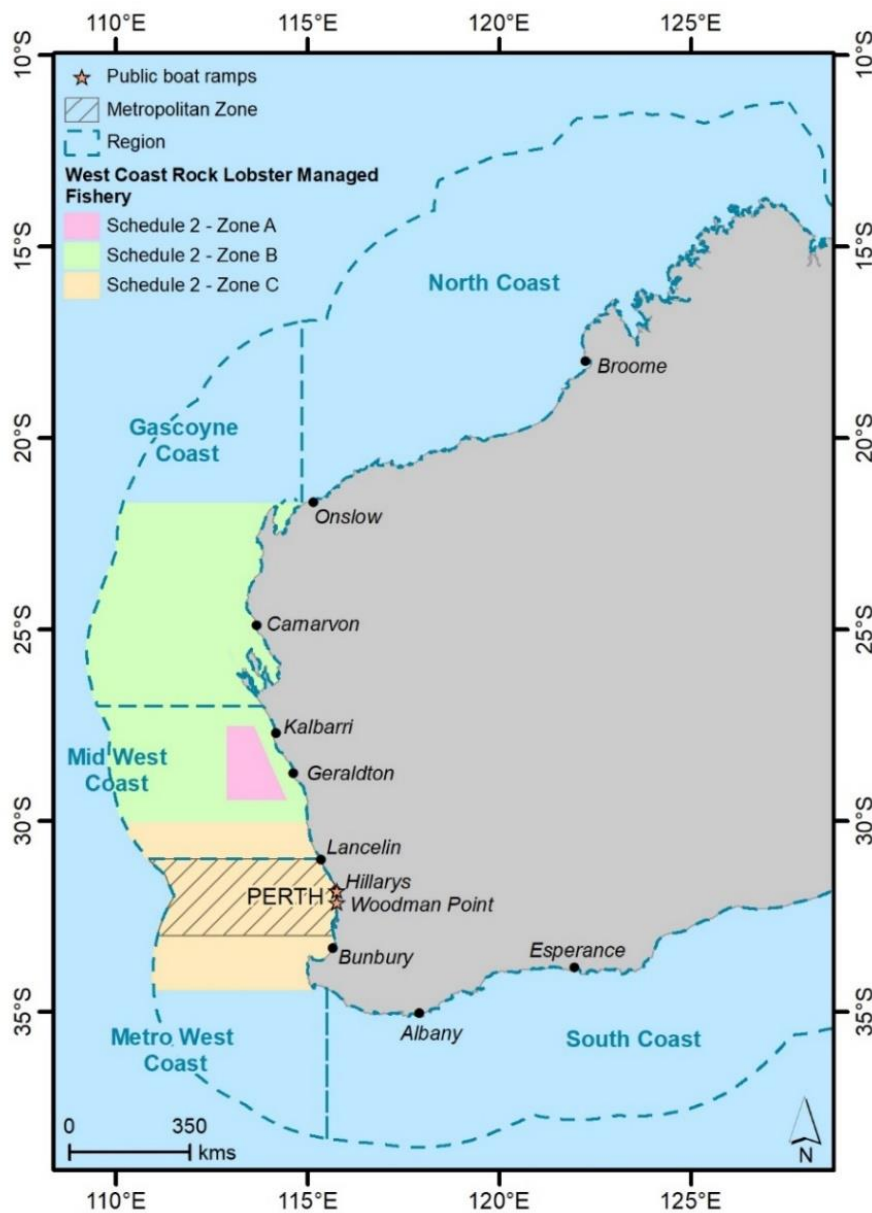


Figure 1 Management zone boundaries for the WRL commercial fishery, reporting regions for licensed recreational fishers during phone-recall surveys and location of boat ramp surveys.

Table 1 Data elements for each data collection method (2018/19–2021/22).

Specification	Item	Phone-recall survey	Boat ramp survey	Tour Operator Returns (Charter Logbook)
Persons in scope	Residency status	All, including Western Australian residents and interstate visitors*	All, including Western Australian residents, interstate and international visitors	All, including Western Australian residents, interstate and international visitors
	Age	<5 years excluded	All	All
	Sampling frame	RL licence holders valid for 12-months prior to survey	Spatio-temporal	Census
Activities	Sectors	Recreational fishing only (traditional/indigenous fishing excluded)		
	Platform	Shore- and boat-based	Boat-based only	
	Boat type	Private-boat and for-hire fishing (charter-boat excluded)		Charter-boat
	Methods	All methods including diving and potting		
Species	Species	All rock lobster species (n=4)	All rock lobster species (n=4)	All species (including rock lobster species)
	Catch	Retained	Retained	Retained and released
	Biological	NA	Carapace length and weight	Carapace length
Geographic scope	Fishing activity	Regions (n=5)	Key public boat ramps in the Metropolitan Zone of the West Coast bioregion – reported to 10 x 10 nautical mile blocks	Statewide, Bioregions (n=4) – reported to 5 x 5 nautical mile blocks
	Fishing access	All shore access and boat launching locations	Key public boat launching locations	All charter boat departure locations
Temporal scope	Coverage	Feb - Jan	Dec - Jan	Feb - Jan
	Day hours	All	6 am–10 am; 12 noon–4 pm	All

* International visitors out-of-scope

2.1.2 Analysis

Raw data on participation, fishing effort and retained catch were expanded to the population of RL licence holders within the recall period using the *survey* package in R, following established protocols for analysis of recreational fishing surveys (Lumley, 2010; Lyle et al., 2010; Ryan et al., 2022). Each estimate has an associated measure of variability, including Standard Error (SE), Confidence Intervals (CI) and Relative Standard Error (RSE). For example, the range around estimated catch is represented as 95% confidence intervals (95% CI).

Prior to the expansion of raw data to the RL licence holder population, the distribution of raw data on effort, as number of days fished per year, and retained catch of WRL per year were explored. The median number of days fished per year was nine for potting (Range = 1–215) and five for diving (Range = 1–140) (Appendix 2). The median retained WRL catch per year was 24 for potting (Range = 1–840) and 12 for diving (Range = 1–545) (Appendix 3).

The sample weight (or expansion factor) for each stratum (RDC) was calculated as

$$\alpha_{hi} = \frac{N_h}{n_h}$$

where α_{hi} is the weight for the RL licence holder i in stratum h , N_h = total number of RL licence holders in stratum h and n_h = number of RL licence holders sampled in stratum h .

In 2021/22, the population total for RL licence holders used to draw the survey sample was a short interval (23 January–22 January) before the recall period and RL recreational fishing season (1 February–31 January). This resulted in a difference of 105 RL licences but enabled the survey to commence as swiftly as possible after the recall period had ended. The number of RL licence holders from the recall period was used to expand raw survey data to population estimates.

Estimates of participation (number of RL holders) are summarised statewide and by region for all rock lobster fishing (*i.e.*, all four RL species) as well as by fishing method for the season (February 2021–January 2022). Estimates of effort are calculated as number of days fished for RL (all species) and are summarised statewide, and by each region and fishing method.

Recreational catch estimates were converted from numbers to weight for comparison against the TARC. The average weight of WRL obtained from the boat ramp survey (see Section 2.2) was multiplied with the raw catch data and then expanded to population estimates for all RL licence holders within the recall period.

Annual statewide and regional estimates of retained catch (weight \pm 95% CI) of WRL are provided for each method (potting and diving). Consistent with other published studies, estimates were deemed to be robust when a sample size of ≥ 30 fishers was achieved and the Relative Standard Error (RSE) was ≤ 0.4 (calculated as the standard error of the sample divided by the estimate) (Ryan et al., 2022). Non-robust estimates are indicated in tables and figures when they occur.

An adjustment of recreational catch estimates (by numbers and weight) from phone-recall surveys are required to account for recall and non-response biases in these survey methods. A constant correction factor was applied to estimated recreational catches from mail surveys conducted from 1986/87–2017/18 (0.39) (Thomson, 2013). A different adjustment value is required for the phone-recall surveys due to the higher response rates as well as lower recall bias when compared to the mail surveys. A correction factor for the 2021/22 phone survey was therefore based on comparisons of estimated recreational catches (potting and diving combined) from three adjusted-mail and phone–recall surveys conducted from 2015/16–2017/18 (0.62) (Trinnie et al., 2021).

2.1.3 Response rate

A random sample of 2,150 people were selected from those who were licensed to fish for RL in the previous 12-months prior to the survey (Table 2). The number of licences in the 2021/22 fishing season was 55,655 and the sample represented ~4% of licence holders. The overall response rate was 96.7%. Six RL licence holders were out of scope (*i.e.*, international visitors).

Table 2 Sample size and response profile by stratum for the phone-recall survey conducted in February 2022. Note: total RL licence holder population valid for period 1 February 2021–31 January 2022.

	Total RL Holders	Initial sample	Sample loss	Net sample	Non-response		Full response	Response rate [^]
					Non Contacts	Refusals		
Metro	31,803	550	92	458	0	19	439	95.8%
Mid-West	7,943	400	80	320	1	11	306	95.6%
Peel	5,760	400	70	330	0	5	323	97.9%
South-West [#]	5,646	400	80	320	0	10	310	96.9%
Country [*]	4,497	400	69	331	1	7	323	97.6%
Out of scope	6							
TOTAL	55,655	2,150	391	1,759	2	52	1,701	96.7%

^{*} Country combines Kimberley, Gascoyne, Goldfields-Esperance, Great Southern RDC and Interstate

[#] Mid-West combined Mid-West and Wheatbelt

[^] Full response / (Eligible + Non-Contacts)

2.2 Boat ramp survey

2.2.1 Survey design

The survey aimed to measure the length and weight of WRL to obtain a representative sample of WRL retained by recreational fishers using a probability-based design, based on a restricted spatio-temporal sampling frame (Smallwood and Ryan, 2020). From this, an index of the average weight retained by recreational fishers was developed to convert estimates of catch by numbers to catch by weight.

This design has been consistent since this survey commenced in 2015/16 (Smallwood et al., 2021; Trinnie et al., 2021). A robust time series of average weight data can therefore be obtained using a pragmatic and cost-effective sampling frame.

The sampling frame for the boat ramp survey coincides with peak activity for the recreational fishery, which occurs in the Metro-West region during December and January, with 42.1% of fishing effort and 46.8% of retained catch for 2021/22 occurring within this time (Appendix 4). Boating activity at boat ramps across the Metro-West region is monitored using fixed cameras and this informed the decision to focus sampling at the two busiest public boat ramps (Hillarys and Woodman Point) within this area (Figure 1; Table 1).

Although the size of WRL are known to vary across latitudes (de Lestang, 2014), the average weight generated from this survey is treated as representative of the WRL recreational fishery. This is due to the location of the sample sites within the range of peak lobster abundance (Bellchambers et al., 2017) and sampling during periods which capture nearly 50% of RL fishing activity statewide (Appendix 4). Regular biological sampling of WRL outside of these surveyed periods further supports this rationale. For example, additional sampling at these key boat ramps in 2015, 2020 and 2021 during November, when an additional 8–11% of statewide fishing effort and WRL catch occurs, revealed little change in average weight with the inclusion of this additional data. Furthermore, annual variation in timing of the synchronised offshore migration of WRL towards the end of each calendar year (de Lestang, 2014) combined with variable weather patterns result in high variability in boating activity in this month. The subsequent challenges in scheduling boat ramp surveys also resulted in a lower number of WRL measurements being obtained during November when compared to December and January.

Data from RL fishers were collected using face-to-face interviews as they returned from their fishing trip. Based on data from fixed cameras monitoring boating activity at Hillarys and Woodman Point, the optimal time for sampling was identified as during the morning (6:00 to 10:00) which was expected to primarily sample fishers using rock lobster pots, and during the afternoon (12:00 to 16:00) which was expected to sample more divers, or potting occurring in deeper waters. Survey days were classified as either weekday (Monday to Friday) or weekend/public holiday (Saturday, Sunday, weekday public holidays). Survey staff were instructed to cancel a shift if thresholds were not met for a number of trailers at the ramp, or if wind speeds exceeded 25 knots at the start of the shift. Cancelled shifts were rescheduled for the same time of day and day type within the month. Biological data such as sex, carapace length (mm), body weight (grams), and appendage (legs, antennae) loss were collected.

2.2.2 Analysis

The estimated catches from the phone-recall survey were converted from numbers to weight for comparison against the TARC. This was calculated as the (arithmetic) average weight combined by sex, and across potting and diving (herein referred to as overall) for WRL in each survey year. Prior to the calculation of mean weight, the

distribution of raw data was explored (Appendix 5). The lower and upper 95% CI for average weight were also calculated.

2.2.3 Response rate

Interviews were conducted with 1,219 vessels at Hillarys and Woodman Point public boat ramps in December and January of 2021/22. The response rate was >99.0%.

2.3 Tour Operator Returns

2.3.1 Data collection

Daily trip sheets are a mandatory reporting requirement for all tour (charter) operators and therefore provide an assumed census of fishing activity (Table 1). The numbers of lobster retained and released by clients on each fishing trip are recorded by the tour operators, and a random sample of lobster carapace lengths are measured from the retained catch.

2.3.2 Analysis

Recreational catch from tour operators were provided for time periods which match the 2021/22 phone-recall survey (*i.e.*, February–January). Analysis of tour operator data prior to 2018/19 was based on financial year.

Data from tour operators could only be reported if more than three operators had provided returns for a particular species, or the temporal or spatial period of interest. Non-reporting of data due to confidentiality has been indicated where it occurs.

Fishing for RL species from tour operators can also be assigned to a specific fishing method (*i.e.*, potting and diving). Separate fishing ‘sessions’ are recorded for each method used on a fishing trip and allowed fishing effort for RL and catches to be assigned to diving (including snorkelling) and potting. However, if the gear type or fishing method used in each session has not clearly been reported or separated on returns, then any fishing for RL species will be assigned to potting. Validation of Tour Operator Returns aims to correct for these situations where inaccurate reporting is occurring, especially in more recent years when there is an increased emphasis on fishing for RL species.

The total number of clients on board each trip in which potting occurred was used as the measure of participation for this method; noting this may be an overestimate as not all clients may have been involved in this activity. For diving, the exact number of participants was recorded and used as a measure of participation. To calculate the total number of participants the values from both methods were combined. On the few occasions (2 trips) where multiple activities occurred in 2021/22, charter clients (18) were assumed to have participated in both activities

Fishing effort for tour operators was measured as the number of days fished and included any trips where any RL species were caught (retained or released). The number of pots used by an operator is not considered in this analysis as the focus is on overall effort, and not considering the various drivers that may affect effort. It is not possible to assign fishing effort if a tour operator was targeting RL species but

caught nothing; and these trips will not be included in any results for participation and fishing effort.

Catches from tour operators were also converted from numbers to weight for comparison against the TARC. This was calculated by multiplying the catch (by numbers) obtained from Tour Operator Returns with an average weight for WRL, which is obtained by utilising Carapace Lengths (CL) measured from lobsters selected at random by tour operators. These random length samples are converted to a single average weight using the following length-weight equation $0.002831 * CL^{2.744}$ (unpublished DPIRD data). Only random length samples which were obtained within the 2021/22 fishing season were included in the calculation of average weight. Measurements were combined across potting and diving (*i.e.*, overall). This differs to analyses undertaken prior to 2018/19 where an average weight was calculated using random length samples obtained across all years.

2.3.3 Response rate

While it is a mandatory requirement for tour operators to submit returns, there can be some delay in processing and data being available for analysis. Data extraction for this report occurred on the 31 May 2022 and at this time >98% of Tour Operator Returns had been entered up until the end of January 2022. Based on prior knowledge of tour operators, the few outstanding returns are unlikely to have catches of RL.

2.4 Recreational harvest

The calculation of the proportion of AHL requires elements from all data collection methods (phone-recall survey, boat ramp survey and Tour Operator Returns) to generate retained catch for the recreational sector by weight. Moreover, as the recreational sector's catch is monitored using the 5-year historic moving average of both the retained recreational catch (from licensed fishers and tour operators) and TARC, data is also required from historical mail-recall surveys completed prior to 2018/19 (Trinnie et al., 2021). Therefore, the 5-year moving average of recreational catch in 2021/22 combines data from the historic mail-recall survey in 2017/18 and phone-recall surveys in 2018/19–2021/22.

3.0 Results

3.1 Participation

3.1.1 *Phone-recall survey*

The total number of RL licences issued statewide in 2021/22 (1 February 2021–31 January 2022) was 55,655. The Metropolitan area had the greatest number of RL licence holders (Appendix 6).

Participation in the RL recreational fishery (all species) by licensed fishers (RL licence holders aged five years and older) in 2021/22 was 67.3% or 37,466 fishers (95% CI 35,980–38,952) (Figure 2a). For those RL licence holders who did not fish in the previous 12-months, this was most commonly for personal reasons (i.e., family, health, work commitments) (54.1%), followed by access (i.e., sold equipment, location closed, relocation) (17.8%) and other (15.1%).

Higher participation occurred in potting (66.7%) compared with diving (25.1%) in 2021/22, with the remaining 8.2% participating in both RL fishing methods (Figure 2b). Fishing for RL from boats had the highest participation (86.9%) compared with from the shore (5.1%), with the remaining 8.0% fishing from both platforms (Figure 2c).

Males accounted for the majority of RL licence holders who fished in 2021/22 (88.8%) compared with females (11.2%; Figure 2d). The highest number of RL licence holders that fished were in the 30–44 and 45–59-year age groups, with 27.8% and 29.0%, respectively (Figure 2g). The lowest numbers of RL licence holders that fished were in the 5–14-year age group (4.0%).

Most RL licence holders fished in the Metro-West Coast in 2021/22 (70.4%), followed by the Mid-West (19.6%) (Figure 2e). Lower proportions of RL licence holders fished in the North (1.2%), Gascoyne (2.5%) and South (1.0%) regions, with the remaining 5.3% fishing across multiple regions.

The number of days fished (by recall) in the previous 12-months is a measure of fishing avidity. RL licence holders were most likely to fish 5–14 days (39.9%) in 2021/22, followed by 15 days or more (30.5%) and 1–5 days (29.6%; Figure 2f).

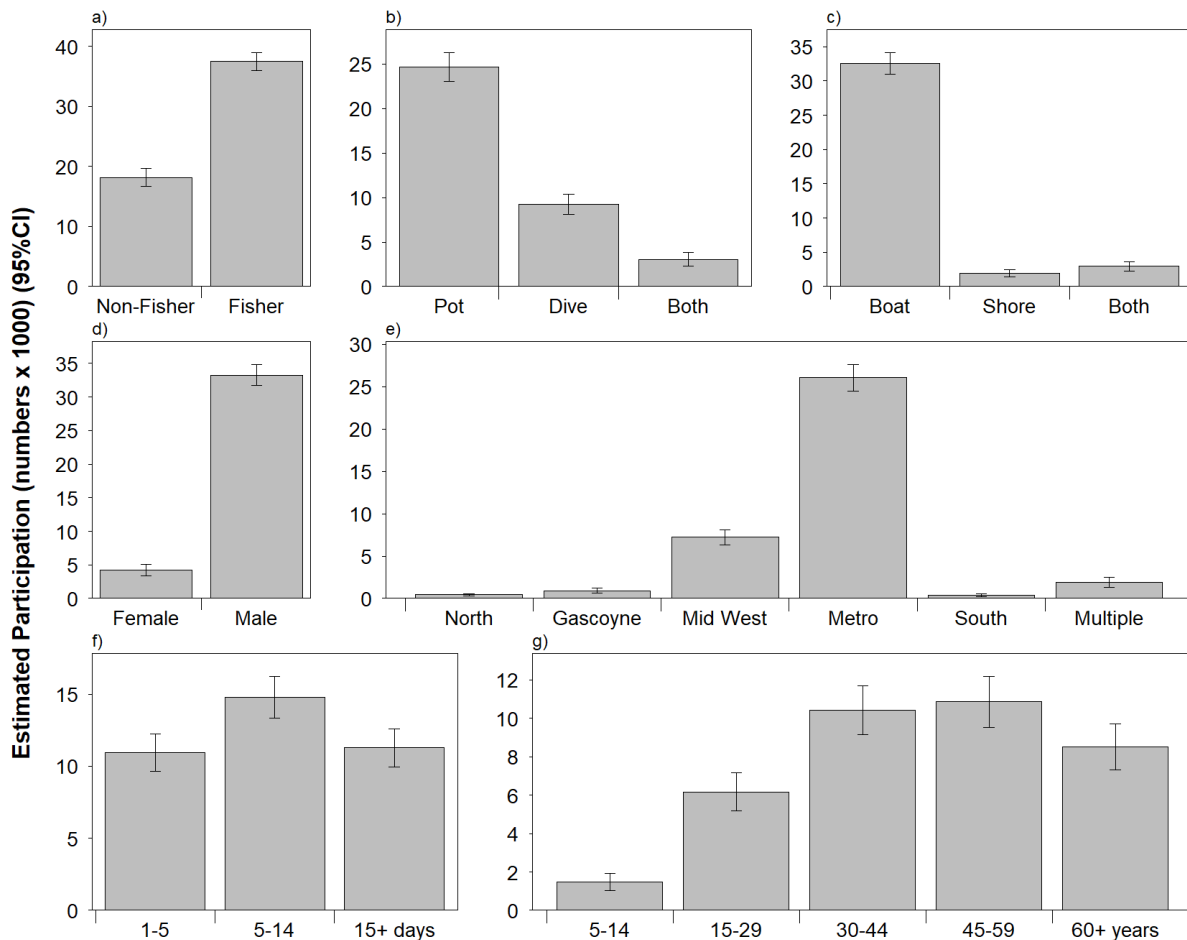


Figure 2 Number of RL licence holders ($\pm 95\%$ CI) aged five years and older in 2021/22 summarised by (a) non-fishers and fishers. For those who fished, summaries are provided by (b) fishing method; (c) platform; (d) gender; (e) bioregion fished (f) avidity (days fished for RL per year); (g) age (years).

3.1.2 Tour operators

There were 59 tour operators who undertook trips which involved catching RL species throughout Western Australia in 2021/22. Over 90% of these tour operators were in the West Coast Bioregion.

Participation in RL fishing in 2021/22 was 15,243 people (clients), of which 85.9% were on trips in which pots were used. Participation in diving for RL species was 14.1%.

Due to confidentiality (*i.e.*, the small number of tour operators undertaking trips which involved catching RL species outside of the West Coast Bioregion) tour operator participation in RL fishing cannot be reported by bioregion.

3.2 Gear type and loss

3.2.1 Phone-recall surveys

Of those RL licence holders who fished using pots, 87.2% used pots constructed predominately of wooden materials (i.e., jarrah batten pots or cane beehive pots). The remaining RL licence holders used plastic pots (8.1%), both wood and plastic pots (3.6%) or pots of unknown construction (1.1%).

RL licence holders who fished using pots were asked to report if any of their potting equipment had been lost or gone missing in the previous fishing season. No gear loss was reported by 69.8% or 19,348 of pot fishers (95% CI 17,791–20,906) while 26.8% or 7,441 (5,766–9,116) reported loss of pots and floats, and 3.1% or 862 (410–1,315) reported the loss of floats only. The remaining pot fishers (0.3%) could not remember or were unsure if gear loss had occurred.

RL licence holders who fished (using any gear type) were also asked to report if they had observed any gear that been lost or gone missing with respect to potting equipment belonging to other fishers (i.e., ropes cut, discarded pots). No gear loss was observed by 60.8% or 22,784 RL licence holders (95% CI 21,196–24,371) while 23.0% or 8,612 (6,796–10,428) observed the loss of pots and floats, and 6.4% or 2,383 (1,722–3,044) observed the loss of floats only. Of the remaining RL licence holders who fished, 9.3% reported hearing about lost potting equipment from other fishers while 0.5% could not remember or were unsure if they had observed

Of those RL licence holders who dived, 50.4% were snorkeling or free diving, with the remainder either using compressed air (i.e., SCUBA or hookah) (37.8%) or a combination of methods (11.8%).

3.2.2 Tour operators

Data on gear type and gear loss by tour operators is not collected in mandatory logbook reporting.

3.3 Effort

3.3.1 Phone-recall surveys

Total fishing effort for RL (all species) by licensed fishers in 2021/22 was 522,019 days fished (95% CI 468,799–575,240); of which 75.8% or 395,781 days (344,426–447,137) was by potting and 24.2% or 126,238 days (104,188–148,288) by diving.

The majority (70.1%) of the fishing effort was in the Metro-West Coast (Table 3). Of this total, 79.0% or 289,087 days (240,210–337,963) was by potting and 21.0% or 76,993 days (60,651–93,335) by diving.

Table 3 Fishing effort (days) for all rock lobster species by licensed fishers obtained using phone-recall surveys in 2021/22 for each region by potting, diving and total with lower (LCI) and upper (UCI) 95% confidence intervals.

Note: (1) values in bold indicate RSE>0.4; values in italics indicate n<30; (2) due to the number of decimal places in the input parameters and rounding, the values across regions with a year may not sum to the totals at a statewide level.

Region	Fishing effort (days)								
	Potting			Diving			Total		
	Estimate	LCI	UCI	Estimate	LCI	UCI	Estimate	LCI	UCI
North	145	0	427	9,281	4,982	13,580	9,426	5,118	13,734
Gascoyne	1,041	72	2,009	13,393	8,362	18,424	14,434	9,208	19,659
Mid-West	104,154	84,273	124,036	23,541	14,011	33,071	127,696	106,417	148,974
Metro-West	289,087	240,210	337,963	76,993	60,651	93,335	366,080	315,671	416,488
South	1,355	273	2,436	<i>3,030</i>	<i>1,559</i>	<i>4,501</i>	4,385	2,570	6,199

3.3.2 Tour operators

Fishing effort (in days fished) based on trips where any RL species were caught by tour operators was 1,636 days in 2021/22. The majority of this effort was obtained by tour operators using potting (84.7%) whereas effort by diving was 15.3%.

Due to confidentiality (*i.e.*, the small number of tour operators undertaking trips which involved catching RL species outside of the West Coast Bioregion) tour operator effort cannot be reported by bioregion.

3.4 Average weight

3.4.1 Boat ramp survey

The overall average weight (in grams) of WRL for boat-based recreational fishers obtained from boat ramp surveys in 2021/22 was 610.7 g (95% CI 597.0–626.9), calculated from 2,487 weight samples.

3.4.2 Tour operators

The number of length samples recorded in Tour Operator Returns in 2021/22 was 12,943 or 37.4% of the total retained catch. The overall average weight (in grams) of WRL obtained from tour operators was 505.6 g (95% CI 502.4–508.9) in 2021/22.

3.5 Retained catch

3.5.1 Phone-recall survey

The overall average weight of WRL obtained from boat ramp surveys (Section 3.4.1) and a correction factor (0.62) (Section 2.1.2) were used to convert statewide (Appendix 7) and regional (Appendix 8) estimates of the retained catch of WRL by number to weight.

The retained catch of WRL by licensed fishers in 2021/22 was 487 t (95% CI 434–541); of which 75.0% or 366 t (320–411) was harvested by potting and 25.0% or 122 t (88–156) by diving.

The majority (72.5%) of the retained catch in 2021/22 was from the Metro-West Coast with 353 t (95% CI 310–397); of which 75.1% or 265 t (226–304) was by potting and 24.9% or 88 t (64–113) by diving (Table 4).

The statewide retained catch (in numbers) of Southern Rock Lobster (*Jasus edwardsii*) and Tropical Rock Lobster species (*Panulirus ornatus* and *P. versicolor*) represented 0.8–1.1% of the total RL catch in 2021/22 (Appendix 7). These species are taken mainly in the South Coast and North Coast, respectively.

Table 4 Retained recreational catch (in tonnes) of WRL by licensed fishers obtained using phone-recall surveys in 2021/22 for each region by potting, diving and total, with harvest ranges (lower and upper 95% confidence intervals).

Note: (1) values in bold indicate RSE>0.4; values in italics indicate n<30; (2) due to the number of decimal places in the input parameters and rounding, the values across regions with a year may not sum to the totals at a statewide level.

Region	Retained catch (tonnes)								
	Potting			Diving			Total		
	Estimate	LCI	UCI	Estimate	LCI	UCI	Estimate	LCI	UCI
North	0	0	0	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>	<i>0</i>
Gascoyne	<i>0</i>	<i>0</i>	<i>1</i>	4	2	5	4	2	6
Mid-West	100	75	125	28	9	48	128	97	160
Metro-West	265	226	304	88	64	113	353	310	397
South	<i>0</i>	<i>0</i>	<i>1</i>	2	<i>0</i>	3	2	1	3

3.5.2 Tour operators

The overall average weight for WRL calculated using tour operator data (Section 3.4.2) was used to convert the statewide retained catch by numbers to weight. The total catch of WRL (by numbers) for tour operators is provided in Appendix 9. Where confidentiality permits (*i.e.*, more than three tour operators reported catch), the statewide retained catch of Southern Rock Lobster (*Jasus edwardsii*) and Tropical Rock Lobster species (*Panulirus ornatus* and *P. versicolor*) are also reported.

The retained catch (in tonnes) of WRL from charter fishers in 2021/22 was 17 t. The majority of the catch was taken by potting (16 t or 93.4%), with the remaining 1 t taken by diving.

Due to confidentiality (*i.e.*, the small number of tour operators undertaking trips which involved catching RL species outside of the West Coast Bioregion) tour operator catches cannot be reported by bioregion.

3.6 Recreational Harvest

3.6.1 Total Allowable Recreational Catch (TARC)

The TARC for 2021/22 was 562 t (Table 5). Assessment of the recreational catch against its allocation of WRL catch is based on 5-year historic moving averages of the retained catch and the TARC (see Section 2.4). Thus, in 2021/22, the 5-year moving average of retained catch was 505 t and the 5-year moving average of the TARC was 520 t.

3.6.2 Allowable Harvest Level (AHL)

In 2021/22, the recreational catch equated to 4.9% of the AHL, which is within the recreational sector's allocation of 5% of the AHL (Table 5).

Table 5 Total Allowable Recreational Catch (TARC), retained catch (licensed fishers + charter) and proportion of Allowable Harvest Level (AHL) attained since 2012/13.

Note:

1. Percentage of 5-year TARC formula: $100 \times (\text{Catch 5-year average} / \text{TARC 5-year average})$;
2. Proportion of AHL formula: $5 \times (5\text{-year moving average retained catch} / 5\text{-year moving average TARC})$;
3. n.a. = data not available prior to implementation of quota management.

Season	AHL (t)	TARC (t)	Estimated Retained Catch (t)	TARC 5-year average (t)	Catch 5-year average (t)	Percentage of 5-year TARC (%)	Proportion of AHL (%)
2013/14	7,760	388	243	-	159	-	n.a.
2014/15	8,080	404	330	339	190	55%	2.8%
2015/16	8,440	422	393	365	241	66%	3.3%
2016/17	9,600	480	461 [^]	403	310	77%	3.8%
2017/18 [*]	10,120	507	489 [^]	440	383	87%	4.4%
2018/19 ^{**}	10,120	506	458 [^]	464	426	92%	4.6%
2019/20 ^{***}	9,800	490	535 [^]	481	467	97%	4.9%
2020/21	10,650	533	537 [^]	503	496	99%	4.9%
2021/22	11,250	562	504 [^]	520	505	97%	4.9%

[^] includes charter catches from logbooks (prior to 2016/17 charter catch was captured within the recreational catch)

^{*} The 2017/18 season covers the period 15 October 2017 - 30 June 2018, prior to the recreational fishery being open year-round from 1 July 2018.

^{**} The 2018/19 season covers the period February 2018 to January 2019. Therefore, 5 months of catch (February–June 2018) is reported in both the 2017/18 season and the 2018/19 season.

^{***} The first recreational season that almost completely aligns with the commercial season, being February 2019 to January 2020.

4.0 Discussion

4.1 Participation

Recreational fishing for RL has been a licensed activity since the 1970s, with mail-recall surveys used for annual monitoring of this fishery since 1986 (Trinnie et al., 2021). This licence has provided revenue to support recreational fishing and a sampling frame to assist dedicated surveys of this specialised fishery. A transition from a mail-recall survey was required for a number of reasons, including addressing a declining response rate (26% in 2017/18). The phone-recall surveys achieved this goal by attaining response rates >96%.

Participation in the RL recreational fishery (all species) by licensed fishers (RL licence holders aged five years and older) in 2021/22 (1 February 2021–31 January 2022) was 67.3% or 37,466 fishers (95% CI 35,980–38,952). This was steady when compared to phone recall surveys conducted between 2018/19–2020/21 (66.6–67.7%) (*i.e.*, the 95% CI overlapped between survey years) and also the 2017/18 mail survey (64%) (Smallwood et al., 2021; Trinnie et al., 2021).

Participation has also been reported for a number of fishery (*i.e.*, gear type, bioregion fished) and demographic (*i.e.*, gender, age, avidity) variables for licensed fishers in 2021/22. These results showed some consistency in participation across licence types. For example, males were the dominant gender type participating in recreational fishing for both RL (89%) and Recreational Boat Fishing (RBF) (87%) licence holders (Ryan et al., 2022). This is the first time that these demographic variables have been reported for RL licence holders. Ongoing reporting and further investigation will enable monitoring of changes in this population over time and help develop a greater understanding of the behaviours and characteristics of RL fishers, and how this may differ between licence types. There is no comparable demographic information of clients collected using Tour Operator Returns.

A summary of the gear type used (*i.e.*, wooden or plastic pots) by licensed fishers revealed >85% of those who fished with pots used those constructed predominately of wooden materials (*i.e.*, jarrah batten pots or cane beehive pots). This phone-recall survey was also the first-time questions relating to gear loss have been asked. Of all RL licence holders who fished using pots, 26.8% reported loss of pots and floats, and 3.1% reported the loss of floats only. Similar proportions of RL fishers observed gear loss with respect to potting equipment belonging to others (*i.e.*, cut ropes, discarded pots). Although general in nature, these questions will assist in monitoring gear loss in this recreational fishery and potentially provide a basis for more targeted data collection around the possible reasons for gear loss (*i.e.*, theft, ropes cut by propellers, bad weather) as well as detailed quantification about the amount and type of material being lost (*i.e.*, detailed description of pot types, rope and float types) and frequency of gear loss. Global awareness of the potential socio-economic and environmental impacts of Abandoned, Lost or Discarded Fisher Gear (ALDFG) is growing, but until now has focused primarily on commercial fishers (Gilman et al., 2021; He and Suuronen, 2018; Richardson et al., 2019).

4.2 Fishing effort and retained catch

In 2021/22 the total fishing effort for RL fishing (all species) was 522,019 days fished (95% CI 468,799–575,240); of which 75.8% or 395,781 days (344,426–447,137) was by potting and 24.2% or 126,238 days (104,188–148,288) by diving. This was steady when compared to phone recall surveys conducted between 2018/19–2020/21 (Smallwood et al., 2021). The greatest effort occurred in the Metro-West Coast, followed by the Mid-West Coast, which was also consistent with previous phone-recall survey years.

The retained catch (by weight) of WRL by licensed fishers was obtained from integrating phone-recall surveys and boat ramp surveys. In 2021/22 the retained catch of WRL by licensed fishers was 487 t (95% CI 434–541); of which 75.0% or 366 t (320–411) was harvested by potting and 25.0% or 122 t (88–156) by diving. This was steady when compared to phone recall surveys conducted between 2018/19–2020/21 (Smallwood et al., 2021). In the context of the time series of retained catches from licensed fishers, which commenced in 1986/87, those in the last 5 years (since 2015/16) have been the highest since data collection commenced (Figure 3a). This followed a period of lower catches from 2005/06–2012/13. The increase in catches since 2012/13 have largely been due to higher catches obtained by potting. Although the catches of RL taken by diving have also increased, this has not been to the same extent as potting and therefore the proportion of catch taken by diving has been generally lower from 2013/14–2021/22 (16.9–26.7%) when compared with 2005/06–2012/13 (Figure 3b).

Exploration of the distribution of raw data for effort and retained catch in 2021/22 also provided greater insight into the behaviour of licensed fishers. The median annual values for effort (nine days per year for potting and five per year for diving) and catch (24 WRL per year for potting and 12 WRL per year for diving) show that the majority of RL recreational fishers only fish for short periods of time each year, which is much less than the permitted 12-months, and their retained catch reflects this level of fishing effort (Appendix 2; Appendix 3).

There was a significant increase in fishing effort and retained catch from 2012/13–2016/17 (Trinnie et al., 2021) and these levels have been maintained since 2018/19. Several management changes have occurred since 2012/13, including increased pot limits, increased bag limits and extended fishing seasons which have increased opportunities for the recreational sector to access this resource (Appendix 1). The most recent management changes occurred in July 2018 and included opening the RL fishery for 12-months each year. WRL catches are also dependent upon a number of biological and environmental factors such as successful puerulus settlement and expected conditions for fishing (Crowe et al., 2013). However, the main reasons for the increase in recreational catch are not only an easing of management regulations, but also increased abundance and size of WRL as a result of the move to a more conservative level of fishing for the commercial sector in the late 2000s which is now targeting maximum economic yield rather than maximum sustainable yield (Caputi et al., 2015; Reid et al., 2013; Stoklosa, 2013). The increase in size of WRL has been demonstrated by the change in mean weight of

WRL caught by licensed fishers since the introduction of boat ramp surveys in 2015/16 (583.8–651.7g) which, although variable between survey years, has been consistently higher than the previously applied constant (500g) (Appendix 10) (Trinnie et al., 2021).

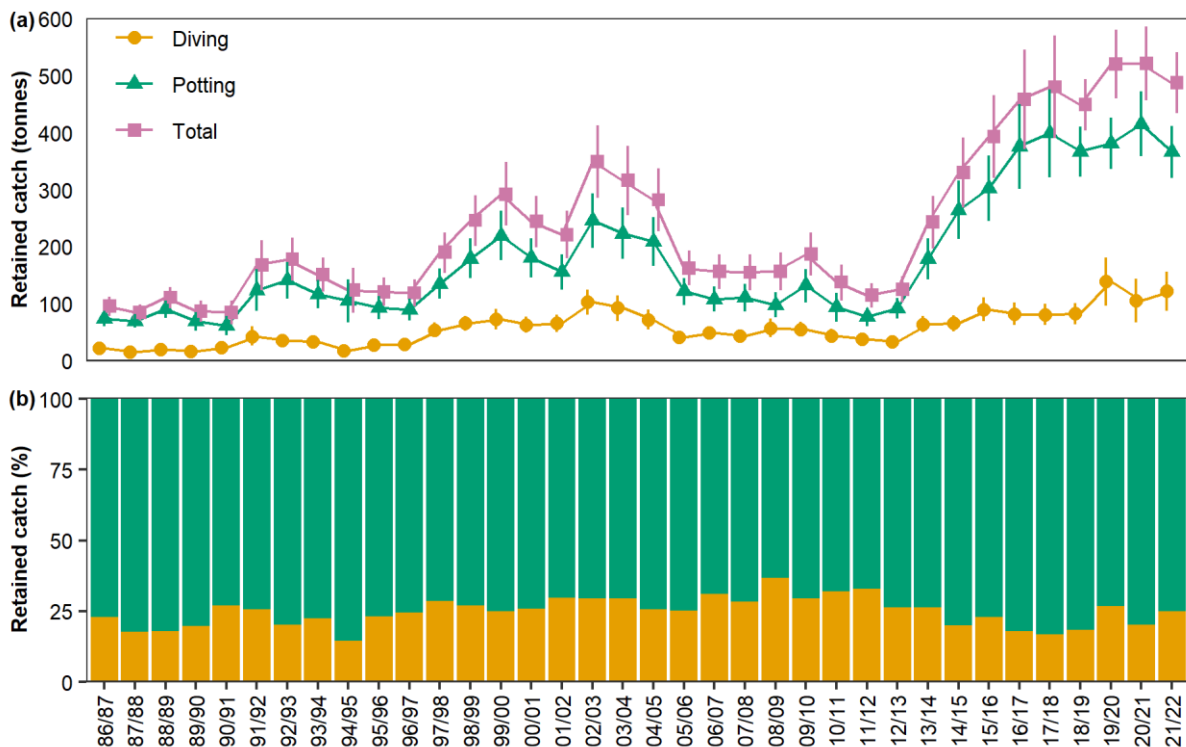


Figure 3 Time series of (a) retained catch (95% CI) and (b) proportion (%) of retained catch of Western Rock Lobster by licensed recreational fishers by potting (green), diving (orange) and total (purple) from 1986/87–2021/22, expanded from Trinnie et al. (2021). Note: A RL licence was required to fish from a charter boat prior to 2016/17 and these catches are included in the retained catch from 1986/87–2016/17, and thereafter in tour operator logbooks.

While the number of tour operators participating in RL fishing was similar in 2021/22 (59) when compared to 2018/19–2020/21 (55–64), there was an increase in participation in 2021/22 (15,243 people), when compared to 2020/21 (13,999 people). There are some limitations around these data (i.e., all clients on board are considered to have participated in any potting which occurs, and the number of clients undertaking multiple trips cannot be ascertained). Nevertheless, participation in 2021/22 is consistent with levels observed in 2018/19 (15,045) and 2019/20 (17,955) (Smallwood et al., 2021). The lower participation in 2020/21 was likely due to travel restrictions implemented as a result of the COVID-19 pandemic. Interestingly, this trend was not reflected in the retained catch which increased annually from 9 t in 2018/19 to 17 t in 2021/22 (Appendix 11). This was substantially greater than the 3 t in 2016/17 when policy changes were introduced to accommodate catches from charter fishing within the Total Allowable Recreational Catch. This included removing the requirement for a RL licence to be held when fishing from a tour operator vessel, with this data subsequently being collected via

Tour Operator Returns (logbooks). This disconnect between participation, fishing effort and retained catch may be due to a number of reasons such as the diverse and changing behaviour of charter fishers in response to shifting policy and other social factors, including travel restrictions due to COVID-19.

A 3-year trial of the most recent changes to RL fishing on tour operator vessels began in November 2019 and includes increases to the number of pots allowed per vessel (from six to 12), as well as increased boat limits on number of lobster (from 24 up to 40 for vessels licensed for six to 10 passengers and 24 up to 40 for vessels licensed for more than 10 passengers). New catch reporting requirements have been implemented to evaluate the success of this trial and will provide an understanding of the effect of these new regulations on catches from tour operator vessels.

Although every effort is made to ensure that data collected from licensed fishers via phone-recall and boat ramps surveys, as well as returns provided by Tour Operators, are accurate and provided in a timely manner, there may be circumstances where additional QA/QC of data may identify data errors which may only be corrected for outside of the reporting period. Tour Operator returns received after a reporting period will also only be included in subsequent fishing seasons. These factors may lead to some estimates being revised in future reporting.

4.3 Management Implications

The recreational fishery has been managed using a statewide TARC since 2010/11. The TARC in 2021/22 was 562 t, the highest of all previous years. The 5-year average recreational catch (from licensed and charter fishing) in 2021/22 represents 4.9% of the AHL. This proportion has been steadily increasing from 2.8% in 2014/15 towards the 5% allocated to the recreational sector (DoF, 2014; IFAAC, 2010). This increase in proportion of AHL taken by recreational fishers was to be expected due to the easing of management regulations, and the reduced level of fishing by the commercial sector which has resulted in increased abundance and size of WRL.

4.4 Future research

Recent management arrangements for the fishery as well as the declining response rate, necessitated a change from mail surveys, which have been run annually since 1986/87, to phone-recall surveys. This change has provided an opportunity to review the existing methodologies and to develop a revised best-practice approach for estimating the recreational catch of WRL. The four research areas (survey modes, recall period, correction factors and average weight) being investigated were described in detail in Smallwood et al. (Smallwood et al., 2021). This research is underway, and findings will be reported in additional publications as they are completed. The application of this research may impact on estimates of participation, fishing effort and retained catch (and their uncertainty). Any revisions will be considered as part of the broader review process. It is anticipated that these changes would be implemented only after consultation with managers, scientists, and stakeholders, and with due consideration given to the effects of any changes on the harvest ranges.

5.0 Acknowledgements

This report would not be possible without contributions for all the RL recreational fishers who voluntarily participated in these fishing surveys. The authors would also like to thank staff from the Department of Primary Industries and Regional Development and Edith Cowan University that provided support and assistance for this project:

- Li Ann Koh and Elvyn Wise from Geospatial Services for preparing licence extracts and maps;
- Veronique Vanderklift, Mark Goninon, Rhonda Ferridge and Vangie Gerginis for assistance with data from Tour Operator Returns;
- Eugene Abrahams, Cassidy Hill, Amber Sky, Sonia Prokojes and staff from the Survey Research Centre (Edith Cowan University) for data collection and entry of the phone surveys;
- Shannon Burchert, Hannah Donnelly, Monica Holland, John Looby, Jessica Neitz, Molly Owens and Mitchell Reid for conducting the on-site interviews and collecting weight measurements at boat ramps and Stuart Blight for his technical assistance.

We also thank Nick Caputi, Simon de Lestang, Lachlan Strain, Rebecca Oliver, Kristi Bower and Brent Wise for reviewing the report and providing valuable comments.

6.0 References

- Baharthah, T., 2007. Comparison of three survey methods applied to the recreational rock lobster fishery of Western Australia. Edith Cowan University.
- Bellchambers, L.M., How, J., Evans, S., Pember, M., de Lestang, S., Caputi, N., 2017. Resource Assessment Report Western Rock Lobster Environmental Resources of Western Australia, Fisheries Research Report No. 279. Perth, Western Australia.
- Caputi, N., de Lestang, S., Reid, C., Hesp, A., How, J., 2015. Maximum economic yield of the western rock lobster fishery of Western Australia after moving from effort to quota control. *Mar. Policy* 51, 452–464.
<https://doi.org/10.1016/j.marpol.2014.10.006>
- Crowe, F.M., Longson, I.G., Joll, L.M., 2013. Development and implementation of allocation arrangements for recreational and commercial fishing sectors in Western Australia. *Fish. Manag. Ecol.* 20, 201–210.
<https://doi.org/10.1111/j.1365-2400.2012.00858.x>
- de Lestang, S., 2014. The orientation and migratory dynamics of the western rock lobster, *Panulirus cygnus*, in Western Australia. *ICES J. Mar. Sci.* 71, 1052–1063. <https://doi.org/10.1093/icesjms/fst205>
- DoF, 2017. Department of Fisheries: Annual Report to Parliament 2016/17. Perth, Western Australia.
- DoF, 2014. West coast rock lobster harvest strategy and control rules 2014-2019, Fisheries Management Paper 264. Department of Fisheries, Perth, Western Australia.
- DPIRD, 2021. Department of Primary Industries and Regional Development Annual Report 2020/21. Perth, Western Australia.
- Gilman, E., Musyl, M., Suuronen, P., Chaloupka, M., Gorgin, S., Wilson, J., Kuczenski, B., 2021. Highest risk abandoned, lost and discarded fishing gear. *Sci. Rep.* 11, 1–11. <https://doi.org/10.1038/s41598-021-86123-3>
- He, P., Suuronen, P., 2018. Technologies for the marking of fishing gear to identify gear components entangled on marine animals and to reduce abandoned, lost or otherwise discarded fishing gear. *Mar. Pollut. Bull.* 129, 253–261.
<https://doi.org/10.1016/j.marpolbul.2018.02.033>
- IFAAC, 2010. Considerations for the Implementation of Western Rock Lobster Sectoral Allocations, Fisheries Management Paper No. 236. Perth, Western Australia.
- Lumley, T., 2010. Complex Surveys: A Guide to Analysis Using R, Biostatistics.
<https://doi.org/10.1002/9780470580066>
- Lyle, J.M., Wotherspoon, S., Stark, K.E., 2010. Developing an Analytical Module for Large-Scale Recreational Fishery Data Based on Phone-Diary Survey Methodology, FRDC Project No. 2007/064.
- Melville-Smith, R., Anderton, S.M., 2000. Western rock lobster mail surveys of licensed recreational fishers 1986/87 to 1998/99, Fisheries Research Report No.

122. Perth, Western Australia.

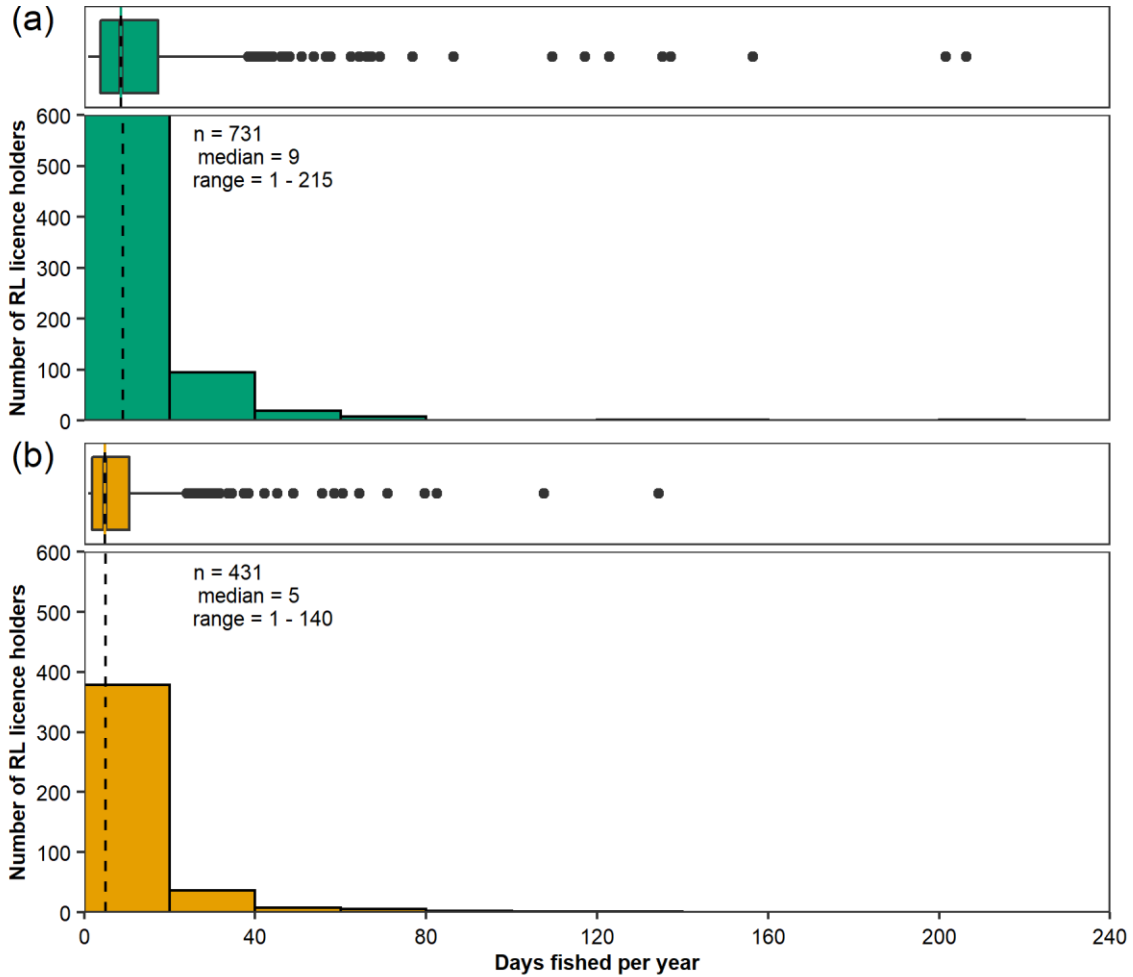
- Newman, S.J., Wise, B.S., Santoro, K.G., Gaughan, D.J., 2021. Status reports of the fisheries and aquatic resources of Western Australia 2020/21. Perth, Western Australia.
- Pollock, K.H., Jones, C.M., Brown, T.L., 1994. Angler survey methods and their application in fisheries management. American Fisheries Society, Special Publication 25.
- Reid, C., Caputi, N., de Lestang, S., Stephenson, P., 2013. Assessing the effects of moving to maximum economic yield effort level in the western rock lobster fishery of Western Australia. *Mar. Policy* 39, 303–313. <https://doi.org/10.1016/j.marpol.2012.11.005>
- Richardson, K., Hardesty, B.D., Wilcox, C., 2019. Estimates of fishing gear loss rates at a global scale: A literature review and meta-analysis. *Fish Fish.* 20, 1218–1231. <https://doi.org/10.1111/faf.12407>
- Ryan, K.L., Lai, E.K., Smallwood, C.B., 2022. Statewide survey of boat-based recreational fishing in Western Australian 2020/21, Fisheries Research Report No. 327.
- Ryan, K.L., Trinnie, F.I., Jones, R., Hart, A.M., Wise, B.S., 2016. Recreational fisheries data requirements for monitoring catch shares. *Fish. Manag. Ecol.* 23, 218–233. <https://doi.org/10.1111/fme.12151>
- Smallwood, C.B., Ryan, K.L., 2020. Benefits of a restricted spatial and temporal survey design for determining average weight of recreational catches. *Fish. Res.* 232, 105735. <https://doi.org/10.1016/j.fishres.2020.105735>
- Smallwood, C.B., Ryan, K.L., Tate, A., Desfosses, C.J., 2021. Recreational fishing for Western Rock Lobster: estimates of participation, effort and catch from 2018/19 – 2020/21, Fisheries Research Report No. 313. Perth, Western Australia.
- Stoklosa, R., 2013. West Coast Rock Lobster Fishery Ecological Risk Assessment. *Fish. Occas. Publ. No. 118* 35. <https://doi.org/10.1016/B978-0-12-409548-9.11137-6>
- Thomson, A.W., 2013. An Estimator to Reduce Mail Survey Nonresponse Bias in Estimates of Recreational Catch : a case study using data from the *Panulirus cygnus* fishery of Western Australia. Curtin University.
- Thomson, A.W., Melville-Smith, R., 2005. Have Different Inducements Used with the Western Rock Lobster Mail Survey of Recreational Licensees Had an Effect on Total Catch Estimates? *North Am. J. Fish. Manag.* 25, 1203–1207. <https://doi.org/10.1577/m04-181.1>
- Trinnie, F.I., Desfosses, C.J., Ryan, K.L., Wise, B.S., 2021. Recreational fishing for Western Rock Lobster: estimates of participation, effort and catch from 1986/87 to 2017/18, Fisheries Research Report No. 299. Perth, Western Australia.

7.0 Appendices

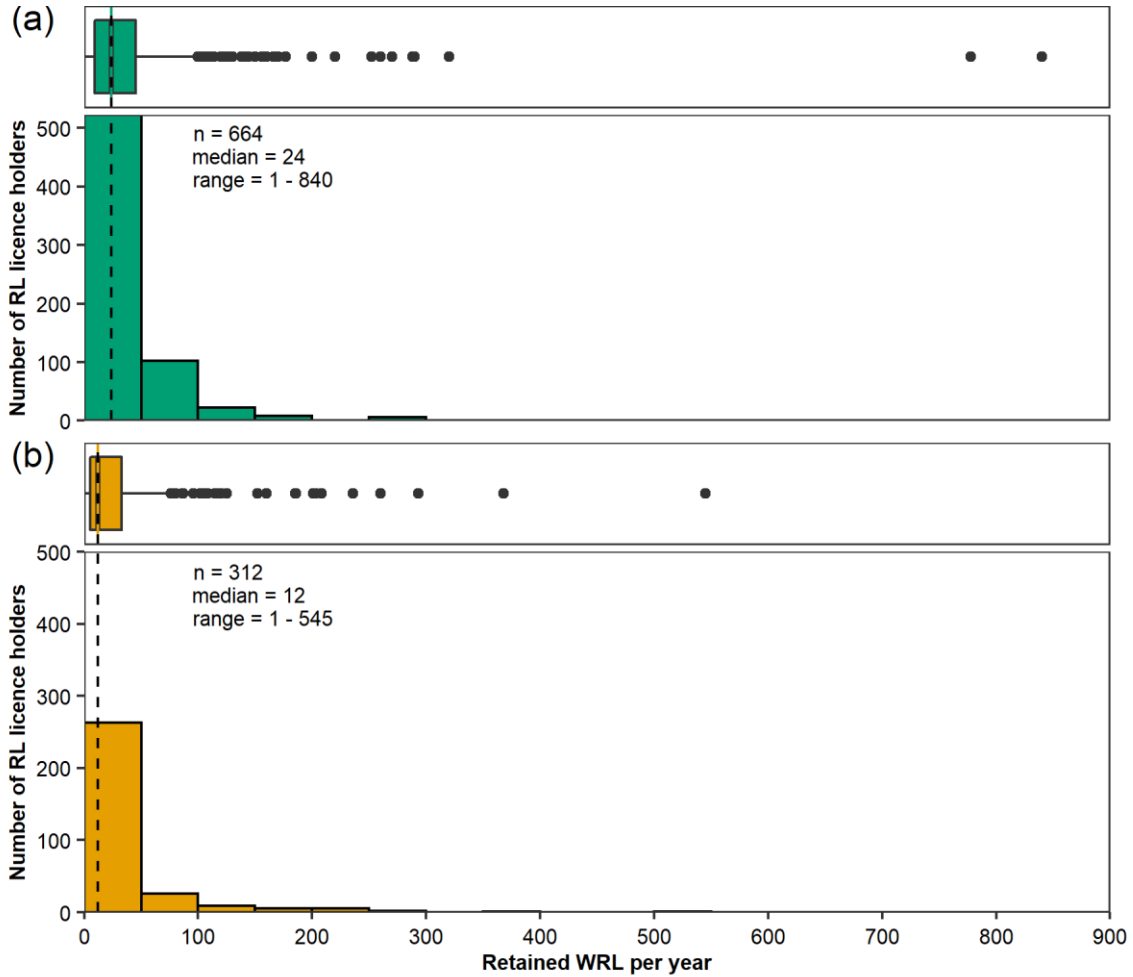
Appendix 1 Management history of the Western Rock Lobster recreational fishery [adapted from Ryan et al. (2016) and Trinnie et al. (2021)].

Year	Management
1970s	Lobster recreational fishing licence (for four rock lobster species)
2000/01	Number of licensed fishers per boat unrestricted; open season from 15 November–30 June; WRL to be tail-clipped; night-time fishing prohibited; gear restricted to 2 pots per fisher; escape gaps in pots to allow undersize WRL to escape; diving restricted to hand collection, snare or blunt crook; protection of reproductive females; minimum carapace length of 77 mm (15 November–31 January) and 76 mm (1 February–30 June); daily bag limit of 8 per fisher and boat limit of 16, where 2 or more licensed fishers; exceptions for Abrolhos Islands season from 15 March–30 June and diving not permitted, and Ningaloo Marine Park daily bag limit of 4 and boat limit of 8
2002/03	Maximum carapace length for female WRL larger than 105 mm (above 30S) and 115 mm (below 30°S)
2005/06	Minimum and maximum carapace lengths reflect the WRL commercial fishery
2008/09	Possession limit of 24 per person; daily bag limit decreased to 6 per fisher and boat limit to 12
2009/10	Maximum carapace length for female WRL decreased to 95 mm (above 30S) and 105 mm (below 30S)
2010/11	Escape gaps defined as a minimum height 55 mm and minimum width 305 mm
2011/12	Minimum carapace length decreased from 77 to 76 mm for entire season
2012/13	Number of licensed fishers per boat increased to 3; increase in pots to 6 per boat, where 3 or more licensed fishers; escape gap height in pots decreased to 54 mm; daily bag limit increased to 8 per fisher and boat limit to 24 where 3 or more licensed fishers; removal of prohibition on diving at Abrolhos Islands
2013/14	Season from 15 October–30 June, except Abrolhos Islands
2016/17	Tour operators permitted to use rock lobster pots as part of the activities undertaken on a fishing tour. Other changes to licensed fishing tours include RL licence not required by a person fishing for rock lobster on a fishing charter boat; maximum of 8 per person, with a boat limit of 24 lobster per trip when there are 3 or more persons on board; up to 6 pots permitted; fishing for RL permitted year around; RL may only be consumed on a fishing tour (Restricted Fishing Tour Operators only).
2017/18	Season open for 12-months (commencing July 2018), noting a transition (or overlap) with the new fishing season occurred from February–June 2018. Pots are permitted to be shared between 2 licensed fishers.
2018/19	New fishing season from February–January in each year, commencing in February 2018.
2019/20	3-year trial commences in November 2019 for selected Tour Operator vessels. Changes include; increase in number of pots allowed per vessel (from 6 to 12 per trip), increased boat limits (from 24 up to 40 for vessels licensed for six to 10 passengers and from 24 up to 80 for vessels licenced for more than 10 passengers); permission for rock lobster to be stored on board within their associated boat limit and permission for Tour Operators to pull, move, set and boat rock lobster pots outside a fishing tour in order to provide a better experience for patrons.

Appendix 2 Distribution of raw data for annual fishing effort (number of days fished) for each RL licence holder surveyed, and who fished for RL, in 2021/22 by (a) potting and (b) diving using boxplots (top panel) and histograms with summary statistics (bottom panel)

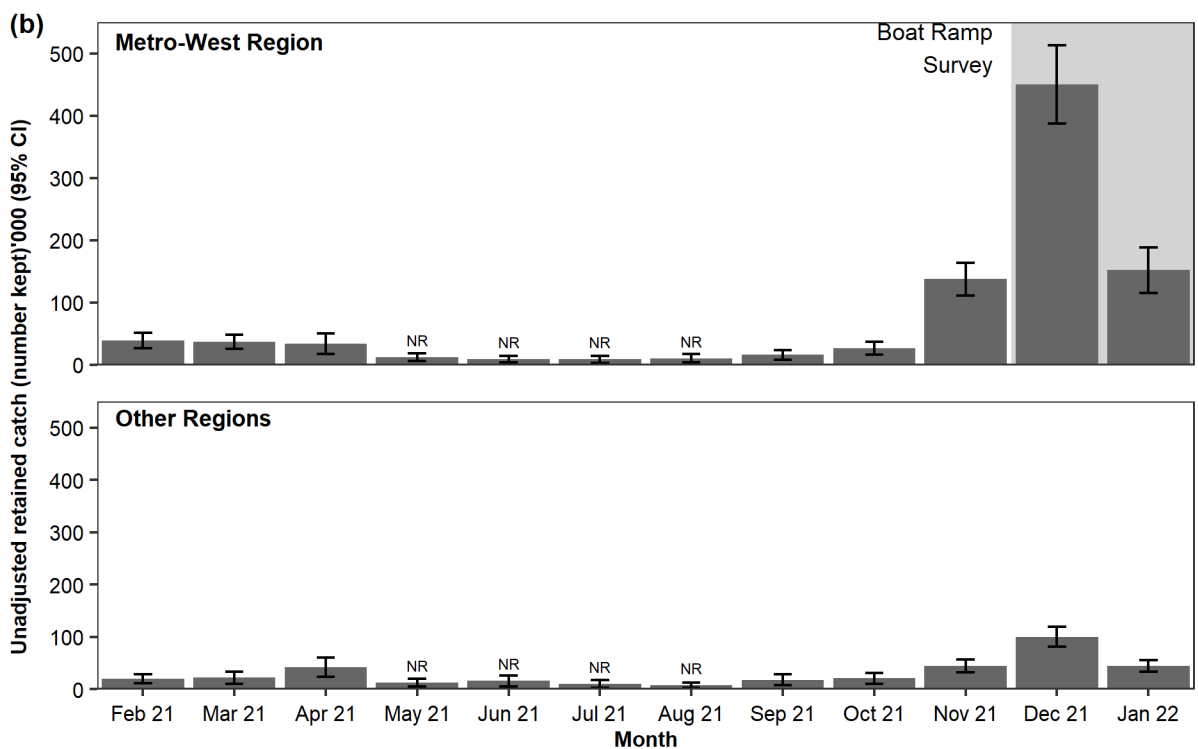
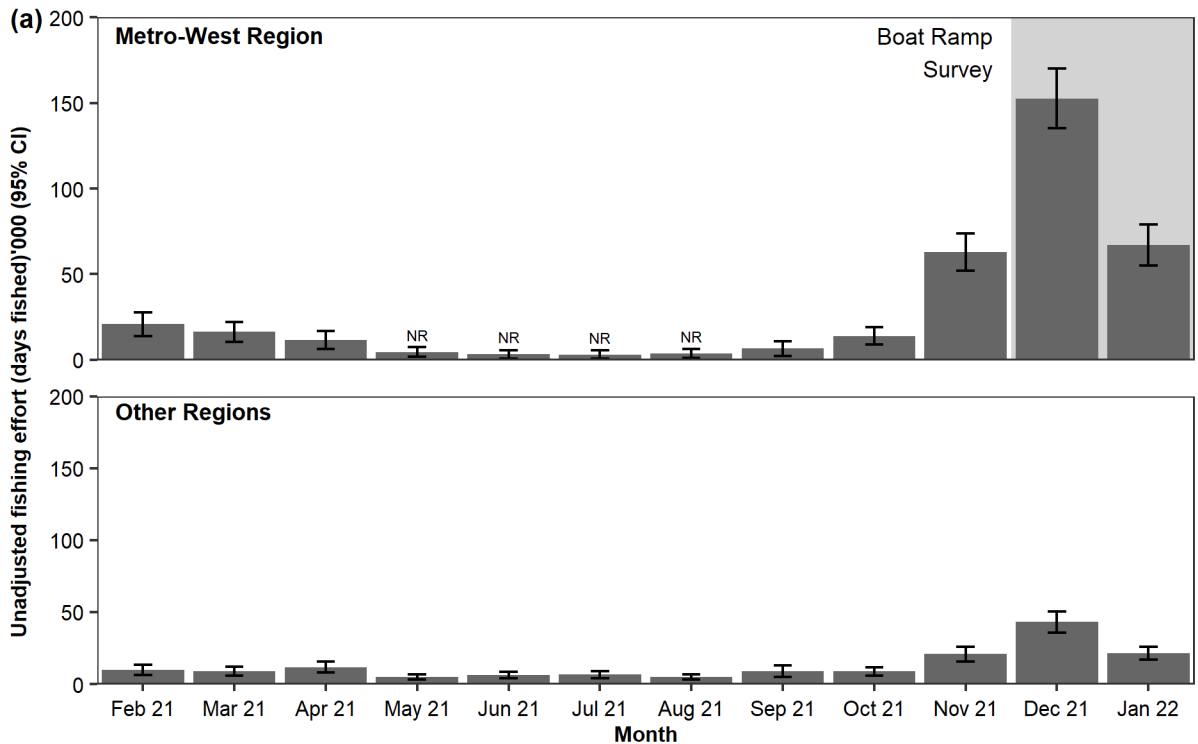


Appendix 3 Distribution of raw data for annual retained catch of WRL (by number) for each RL licence holder surveyed, and who fished, for RL in 2021/22 by (a) potting and (b) diving using boxplots (top panel) and histograms with summary statistics (bottom panel)

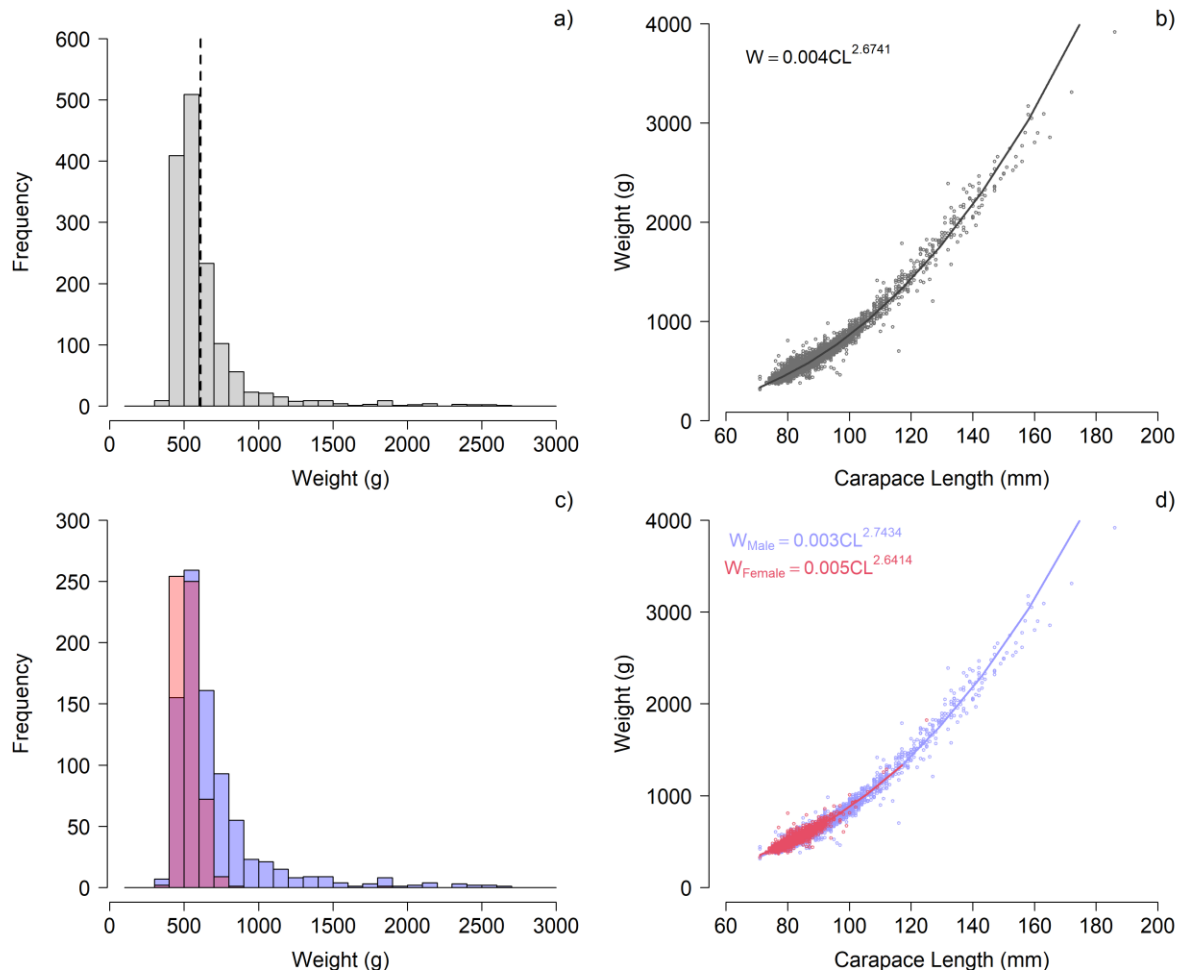


Appendix 4 Unadjusted (a) fishing effort (all species) and (b) unadjusted retained catch (in numbers) (Western Rock Lobster, *Panulirus cygnus*) by month and region from the 2021/22 phone-recall survey, with grey shading indicating spatio-temporal extent of the Boat Ramp Survey.

Note: NR = non-robust estimates where RSE>0.4 and sample size n<30.



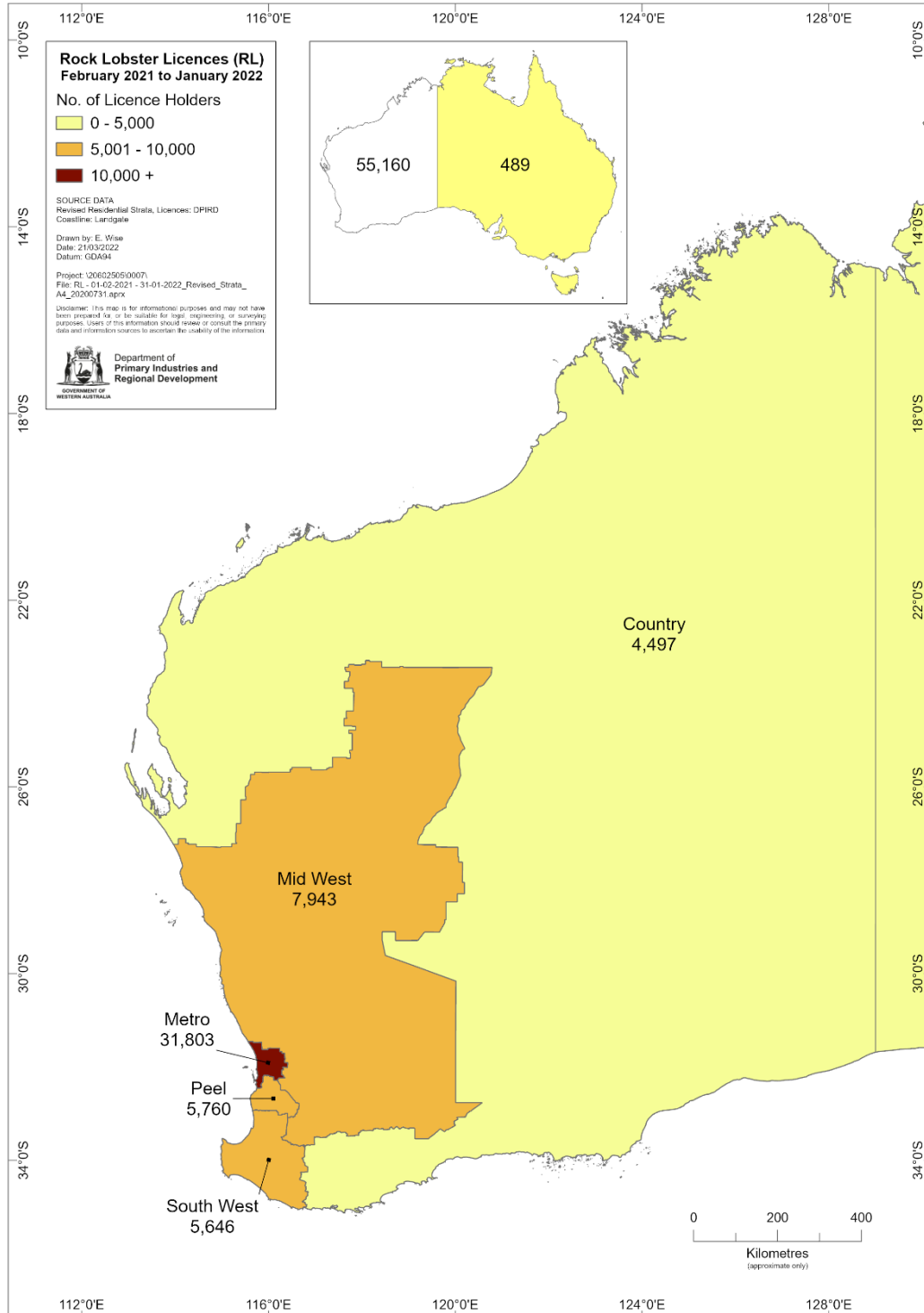
Appendix 5 Distribution of weight measurements for WRL shown as (a) histogram of weight combined across sexes for 2021/22 with arithmetic mean (dotted line), (b) length-weight relationship combined across sex for 2015/16–2021/22, (c) histogram of weight for each sex in 2021/22 and (d) length-weight relationship for each sex for 2015/16–2021/22.



Appendix 6 Number of RL holders within the modified Regional Development Commission Boundaries from 1 February 2021 to 31 January 2022.

Note:

1. country total includes interstate RL holders
2. out-of-scope fishers (n=6) excluded



Appendix 7 Statewide *unadjusted* retained catch (in numbers) of Western Rock Lobster (*Panulirus cygnus*), (Southern Rock Lobster (*Jasus edwardsii*) and Tropical Rock Lobster species (*Panulirus ornatus* and *P. versicolor*) obtained during the phone-recall survey for 2021/22 by potting, diving and total (combined methods).

Note:

3. these estimates have not been adjusted to account for biases in survey methods
4. values in bold indicate RSE>0.4; values in italics indicate n<30.

Season	Retained catch (numbers)								
	Potting			Diving			Total		
	Estimate	LCI	UCI	Estimate	LCI	UCI	Estimate	LCI	UCI
Western Rock Lobster (<i>Panulirus cygnus</i>)									
2021/22	965,442	846,402	1,084,482	321,815	232,060	411,571	1,287,257	1,146,509	1,428,006
Tropical Rock Lobster (<i>Panulirus ornatus</i> and <i>P. versicolor</i>)*									
2021/22	0	0	0	14,501	9,116	19,887	14,501	9,118	19,884
Southern Rock Lobster (<i>Jasus edwardsii</i>)									
2021/22	3,405	1,219	5,592	6,928	4,166	9,689	10,333	6,785	13,880

Appendix 8 Regional *unadjusted* retained catch (in numbers) of Western Rock Lobster (*Panulirus cygnus*) obtained during phone-recall surveys for 2021/22 by potting, diving and total (combined methods).

Note:

1. these estimates have not been adjusted to account for biases in survey methods
2. values in bold indicate RSE>0.4; values in italics indicate n<30.
3. due to the number of decimal places in the input parameters and rounding, the values across regions with a year may not sum to the totals at a statewide level.

Region	Retained catch (numbers)								
	Potting			Diving			Total		
	Estimate	LCI	UCI	Estimate	LCI	UCI	Estimate	LCI	UCI
2021/22									
North	0	0	0	<i>14</i>	<i>0</i>	<i>41</i>	<i>14</i>	<i>0</i>	<i>41</i>
Gascoyne	951	<i>0</i>	1,943	9,751	5,119	14,383	10,702	5,904	15,501
Mid-West	264,091	197,316	330,866	74,609	22,507	126,710	338,700	255,505	421,895
Metro-West	699,603	597,177	802,030	233,477	168,575	298,378	933,080	817,795	1,048,365
South	796	<i>0</i>	1,607	3,965	1,088	6,842	4,761	1,780	7,742

Appendix 9 Statewide retained catch (in numbers) of Western Rock Lobster (*Panulirus cygnus*), Southern Rock Lobster (*Jasus edwardsii*) and Tropical Rock Lobster species (*Panulirus ornatus* and *P. versicolor*) in 2021/21 for potting, diving and total (combined methods) from Tour Operator Returns.

Season	Retained catch (numbers)		
	Potting	Diving	Total
Western Rock Lobster (<i>Panulirus cygnus</i>)			
2021/22	32,342	2,300	34,642
Tropical Rock Lobster (<i>Panulirus ornatus</i> and <i>P. versicolor</i>)			
2021/22	<3 operators		23
Southern Rock Lobster (<i>Jasus edwardsii</i>)			
2021/22	<3 operators		

Appendix 10 Timeline of retained catch (in tonnes) from licensed fishers by potting, diving and total (combined methods) from 1986/87–2021/22 with harvest ranges (lower and upper 95% confidence intervals).

Note:

1. Data for 1986/87–2017/18 were collected using mail surveys (Trinnie et al., 2021);
2. Average weight for 1986/87–2014/15 was a constant value of 500g (Trinnie et al., 2021);
3. A RL licence was required to fish from a charter boat prior to 2016/17 and these catches are included in the retained catch from 1986/87–2016/17.

Season	Avg wt	Retained catch (tonnes)								
		Potting			Diving			Total		
		Estimate	LCI	UCI	Estimate	LCI	UCI	Estimate	LCI	UCI
1986/87	500	74	61	87	22	18	26	96	79	112
1987/88	500	70	58	82	15	12	17	85	71	99
1988/89	500	91	75	106	20	16	24	111	92	129
1989/90	500	69	53	85	17	12	23	87	68	106
1990/91	500	62	45	78	23	15	32	85	64	106
1991/92	500	124	88	161	43	27	60	168	124	211
1992/93	500	141	109	173	36	26	47	178	140	216
1993/94	500	117	92	141	34	26	43	151	121	181
1994/95	500	105	67	143	18	12	24	124	84	163
1995/96	500	93	73	113	28	20	36	121	97	146
1996/97	500	90	71	109	29	22	36	119	95	143
1997/98	500	135	109	162	54	42	67	190	154	225
1998/99	500	179	145	214	66	53	79	246	201	290
1999/00	500	219	176	263	73	55	91	292	237	348
2000/01	500	181	146	215	63	49	77	244	199	289
2001/02	500	156	125	186	66	50	81	221	180	263
2002/03	500	246	198	293	103	81	125	349	285	413
2003/04	500	223	179	268	93	70	115	316	255	376
2004/05	500	209	166	252	72	55	90	282	227	337
2005/06	500	122	98	145	41	32	50	162	132	193
2006/07	500	108	86	130	49	37	60	157	126	187
2007/08	500	111	86	135	44	34	54	155	124	187
2008/09	500	98	76	120	57	41	74	157	124	190
2009/10	500	132	102	161	55	43	68	187	149	225
2010/11	500	94	68	119	44	32	56	138	106	169
2011/12	500	77	61	92	38	29	46	115	93	136
2012/13	500	92	74	110	33	26	40	125	102	148
2013/14	500	179	143	215	64	50	79	243	197	289

Season	Avg wt	Retained catch (tonnes)								
		Potting			Diving			Total		
		Estimate	LCI	UCI	Estimate	LCI	UCI	Estimate	LCI	UCI
2014/15	500	264	213	316	66	51	80	330	269	391
2015/16	583.8	302	245	360	90	70	111	393	320	465
2016/17	578.8	376	301	450	82	63	102	458	371	545
2017/18	573.8	399	321	476	81	63	100	480	390	570
2018/19	604.0	367	323	410	83	64	101	449	404	494
2019/20	651.7	381	336	426	139	96	181	520	460	580
2020/21	587.4	415	359	472	106	67	144	521	456	586
2021/22	610.7	366	320	411	122	88	156	487	434	541

^ The 2018/19 season covers the period February 2018 to January 2019. Therefore, 5 months of catch (February–June 2018) is reported in both the 2017/18 season and the 2018/19 season. This overlap accounted for 33% (152 t) of the retained catch in the 2018/19 season.

Appendix 11 Timeline of retained catch (in tonnes) from tour operators by potting, diving and total (combined methods) from 2016/17–2021/22.

Note:

1. Data extracted from tour operator database on 31 May 2022;
2. Tour Operator catch prior to 2016/17 was captured within the retained catch from licensed fishers;
3. Average weight calculated using random length samples reported on Tour Operator Returns within each season and converted to weight using a length-weight equation.

Season	Avg wt	Retained catch (tonnes)		
		Potting	Diving	Total
2016/17	593.9	2	1	3
2017/18	593.9	8	1	9
2018/19 [^]	569.0	8	1	9
2019/20	545.6	14	1	15
2020/21	494.9	15	1	16
2021/22	505.6	16	1	17

[^] The 2018/19 season covers the period February 2018 to January 2019. Therefore, 5 months of catch (February–June 2018) is reported in both the 2017/18 season and the 2018/19 season. This overlap in reporting periods accounted for 48% (4.5 t) of the retained catch from Tour Operator Returns in the 2018/19 season.